SENESCENCE AND EXTINCTION IN INLAND LAKES OF MICHIGAN

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ABSTRACT

SENESCENCE AND EXTINCTION IN
INLAND LAKES OF MICHIGAN

by Edward Allison Kirkby

Senescence and extinction were studied in inland lakes with basins in glacial drift in the Lower Peninsula of Michigan. Several hundred lakes were given a cursory examination while 23 others were studied in detail, using a sounding rod to determine sediment thickness and depth to the original bottom.

All the lake basins had been modified by sediments since they originated, after the retreat of the fourth stage of the Pleistocene. The dominant sediments are peat and marl.

A correlation exists between the slope of the original bottom in a lakeward direction and the dominant type of sediment. Original bottoms usually dip at 13 degrees or less in lakes where peat dominates, but 14 degrees or more where marl is the dominant sediment. Calcium carbonate may be carried into any lake basin intersecting the groundwater table but is deposited as marl only where acids do not exist in quantities capable of neutralizing calcium carbonate. The most favorable places for marl deposition would be in lakes with steep original bottoms that limit the growth and migration of attached aquatic vegetation.

Shallow and deep lakes are defined on the basis of the original bottom sloping in a lakeward direction and the dominant sediment. Deep lakes have an original bottom dipping 14 degrees or more and (or) marl is the dominant sediment. Shallow lakes have an original bottom dipping 13 degrees or less and (or) peat is the dominant sediment. Deep lakes are less prone to senescence and extinction than shallow lakes.

The size and shape of the lakes, size and relief of the drainage area have little bearing on the relative resistance of the lake to senescence and extinction. No correlation exists between the number of extinct lakes and the elevation, surface formations, soils, physiographic province, and relative age of the region they occur in. No visible evidence of accelerated aquatic vegetation growth due to human effluent, agricultural fertilizers and manures were found.

Sediment coring may reveal a relationship between sediment types, deposition patterns, and climatic pulsations. Coring was attempted but efforts were unsuccessful.

SENESCENCE AND EXTINCTION IN INLAND LAKES OF MICHIGAN

By

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CHAPTER I

INTRODUCTION

Lakes and Lake Activities

Michigan is a water wonderland and a land of lakes, including over 29,000 natural inland lakes (Humphrys, 1963). Each county has one or more lakes and the number may be increasing with the addition of artificial or man-made lakes.

The shores of lakes in the southern part of the Lower Peninsula have been in various stages of development since the advent of the horseless carriage. Now freeways have reduced driving times, as salaries have increased and the work week decreases, causing many people to seek out lakes in the northern part of the Lower Peninsula, and Upper Peninsula.

Most lakes are used for one or more forms of recreation. Many are used for swimming, waterskiing, fishing, hunting and viewing. Some are used throughout the year, including winter months when ice skating, sleding, ice fishing, snowmobiling, ice boating and sports car racing may be carried on.

Unfortunately, not all lakes can support a variety of activities. Many lakes have evolved into swamps and peat bogs where recreation may be limited to bass fishing and duck hunting, at most. Other lakes are extinct, but may be utilized by wild animals, or exploited by peat and marl operators.

Statement of the Problem and Intentions of the Study

Lakes are grand but most are temporary features on the landscape, geologically speaking. The origin of most lakes in the Great Lakes area may be traced to the oscillatory retreat of glaciers that melted away over 10,000 years ago. (Figure 1.) The basins of most lakes show indications

(Dates after Hough, 1958; Wayne, 1965; and Zumberge, 1956)

Figure 1. Halt of Retreating Ice Front

of senescence or extinction in the form of swampy, peat-filled margins, or shallow areas controlled by aquatic vegetation. This phenomenon has been observed at glacial drift lakes in Indiana (Blatchley, 1901) and Minnesota (Zumberge, 1952) and is probably characteristic of most lakes with origins dating back to the retreat of glaciers during the Pleistocene.

Since senescence and extinction are common to most lakes it was felt that a geologic study might produce new evidence useful in determining the causes of senescence and extinction. The intention of this study is to determine how lakes become senescence and extinct; the extent of sediments filling in selected lakes, and why lakes, and parts of lakes become senescent and extinct.

This study should be of interest to riparians, lake associations, dredging companies, lake builders and developers, geologists, biologists, limnologists, peat and marl producers.

Previous Investigations

Previous investigations of lake senescence and extinction in Michigan consist of briefly explaining the origin, development, and extinction of lakes, or making cursory inspections of marl and peat deposits and noting their quality and commercial possibilities. These studies did not equate the original bottom slope with the predominant type of sediment, and relate senescence and extinction possibilities of the lake.

Origin of lakes, former lake levels and extinction is explained in "Inland Lakes of Michigan," Michigan Geological Survey Publication 30 (Scott, 1921). Inland lakes being extinct or senescent are described in reports about marl (Hale, 1903), peat (Burns, 1904; Davis, 1907), and surface geology (Lane, 1908, p. 126). Inland lake level declines are mentioned for the Lower Peninsula (Rominger, 1876), Muskegon County (McLouth, 1902, p. 105), and part of Oakland County (Stanley, 1936, pp. 52-53).

Sources of Information

Depth and area of the lakes were obtained from the Fish Division, Michigan Department of Conservation, Lansing. When hydrographs were unavailable, air photos and county soil studies were used as a base for delineating the shape and computing the size of lakes. Drainage area size, maximum feet of relief, prominences and landmarks were determined from air photos and U. S. Geological Survey topographic quadrangle sheets, and extent and type of peat deposits adjacent to lakes from county soil studies. Glacial drift thickness information is from oil and gas exploratory logs published by the Geological Survey Division, Michigan Department of Conservation, Lansing.

Published and unpublished literature prepared by the Geological Survey Division, Michigan Department of Conservation, was searched for lake references. Cloverdale, Long, and Guernsey lakes were visited during a statewide marl survey (Hale, 1903).

Location of Lakes

Twenty-three inland lakes in Barry, Clare, Eaton, Kalkaska, Missaukee, Osceola, and Wexford counties were studied in detail (Figure 2). In addition, several hundred lakes in the Lower Peninsula were visited and given cursory examinations.

Procedure

An attempt was made to select lakes underlain by 200 or more feet of glacial drift, without inlets or outlets, having public access, limited shore and upland development, in isolated locations. As might be expected, an accessible lake meeting this criteria was hard to find. The field work was begun in 1963 and completed in 1966.

The primary mission at each lake was to determine depths to the present and original bottoms using a sounding rod constructed of one-half inch steel pipe. Pipe lengths to 35 feet were experimented with, but the most satisfactory was 21 feet. The sounding rod was marked at five-foot

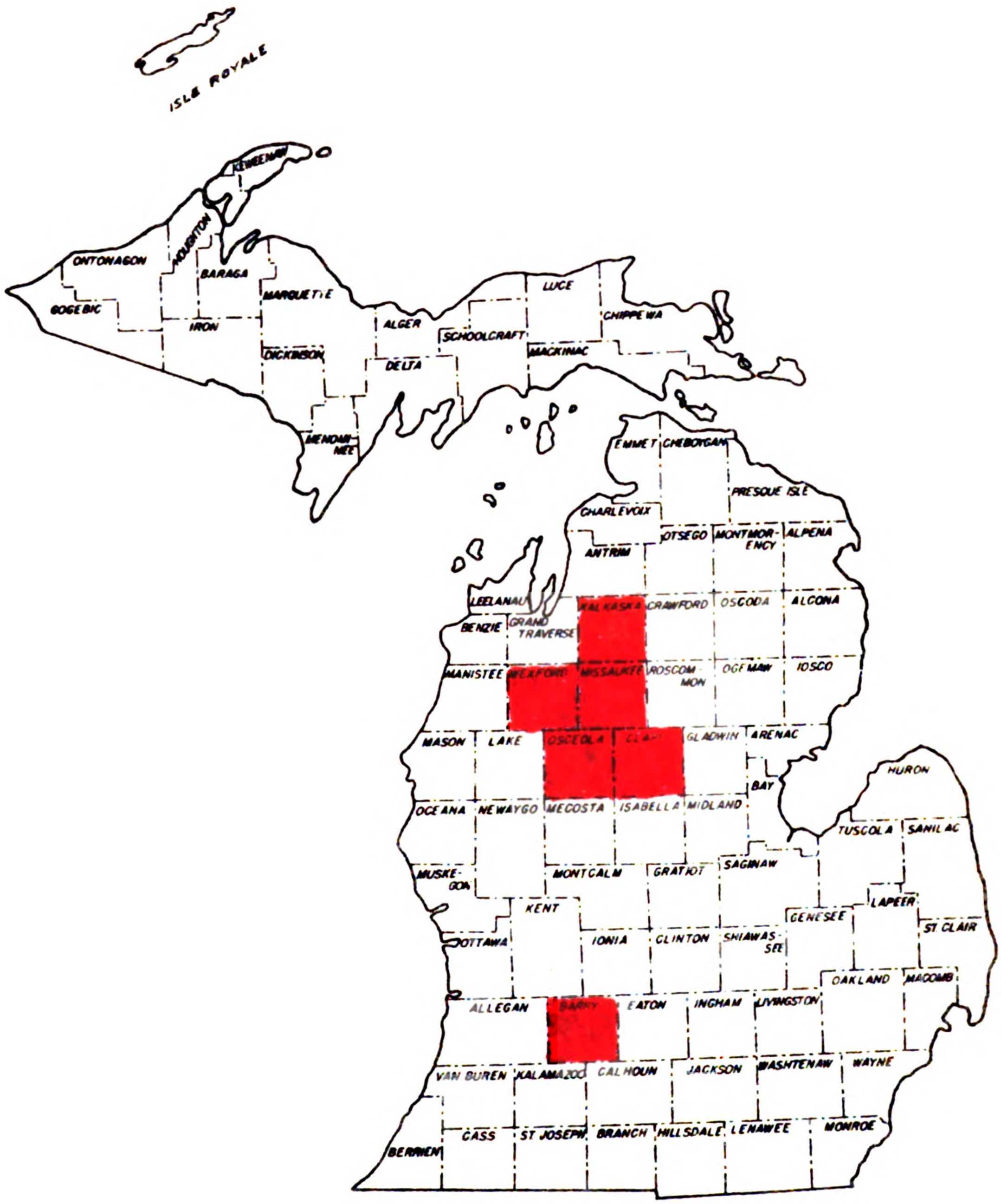


Figure 2. Location of Counties
Where Lakes Were Studied in Detail

intervals. A steel tape was used to obtain a measurement to the nearest foot. The sounding rod was operated from a small rowboat while a second person recorded data and stabilized the craft (Figure 3).

If the lake bottom was not visible, the sounding rod was moved to and fro as it was lowered vertically. It was difficult to move the sounding rod when the present bottom was reached.

The original bottom of the lake basin is the probable bottom formed as the ice melted. The original bottom is composed of clastic sediments usually overlain by marl, peat or both. It is the place where the sounding rod will not descend further. Often, the original bottom was not reached so efforts were abandoned at that station to locate it.

Depths to the present and original bottoms enabled the writer to compute bottom slopes, and thickness of sediments. Cross sections were drawn from the measurements.

Sediment-type marl, peat, or a combination was determined from samples adhering to the sounding rod. Peat less than one foot thick did not adhere. Submergent aquatic vegetation, muskgrass and pondweed were brought to the surface.

Station locations were determined by estimating distances from shore features on U. S. Geological Survey topographic quadrangles. When checked from shore, stations were within 35 to 50 feet of locations on hydrographs used as a base. Greater station location accuracy was possible within 250 feet of the shore.

The drainage area was checked for relic shorelines, outlets and inlets at the 23 lakes studied in detail. Soil composition, shore development, and recent lake level changes were also noted.

Various types of homemade coring devices of various lengths were built and tested. It was hoped that a continuous core of sediments could be recovered and studied at each of the 23 lakes, thereby shedding new light on sediment deposition. However, the coring phase of this project was unsuccessful and abandoned.

Sounding rod in raised position

Sounding rod at original bottom

Figure 3. Sounding Rod Operation

CHAPTER II

ORIGIN OF INLAND LAKES

Most of Michigan's inland lake basins are located in glacial drift. Glacial drift is soil materials transported and deposited by glaciers that retreated from the Midwest over 10,000 years ago (Figure 1). However, lake basins existed in Michigan long before the Pleistocene or "Ice Age." Probably, preglacial lake basins occurred in the bedrock surface as they do today in parts of the western half of the Upper Peninsula and Isle Royale. Such basins originated from folding, faulting, or differential erosion of the rock (Plate 1). Examples are Lake Gogebic and Lake of the Clouds.

Lakes may originate in preglacial bedrock valleys that are later dammed by glacial drift (Plate 2). Origin of these lakes may be traced to the time of glacial advances when temperatures declined and precipitation collected to form ice in the valleys. Ice would preserve the shape of the valleys and become part of the regional ice mass as glaciers advanced over the area. During glacial retreat, ice in the valleys being thicker and probably insulated by glacial drift, would melt at a slower rate than the glacier. A lake basin or basins resembling a valley developed as the ice in the valley melted (Ferris, 1954, p. 31). Examples are several narrow "chains of lakes" in T6-7S, R3-4W, Hillsdale County, an area of thin glacial drift (Plate 3).

Lakes similar in appearance and origin to preglacial valley lakes may develop in glacial drift (Plate 4). The difference occurs because the valleys are located in glacial drift laid down during an earlier glacial advance. An example is the chain of lakes made up of Wilkinson, Cloverdale, and Long lakes, T2N, R9W, Barry County, an area of thick glacial drift (Plate 5).

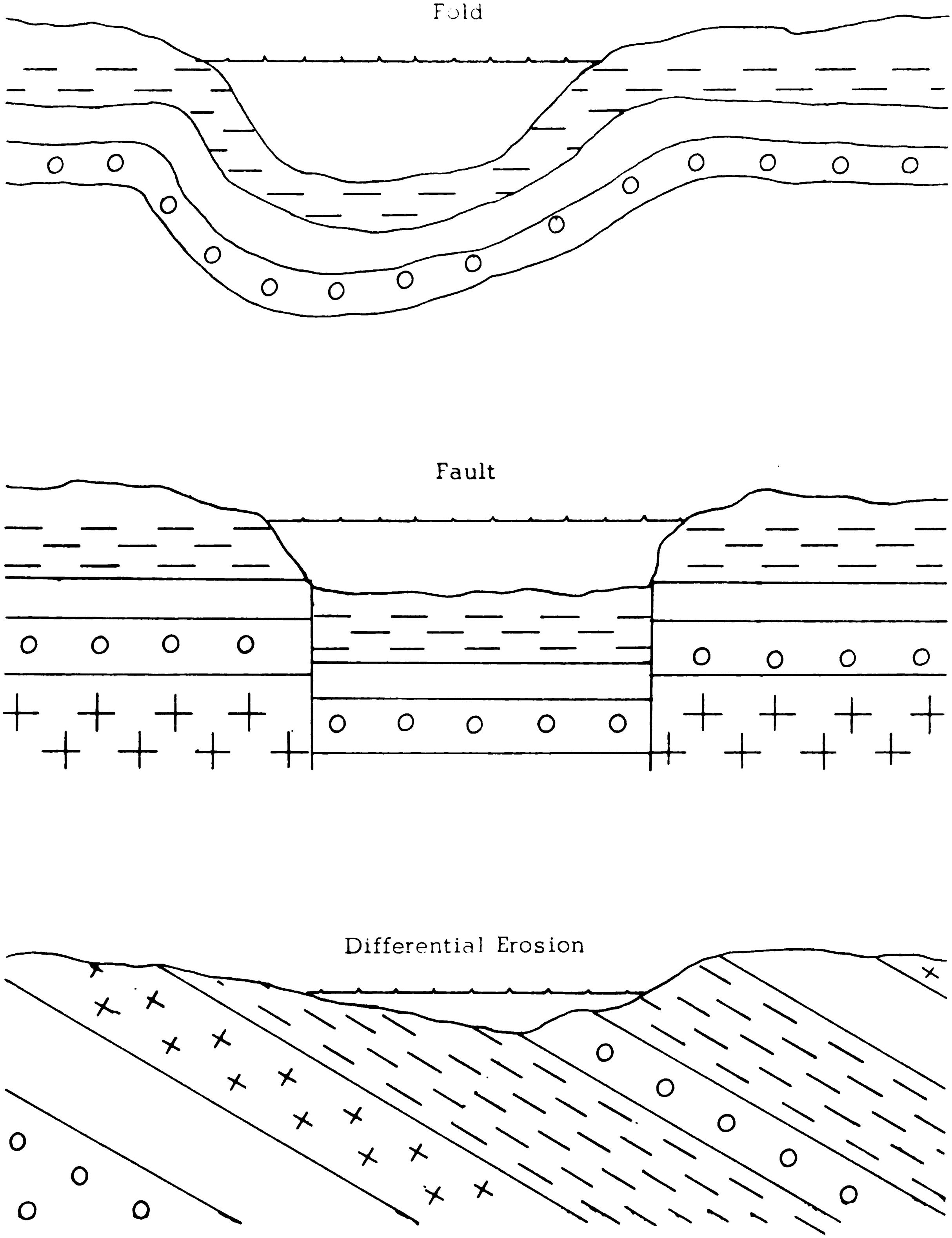
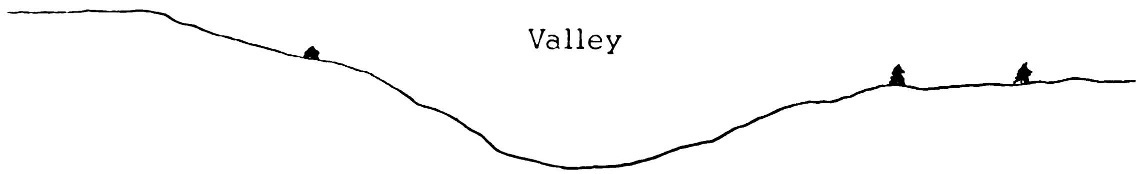
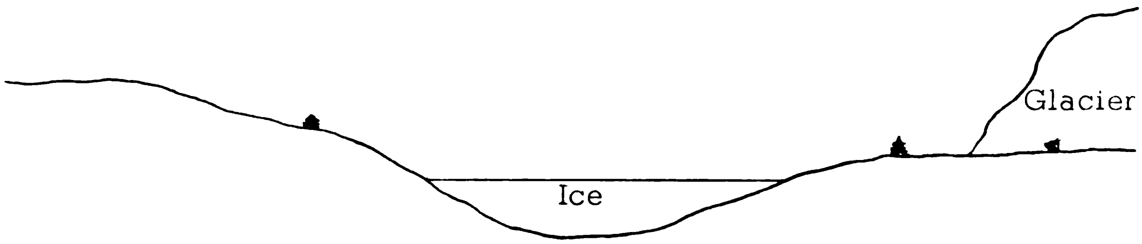
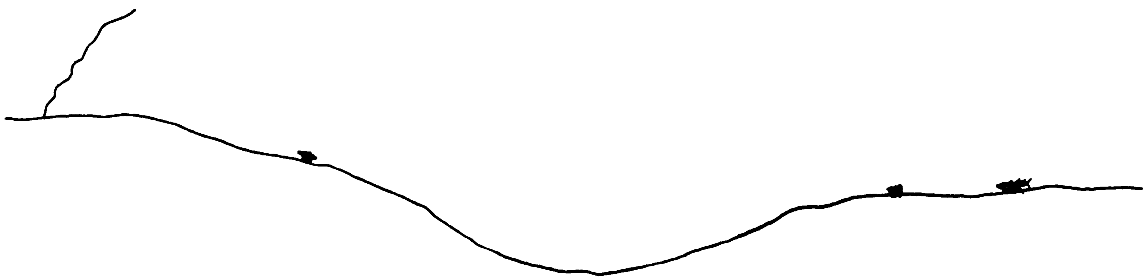


Plate 1. Bedrock Basins

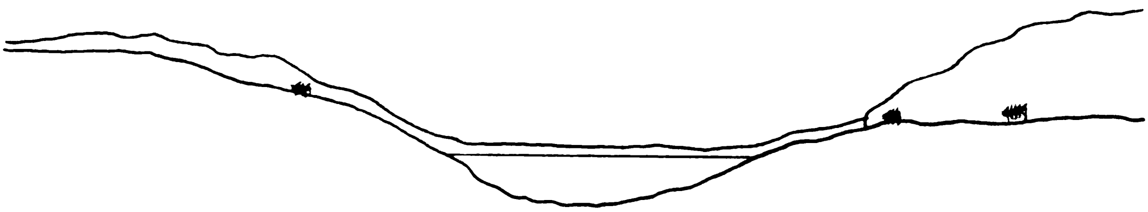




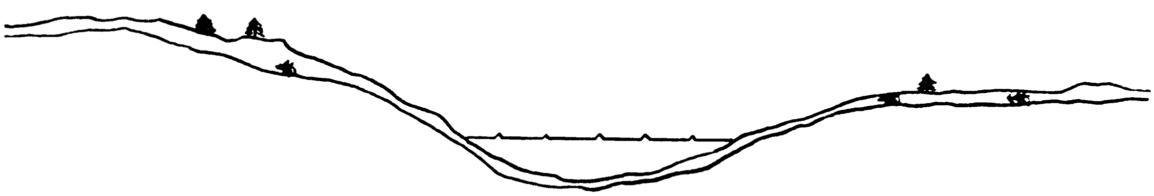
Ice Collects in the Valley as the Glacier Advances



Ice in the Valley Becomes Part of the Regional Ice Mass



Glacial Drift is Deposited as the Glacier Retreats



Bedrock Valley Lake

Plate 2. Bedrock Valley

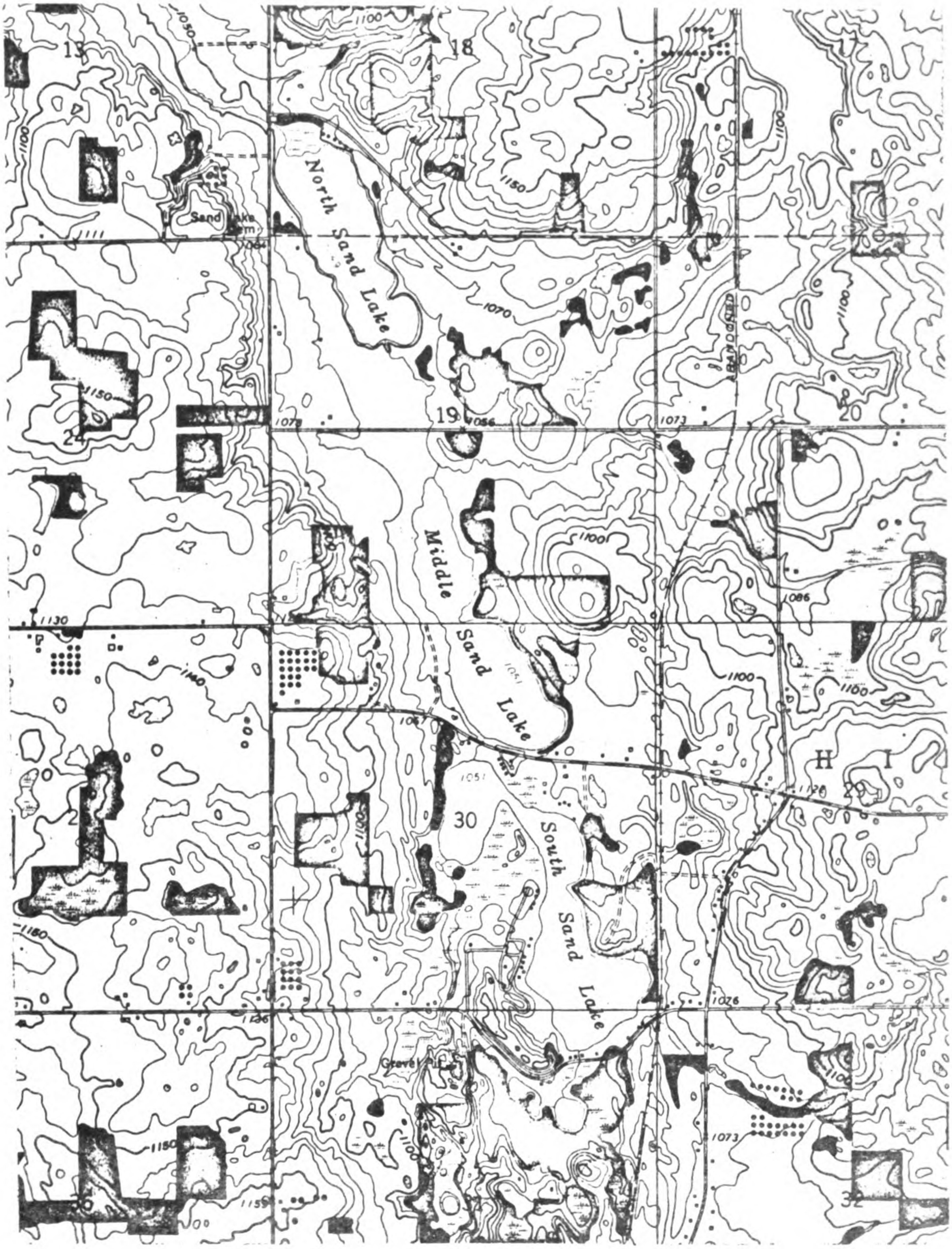
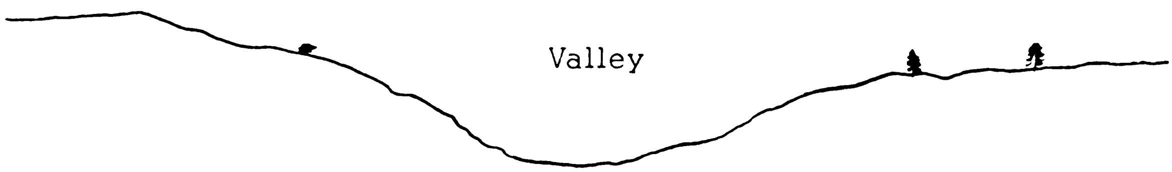
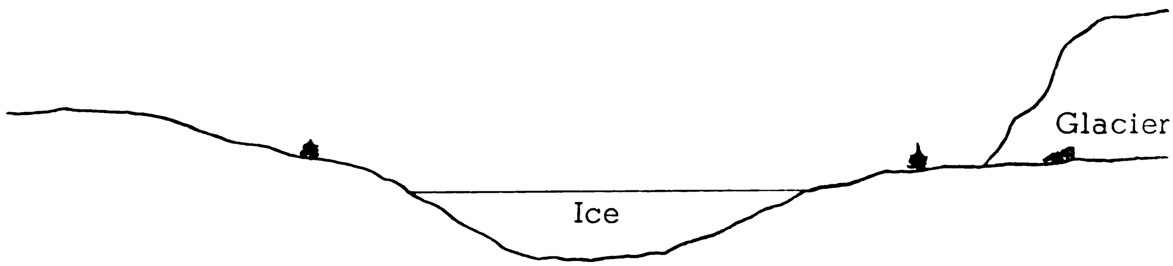
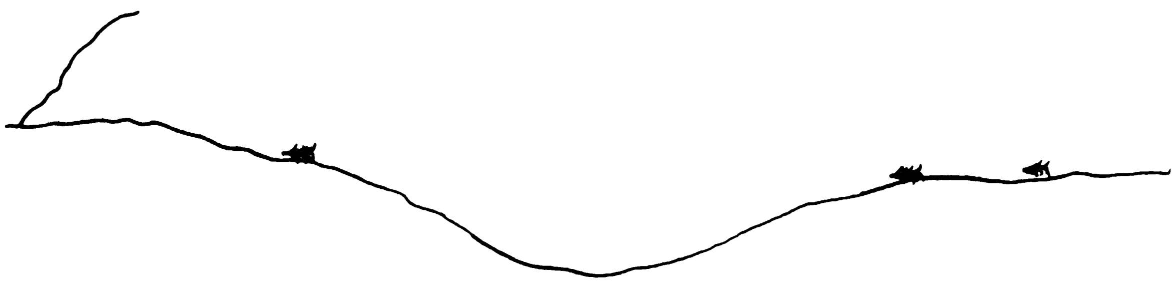


Plate 3. Lakes in Preglacial Bedrock Valley

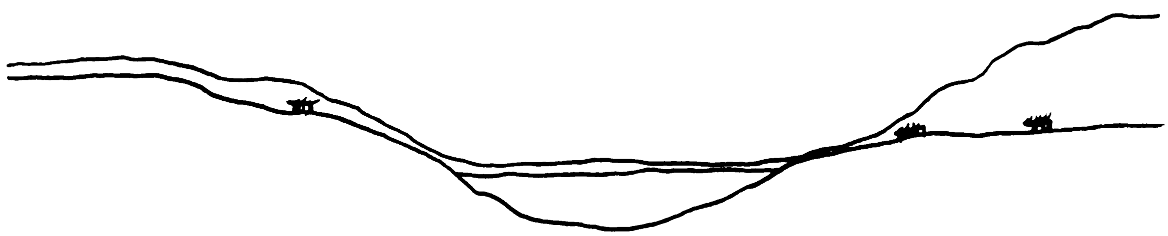




Ice collects in the valley as the glacier advances



Ice in the valley becomes part of the regional ice mass



Glacial drift is deposited as the glacier retreats

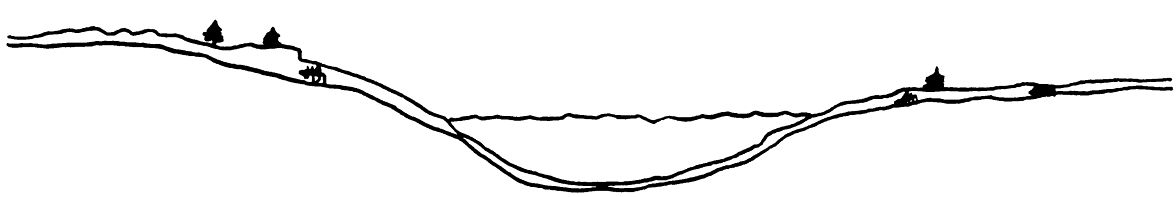


Plate 4. Glacial Drift Valley Lake

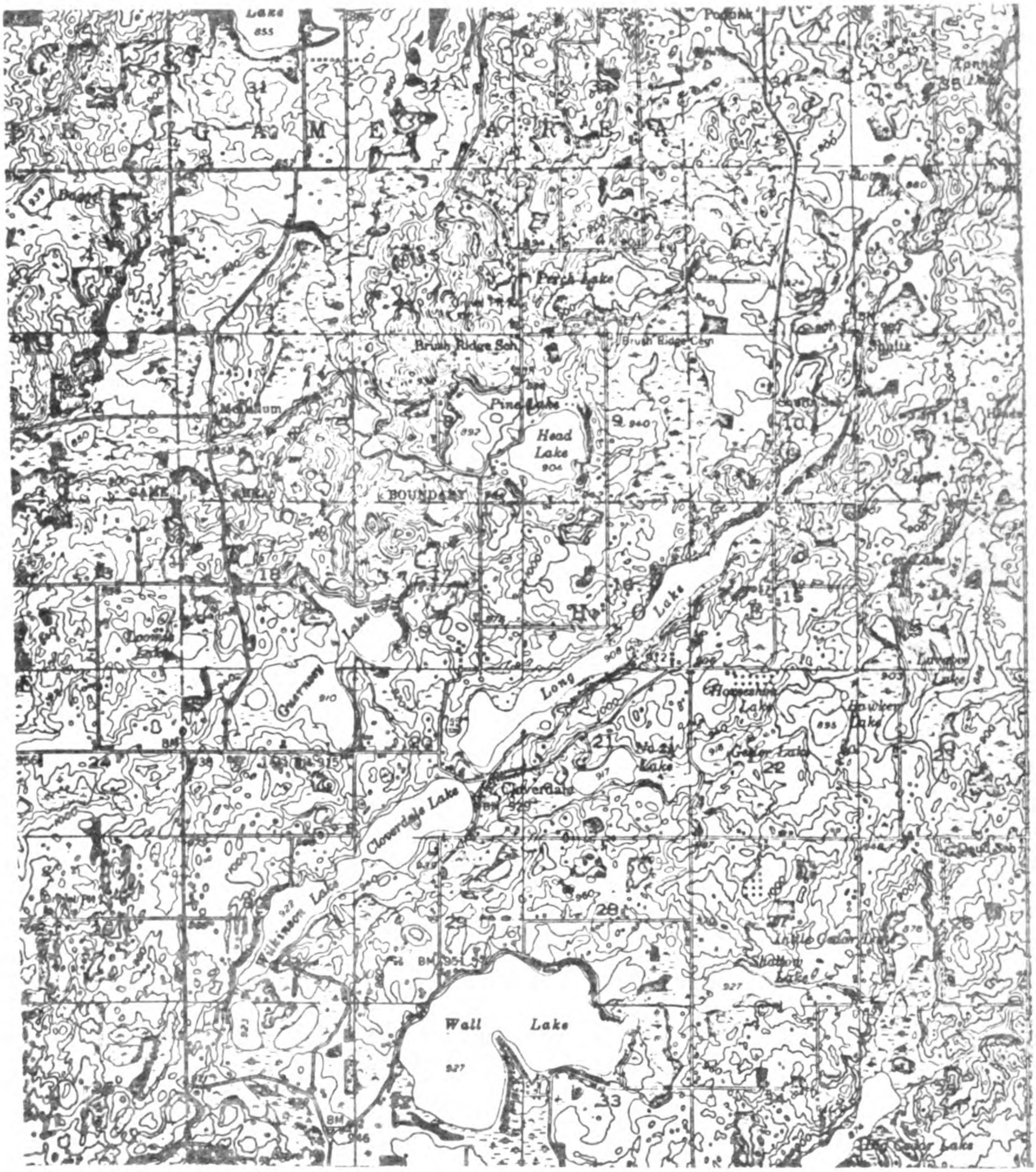


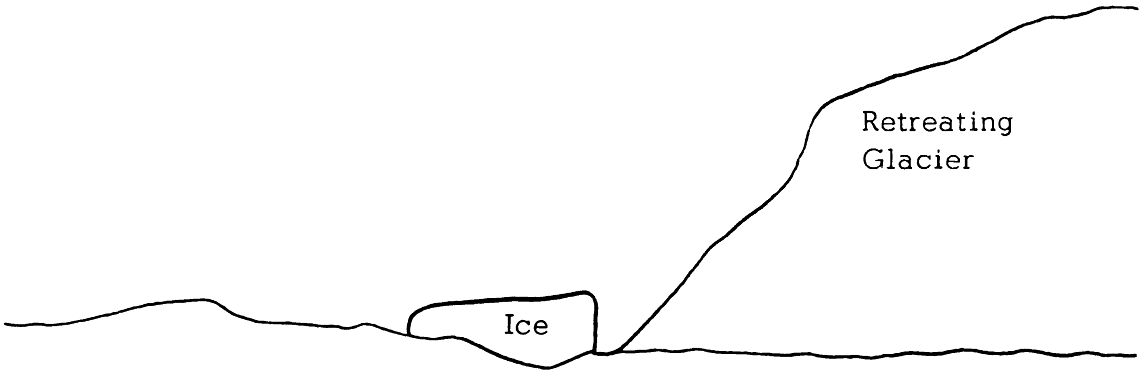
Plate 5. Lakes in Glacial Drift Valley

The majority of inland lakes in Michigan are pit and pot hole lakes whose origin is in blocks of ice separating from the margin of a retreating glacier (Plate 6). The ice block may be buried by glacial drift, gradually melting and leaving a pit. Size and shape of the pit is a reflection of the size and shape of the ice block and the depth is directly proportional to the thickness of the ice block minus the thickness of glacial drift deposited on it. The pit becomes a lake if it intersects the groundwater table or is intersected by a stream. Examples are Houghton and Higgins lakes, and most smaller inland lakes in Michigan.

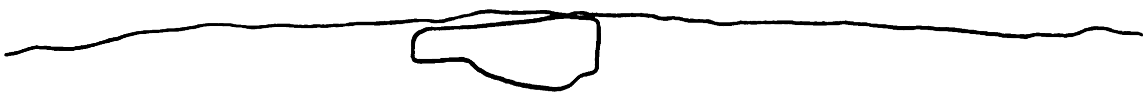
A perched lake basin is located above the groundwater table (Plate 7). These may start on sandy soils when runoff washes clay particles from surrounding slopes into the bottom and edges of a basin. Clay particles form an impervious seal preventing water from leaving the basin as rapidly as it enters, causing the lake level to rise as more water enters. The perched lake development process may be observed on a small scale on sand dunes during and directly after a heavy rain.

Wave action may form sand bars and spits that can gradually close the mouth of a bay, forming a separate lake. Bays and rivers with little current may be dammed by migrating sand dunes to form lakes (Plate 8).

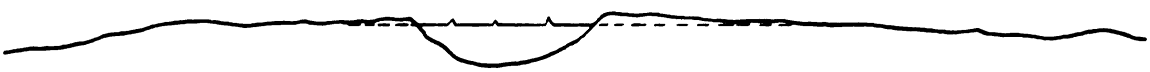
Lakes may develop in areas cleared of dense coniferous forests (Sigler, 1927). During the reign of the forests much precipitation would be intercepted by tree limbs or quickly infiltrate the soil before it could runoff. The groundwater table could also be low if it was intersected by tree roots because of the vast amounts of water used by the trees. However, if the timber was cut, precipitation would no longer be intercepted nor would living tree roots lower the groundwater table, so low places, especially basins, could fill with water becoming small lakes (Plate 9).



Ice Block Calves Off the Retreating Glacier



Ice Block is Buried by Glacial Drift

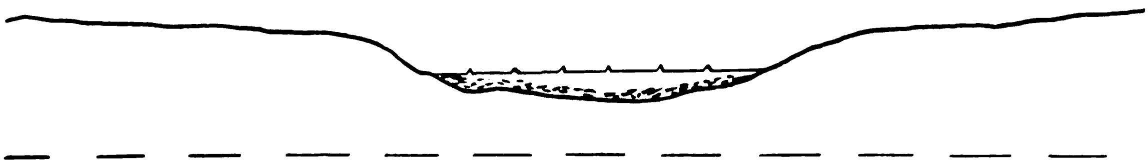


Ice Block Melts Forming Lake Basin

Plate 6. Pit Lake

Groundwater Table

Perched Basin



Sediments Collect in the Basin Raising the Water Level

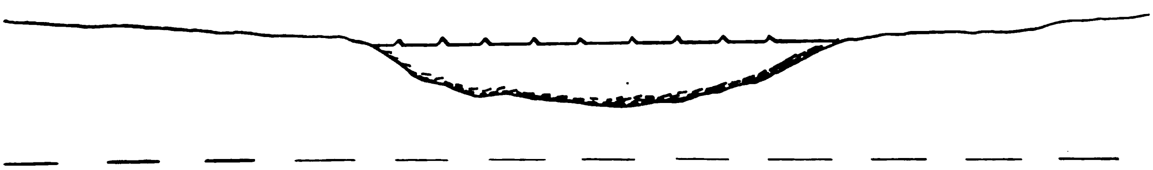
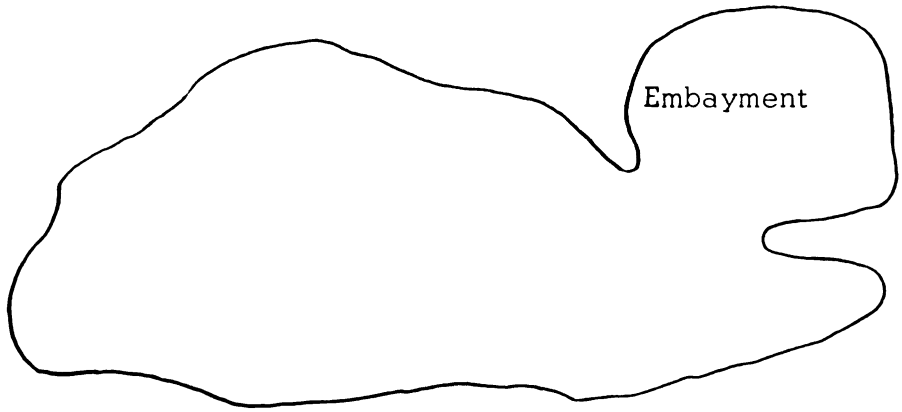
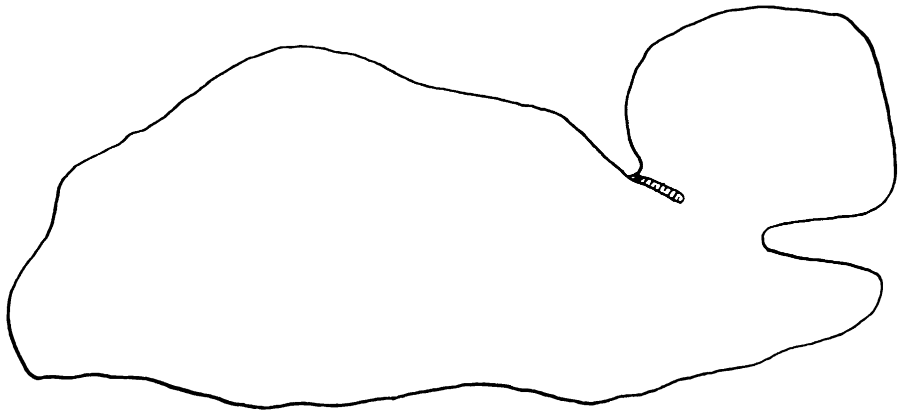


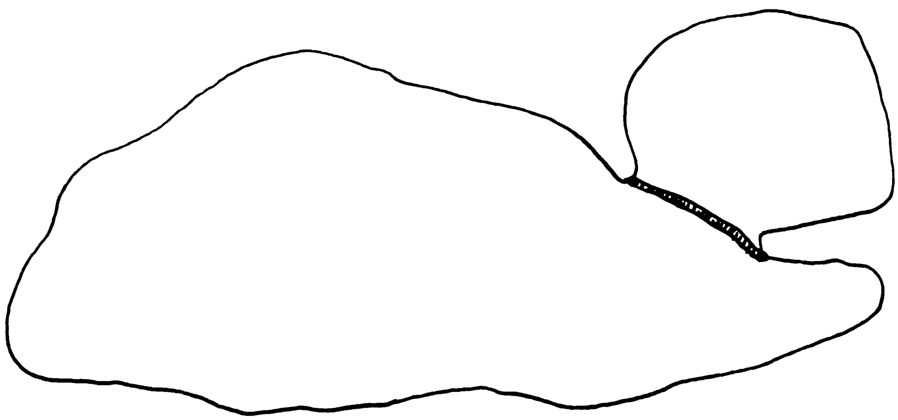
Plate 7. Perched Lake



Lake Basin



Bar Forming Across the Mouth of the Embayment



Bar Separates the Lake and Embayment

Plate 8. Origin of Two Lake Basins

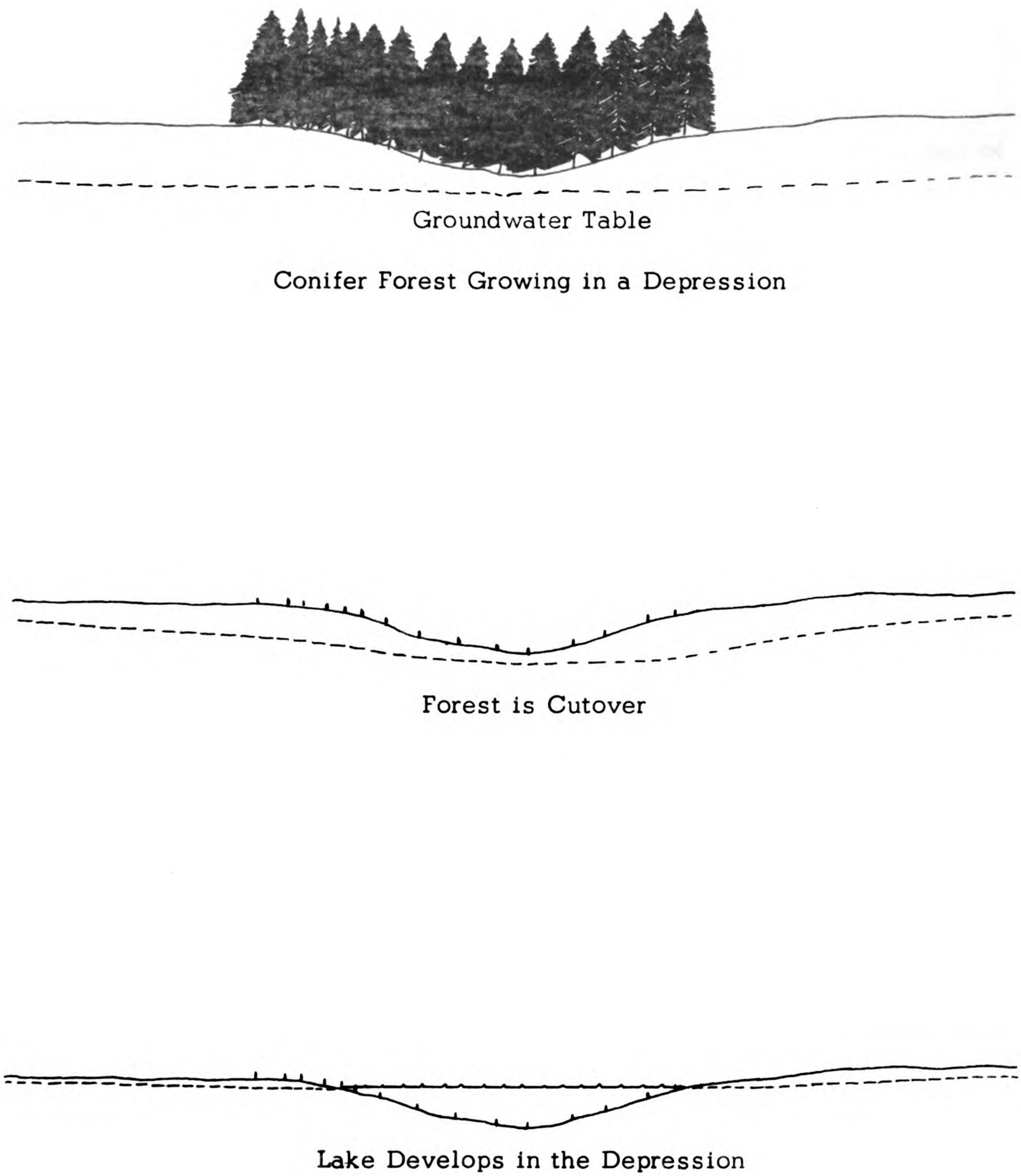


Plate 9. Lake in Cutover Forest

CHAPTER III

SENESCENCE AND EXTINCTION IN LAKES

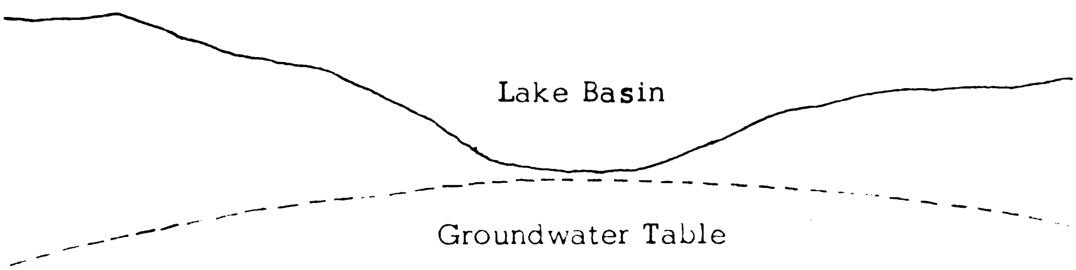
Senescence and extinction may affect an entire lake or only a part of it. Senescence is characterized by shallow water covering sediments and roots of flourishing aquatic vegetation where wave action is non-existent or slight. When these characteristics are present, the lake may be nearing extinction.

Extinction occurs when the lake basin, or parts of it, no longer contains water permanently (Plate 10). Extinction may be temporary, a loss of water without permanent damage to the lake basin, or permanent, when the lake basin's water-holding capacity has been replaced by sediments (Chrow, 1964, pp. 23-41). These stages in lake development are aided by clastic sediments, marl, peat deposition, and climatic conditions. Man's use of the lake and surrounding upland may accelerate senescence and extinction.

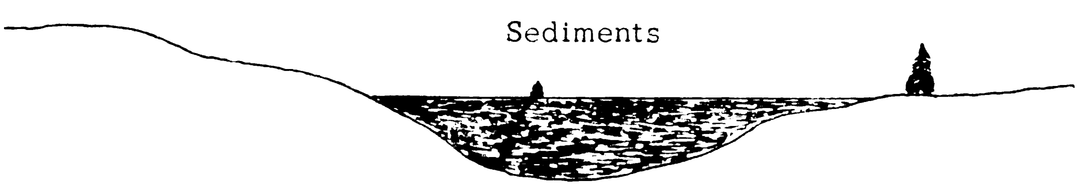
Role of Clastic Sediments

Clastic sediment deposition probably occurs as soon as an ice-filled depression is exposed by a retreating glacier. The retreating glacier may cover the ice-filled depression with drift composed of sediments ranging from boulders to clay, and deposited in the depression as the ice melts. Thickness of glacial drift regulates the melting time of ice in depressions and the original depth of the lake basin.

Clastic sediments may be deposited in lakes by effluent streams and runoff from bare slopes, excavations, ditches, and roads in the drainage area. Wave action may result in shore erosion with the sediments deposited beneath wave base and in embayments. Shore erosion enlarges the surface area of the lake, but the eroded sediments decrease the depth



Temporary Extinction



Permanent Extinction

Plate 10, Types of Extinction

and volume (Plate 11). Wind-blown sand may fill lakes located on sandy soils.

Depressions not containing ice may be filled by clastic sediments deposited by glacier melt-waters eliminating the possibility of a lake originating there.

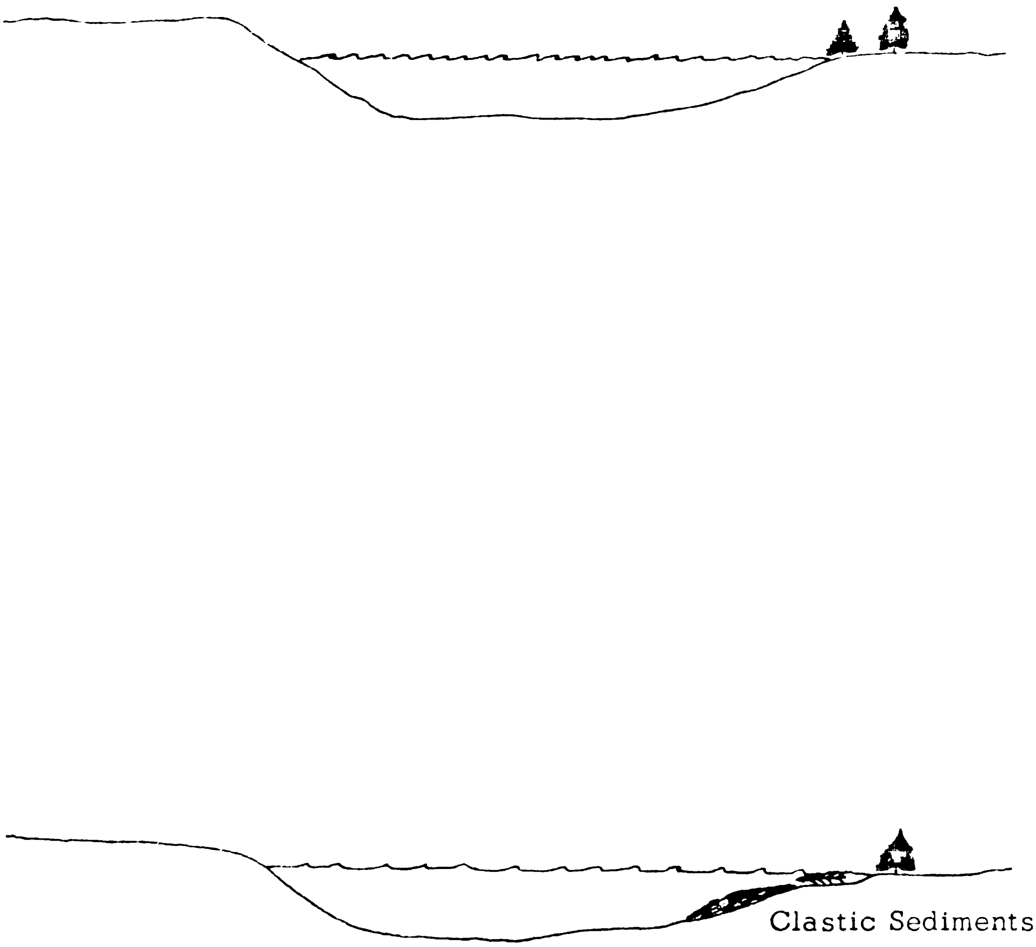
Clastic sediment deposition may be studied when the lake bottom is exposed. However, where these sediments are overlain by marl and peat and it is impossible to examine them without coring because the basins of most glacial drift lakes are composed of clastic sediments.

Role of Marl

Marl is a calcium carbonate sediment varying from chalk white to dark gray, usually unconsolidated, and dissolving with effervescence in a mild acid. It is carried by ground water into lakes where it may be precipitated by chemical (Hale, 1903; Lane, 1908), animal (Hale, 1903), or vegetable (Davis, 1903; Pollack, 1918) means.

Calcium carbonate occurs in glacial drift as limestone and dolomite fragments moved from bedrock of the same kind by the glaciers. Exposed carbonate fragments may be eroded from glacial drift and deposited in lakes by runoff. However, the greatest amount of carbonate was deposited within glacial drift where it could not be eroded by runoff, but is leached by ground water. The carbonate fragments may be located within the surface drainage area, or the groundwater drainage area.

Marl may play a major role in the senescence and extinction stages of a lake's development. Its deposition begins in shallow water and gradually moves lakeward, often more rapidly than encroaching vegetation (Bergquist, 1928, p. 280). Shallow water becomes even shallower as marl is deposited thereby reducing wave action and providing a desirable habitat for aquatic vegetation. The marl depositional pattern may result in an abrupt, steep slope from shallow to deep water (Hooper, 1956, p. 115), the familiar "drop off."



Shore erosion increases the surface area but decreases the depth and volume.

Plate 11. Effects of Shore Erosion

The presence of marl is usually indicated by a white to gray coating on semi-emergent vegetation, stones, and other objects. Marl is also indicated by the plant Potentilla sp. (Bergquist, 1928, p. 282) while Chara sp., muskgrass, and Potamogeton sp., pondweed, grow in areas where marl is accumulating.

Marl pebbles may occur where there is an abundance of phosphates (Eyster, 1958) or indicate the purity of marl (Pollack, 1918, p. 251).

Role of Peat

Peat is the partially decomposed remains of water-saturated stems, leaves, and seeds. It varies in color from light yellow when young, to dark brown when older and more decomposed (Soper, 1922). Peat is approximately 10 percent solid matter and 90 percent water, with a specific gravity of 0.1 to 1.06, and weighing seven to 65 pounds per cubic foot (Soper, 1922, p. 13). Specific gravity and weight of peat are dependent on moisture content, type of peat, decomposition and sediments deposited with it. Muck is the darkest and most thoroughly decayed peat (Transeau, 1906, p. 35).

Peat may be traced to vegetation being introduced to lakes in their youth by wind and birds (Schlicting, 1958). The first aquatic plants to adapt to a new environment are pioneers who improve the lake bottom habitat so less tolerant vegetation can root. Succession that follows is shallow-water vegetation gradually moving lakeward as soon as depth, light, water temperature, aeration, physical and chemical composition of the substratum, are favorable for their survival. The accumulation of plant debris accelerates the filling-in process of the lake basin and consolidates the false bottom (Dansereau, 1952, p. 510). Vegetation may also be aided in its lakeward trek as a result of outlets being eroded, lowering the lake level. Plant succession reduces evapotranspiration losses by shielding the water from solar radiation, dropping its temperature and evaporation rate (Chrow, 1964, pp. 6-23).

Marl

Peat

Plate 12. Marl and Peat

Aquatic vegetation types may adapt to one environment more readily than another with the most prolific growth of attached vegetation occurring on sedimentary peat, organic mud or clayey inorganic mud (Veatch, 1933, p. 411). *Pontederia sp.*, and *Sagittaria sp.*, arrowhead, may grow with *Nymphaea sp.*, water lily, or nearer shore but are most prolific in shallow alkaline water over clayey inorganic mud and peaty sand (Veatch, 1933, p. 413).

Vegetation can change an alkaline marl lake, or parts of it, into an acidic peat environment. This change will occur when decomposing vegetation nearly covers parts or all of a lake basin (Veatch, 1933, p. 411). When this condition is reached, acid-tolerant plants such as leatherleaf may develop and gradually crowd out the original alkaline vegetation. Deep, open water may remain alkaline until completely surrounded by acid bog vegetation (Veatch, 1933, p. 411). The acidic or alkaline reaction arises from decomposing vegetation in the lake and not directly from either living or dead marginal vegetation (Welch, 1936, p. 739).

A lake may be completely ringed by aquatic vegetation or a bog margin. The bog margin prevents upland sediments from entering and decreases the surface area of the lake and the effectiveness of wave action. Extinction is rapid once a bog margin and false bottom develop (Jewell, 1929, p. 473).

Natural regression of the lake basin toward drier conditions occurs when the transpiration rate of vegetation becomes greater than the water-retaining capacity of the peat mass (Dansereau, 1952, p. 494).

Organic matter may accumulate at the rate of two feet annually (Coburn, 1933, p. 58) but a long-range estimate of 0.72 to 2.16 inches per century (Soper, 1922, p. 13) seems more likely. Mats of aquatic vegetation have been reported to grow lakeward one foot every three years (Olson, 1944, p. 41).

Role of Men

Man's activities can also decrease the size of lakes. These include dredging outlets, improving drainage facilities, upland developments, water pumpage, allowing effluent to enter, deforestation and reforestation.

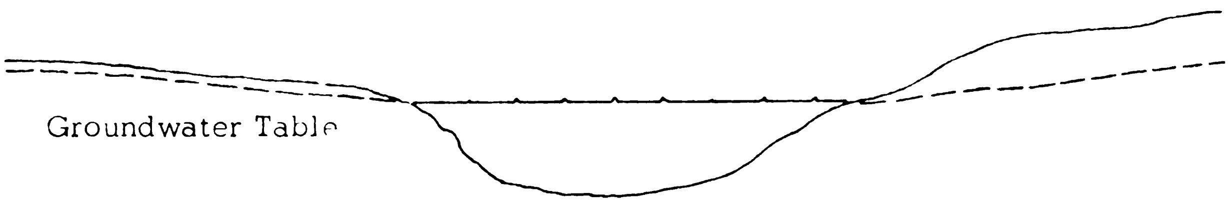
Historically, land covered by lakes has been considered more valuable than the lakes. Often the outlet was dredged with intentions of completely draining the lake. This activity was successful in many instances but equally as unsuccessful in others resulting in a shallower lake fit neither for plowing or fishing. Such a lake could easily be commanded by aquatic vegetation.

Better drainage was reported as a cause of lower lake levels in the Huron River valley over 60 years ago (Weld, 1904, p. 48). Tiling of fields in the drainage area (Plate 13) of a lake may have an adverse effect on the lake level (Veatch, 1940, p. 103). Good drainage increases runoff causing less water to reach the groundwater table, thus lowering it. A lower groundwater table means less available water to replenish evapotranspiration losses from the lake.

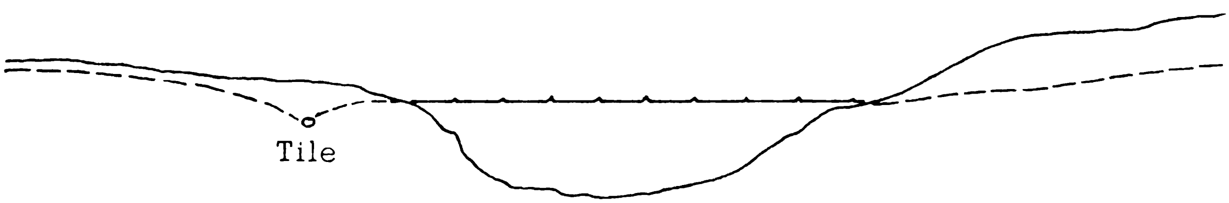
Runoff is also increased by extensively developing the drainage area. Roofs, roads and ditches speed water to the lake where it may be discharged through an outlet.

Pumping water from the lake or drainage area in quantities the groundwater reservoir is unable to immediately replenish may cause the lake level to decline and vegetation to invade. Excessive pumping lowers the groundwater table and lake level.

Effluent entering a lake will charge it with nitrates and phosphates that make for prolific algal booms. Residues deposited reduce the volume of the basin. Riparians may contribute 15-20 grams of nitrogen per person per day to the lake through use of private sewage disposal systems placed adjacent to the lake so they can drain through ground water into the lake (Nichols, 1965, p. 1322). Effluent entering Crooked Lake in Barry County from a nearby dairy products processing plant adversely affected the quality of water, causing a prolific growth of aquatic vegetation. The same was true of "treated sewage" entering Jordan Lake at Lake Odessa.



Before tile



Tile installed recently

Lower lake level and groundwater table

Plate 13. Effects of Tiling

Deforestation (Plate 14, Figure 1) may accelerate senescence (Jewell, 1929, p. 471). Without humus or forests to protect upland slopes, water may easily erode them, depositing clastic sediments into the lake. With no forest cover, rain may pack the soil, increasing runoff.

Reforestation (Plate 14, Figure 2) may have a long-range effect on water yield (Eschner, 1965). A dense growth of conifers may intercept a good share of available precipitation. Roots can also lower the groundwater table.

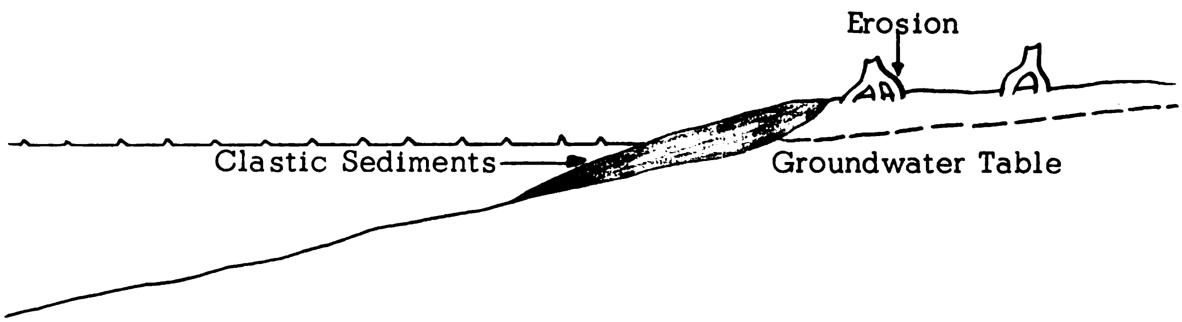


Figure 1. Deforestation

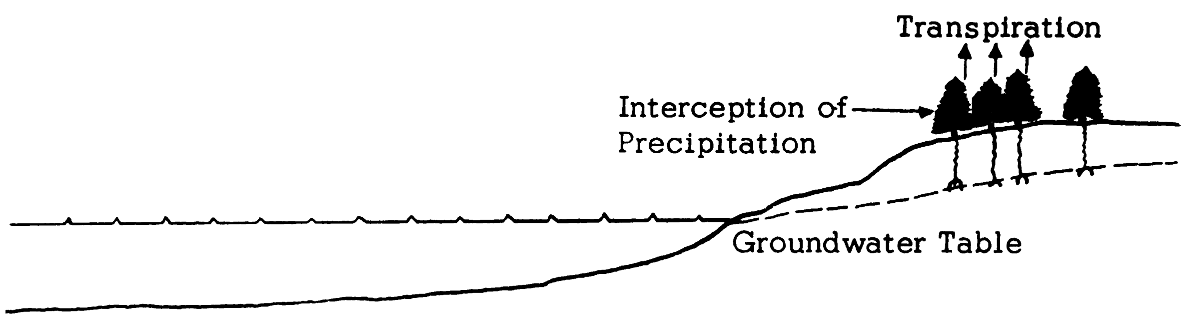


Figure 2. Reforestation

Plate 14. Deforestation and Reforestation

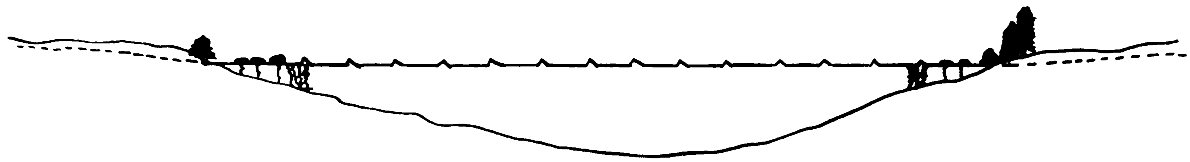
Role of Climate

Climatic conditions have varied in the past as they do today. Climatic variations may be indicated by archeological records, fossil animals and plants, spores and pollen.

Pollen indicates higher temperatures than today, lasting from about 5000 to about 2000 B.C. followed by a general cooling trend that reached a minimum about 500 B.C., followed by another temperature rise. The last major warming trend before the present time, occurred about 1000 to 1300 A.D. About 1600 A.D. the climate changed again toward cooler conditions and a "Little Ice Age" that lasted from about 1650 to about 1850 A.D. In the northern hemisphere, during the past century, there have been cyclic fluctuations, warmer to colder trends, each lasting about a decade. The trend has been toward warmer temperatures than recorded in decades prior to 1900. Since 1920, there has been a mean annual rise in temperature of about 3.5° F., and the rise in winter temperatures has been about twice as much as summer temperatures (Dorf, 1960).

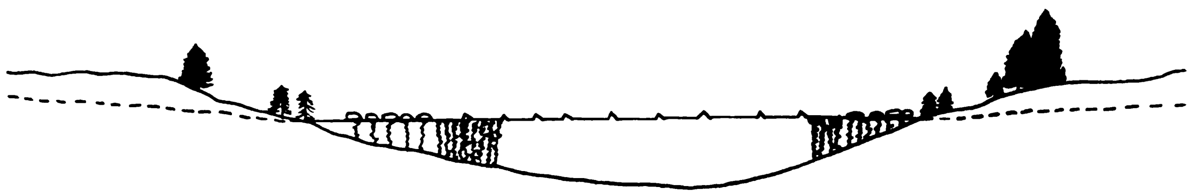
Presently, the northern hemisphere may be entering a 90-year cycle of cooler temperatures (Maynard M. Miller, 1967, oral communication). The earth may be heading toward another glacial stage, perhaps 10,000 to 15,000 years hence (Dorf, 1960, p. 362).

Aquatic vegetation may be aided by local hydrologic changes, shown by shorelines and lake level evidence at higher elevations than the present lake level. Shorelines and evidence of lower lake levels would be concealed by sediments. Warmer climate conditions caused the glaciers to retreat, accompanied by less precipitation and lower lake levels. Cooler weather triggered minor glacial advances characterized by greater precipitation and probably higher lake levels. Lower lake levels enabled vegetation to migrate lakeward and left shallow water areas shallower or exposed to the atmosphere. When lake levels rose again or returned to their former higher levels, much of the aquatic vegetation died when it was unable to adapt to greater depths. Vegetational remains accumulated resulting in the area of accumulation being shallower than prior to low water conditions (Plate 15). Aquatic vegetation may root easily in soil that lies under newly formed water area (Indiana Water Resources Division, 1949, p. 7). Climatic related fluctuations in lake levels continue to occur, with higher levels after abundant precipitation, and lower levels in times of drought.

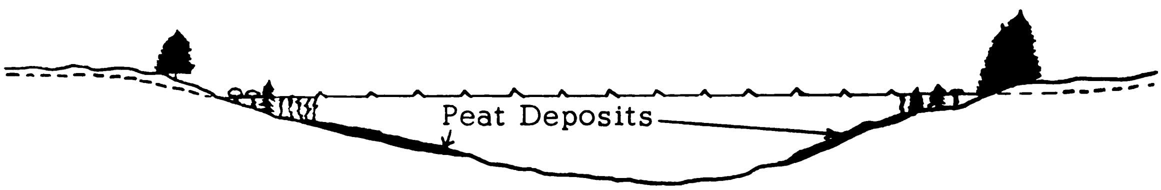


Before drought

Lower lake level enables vegetation to migrate lakeward



Upland vegetation also migrates lakeward if drought is prolonged



Drought ends and lake level rises. Vegetation must readjust. Peat deposits remain.

Plate 15. Effects of Drought

CHAPTER IV

LAKES STUDIED

Barry County

Eight lakes were studied in Barry County (Map 1). Glacial drift was at least 200 feet thick in the vicinity of the lakes.

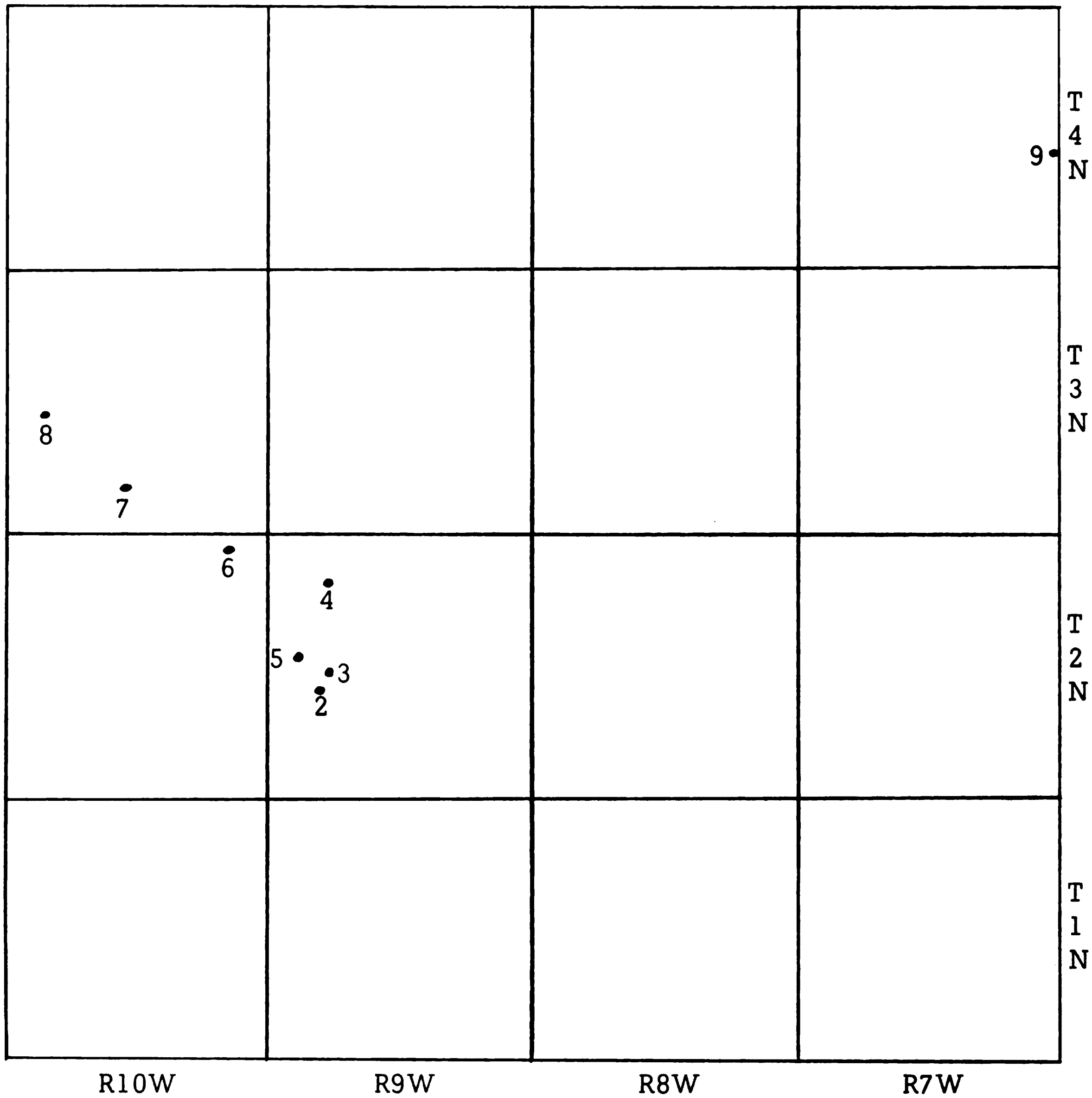
Barry County was subject to a drought resulting in a 28.88 inch precipitation deficiency from 1960 through 1964 (Michigan Water Resources Commission, 1965, p. 6) and a 20.75 inch precipitation deficiency from January 1962 to June 1964 (Michigan Water Resources Commission, 1964). Drought conditions prevailed through August 1965.

Lower lake and stream levels resulted from drought conditions. Many lake levels were the lowest in recent history according to area residents. Other lake levels were normal.

Cloverdale Lake

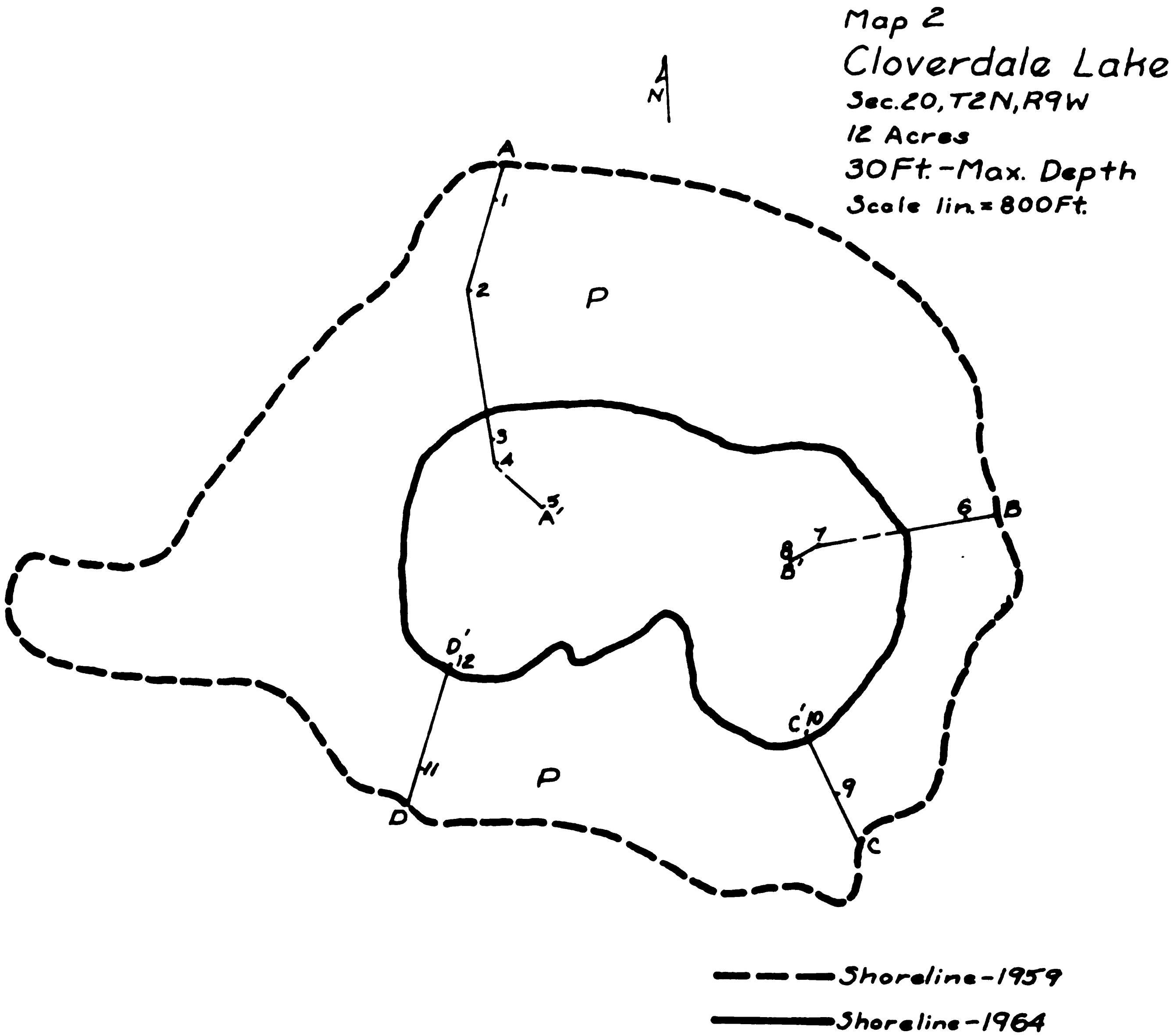
Cloverdale Lake (Map 2) is in sections 20 and 29, T2N,R9W, but has been intermittent in the latter section for about 40 years (Deeter, 1928). The surface area in January 1959 was 58 acres (Michigan Department of Conservation) or about 125 acres if the intermittent area was included. The surface area was 12 acres with a maximum depth of about 30 feet in August 1964.

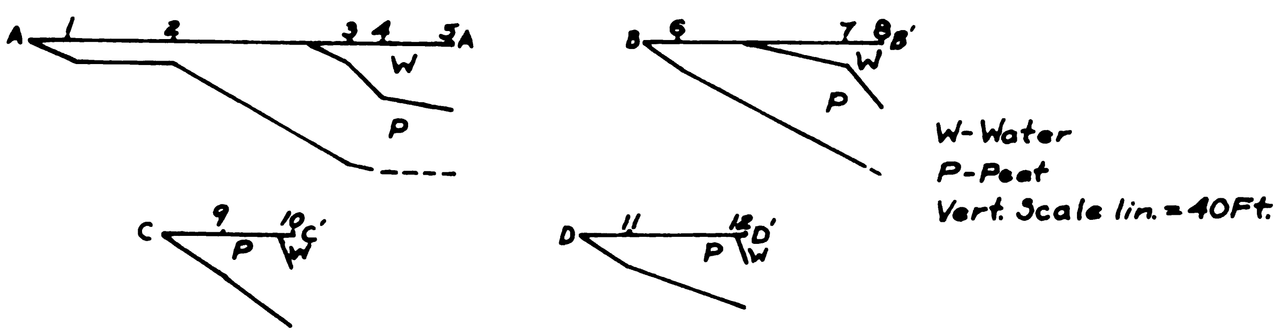
Cloverdale Lake was served by an inlet from Wilkinson Lake, and an outlet flowed into Long Lake. A water-powered mill was operated between Cloverdale and Long Lakes in earlier times (Lake, 1873) using 15 (Hale, 1903, p. 117), or 16 (Hale, 1903, p. 110) feet or more difference in lake levels. An elevation difference of 12 feet between Cloverdale and Long Lakes is noted on a U. S. Geological Survey topographic quadrangle (Hastings 15" sheet, 1951) of the area. The inlet and outlet have not



2. Cloverdale Lake
3. Long Lake
4. Head Lake
5. Guernsey Lake
6. Daggett Lake
7. Long Lake
8. Little Payne Lake
9. Carr Lake

Map 1. Barry County





Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12
Depth	—	—	3	11	13	—	4	13	—	7	—	5
Original Depth	4	4	25	26	26	5	23	26	8	19	6	14
Pondweed	—	—	✓	—	—	—	✓	—	—	✓	—	✓

functioned since 1956. In August 1964 the lake level was four to six feet below the 1920 level according to local residents.

The drainage area is about 400 acres. It is composed of unsorted sand, gravel, boulders and clay. Dark brown, pulpy peat deposits surround the lake. The east shore is the site of seven cottages and a county park. A boat livery is operated on the south shore. Access to the water was through a dredged channel.

The original bottom slopes lakeward at three degrees. Dark brown, pulpy peat is deposited over the original bottom. The peat may also be yellow-brown to light brown where dead aquatic vegetation has decomposed at the water's edge.

Pondweed was the only noticeable attached aquatic vegetation growing. It grew prolifically up to depths of 11 feet. Dead pondweed built an abrupt slope of about 35 to 40 degrees along the eastern shore at the waters edge. The vegetation was deposited by wind and wave action, being held against the shore by the addition of more dead pondweed.

Long Lake

The Long Lake (Map 3) level has remained unchanged for the past 40 years (1964) according to local residents. An outlet flows most of the year but an inlet from Cloverdale Lake has not functioned since 1956.

The drainage area is about 1,150 acres with maximum relief of about 115 feet. The drainage area is composed of unsorted sand, gravel, boulders, and clay. Parts of the drainage area are used for pasturing cattle. Numerous cottages are present but additional space is available for development. A resort and boat livery are located on the east shore.

The original bottom slopes lakeward at 14 to 18 degrees. Chalky gray marl is deposited over it. Calcium carbonate in solution gives the lake an emerald blue cast.

The present bottom slopes lakeward at less than one degree in the "shallows," water less than four feet deep in the north and central parts,

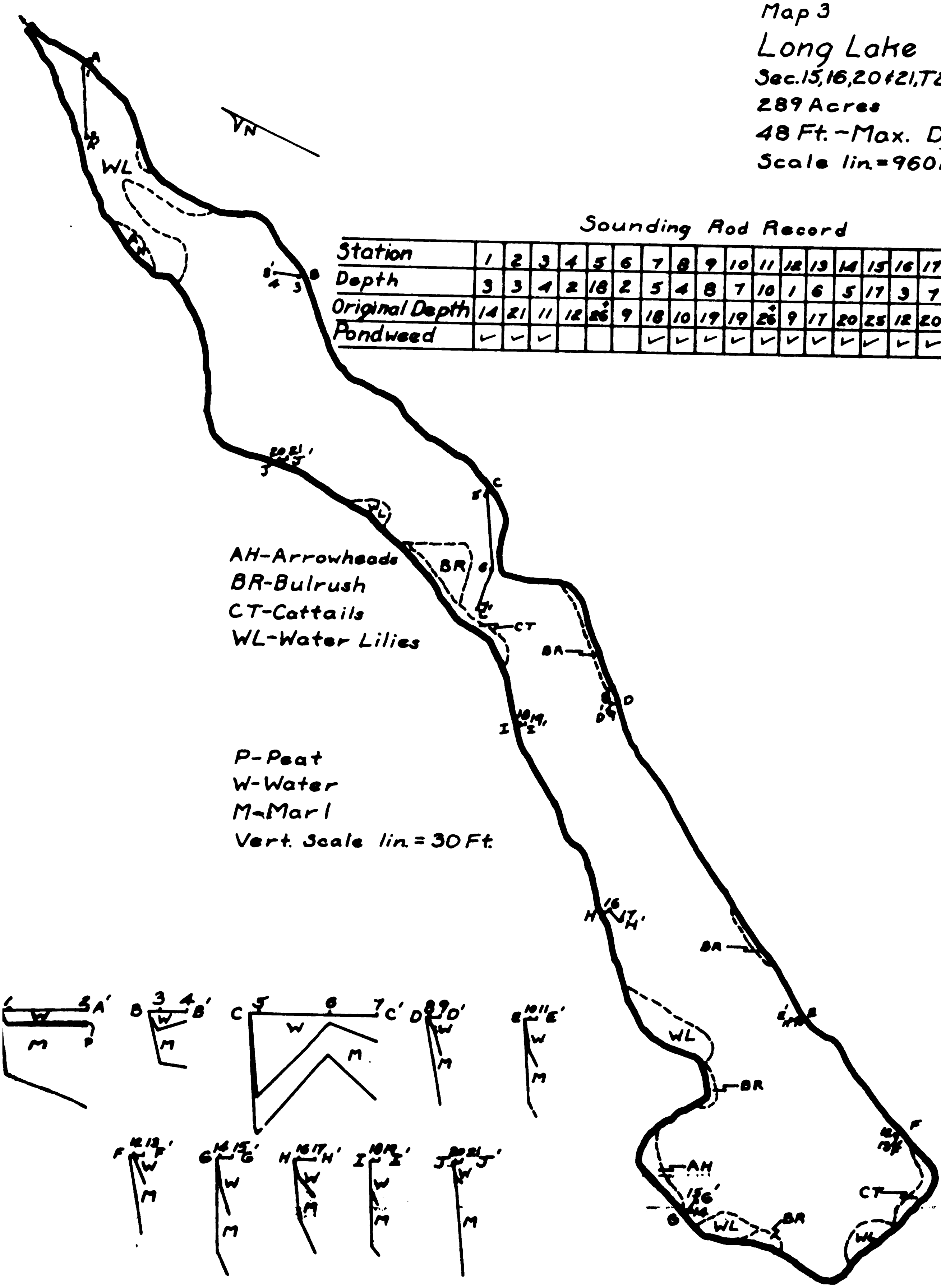
Map 3

Long Lake

Sec. 15, 16, 20 & 21, T2N, R9W
289 Acres
48 Ft. – Max. Depth
Scale 1in. = 960 Ft.

Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Depth	3	3	4	2	18	2	5	4	8	7	10	1	6	5	17	3	7	7	9	3	4
Original Depth	14	21	11	12	26	9	18	10	19	19	26	9	17	20	25	12	20	18	20	4	25
Pondweed	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	



to about 35 degrees elsewhere. The latter measurement was common, sometimes less than 20 feet from shore, giving an appearance of a "drop-off." A dark brown, fine-textured peat layer, less than six inches thick is deposited over marl in the shallows at the north end of the lake.

Pondweed, muskgrass, water lily, arrowhead, and bulrush were the attached aquatic vegetation growing in 1964. Pondweed grew at a depth of 17 feet. However, pondweed and muskgrass seldom grew at depths over 10 feet. Water lily and arrowhead grew at depths to five feet, but most prolifically in the shallows. Bulrush grew sparse in depths to three feet. Cattail grew on peat deposits adjacent to the shore and lakeward but seldom at depths greater than a few inches.

Head Lake

The drainage area of Head Lake (Map 4) is 403 acres with maximum relief about 100 feet. The drainage area is composed of unsorted clay, gravel and boulders, with a maximum relief of about 100 feet. Parts of the drainage area are used for pasture. About 10 cottages and mobile homes are distributed along the shore leaving most of the lake frontage available for development. Access may be gained from a county road passing within 10 feet of the west shore.

The lake level has not fluctuated over two feet during the past 25 years (1965) according to local residents. The lake level was about six inches below normal in August 1965.

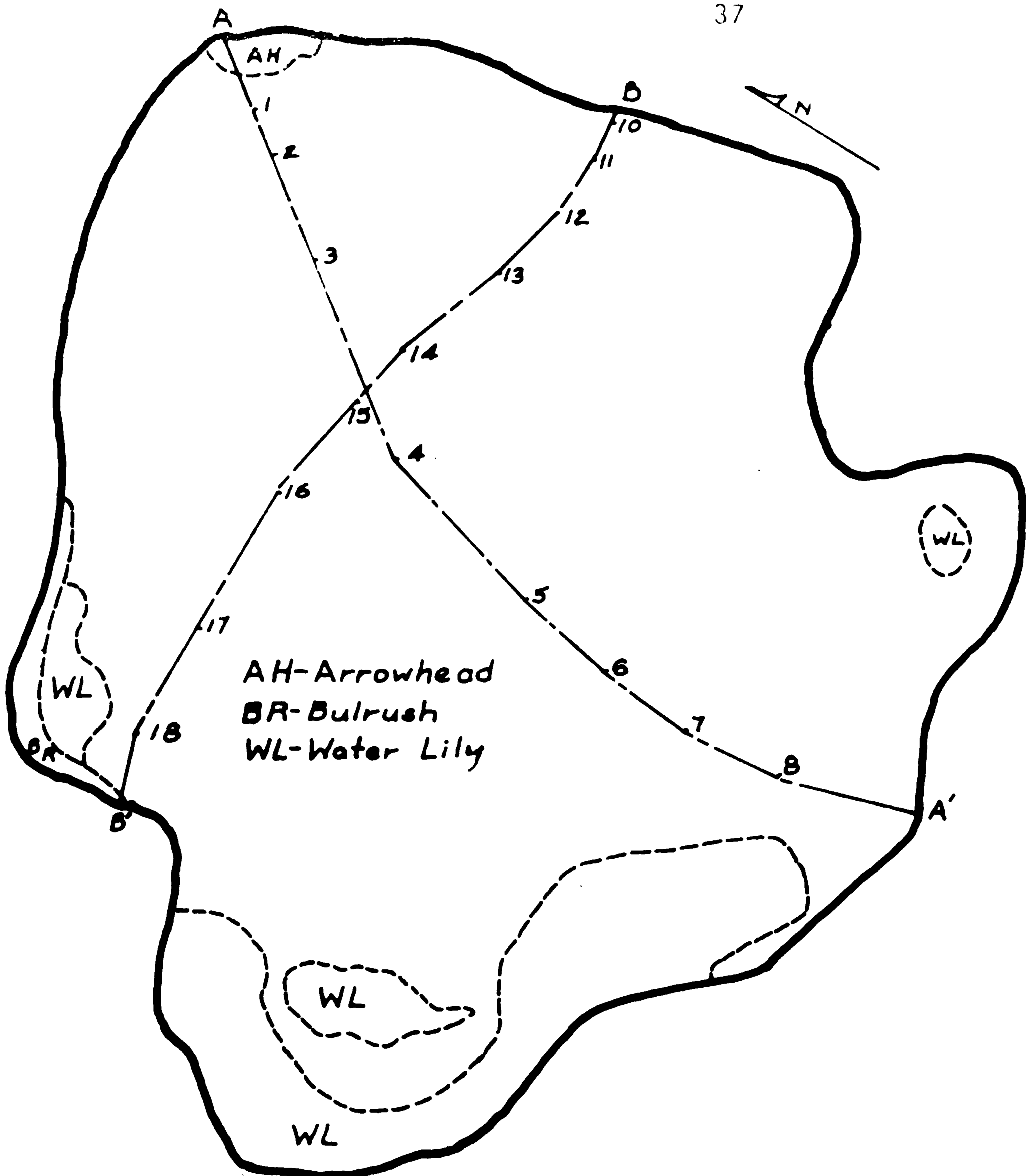
The original bottom slopes lakeward at two to four degrees. Dark brown, pulpy peat is deposited over the original bottom. Peat is yellow-brown in areas where it recently decomposed. Brown leavy peat occurred in places near the east shore where oak leaves have accumulated.

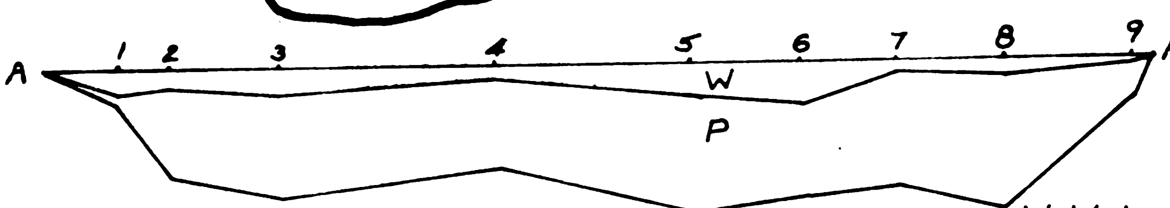
Pondweed, water lily, arrowhead, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to six feet. Water lily grew at depths to two feet. Arrowhead grew sparsely at depths to one foot. Bulrush grew at depths to one and one-half feet.

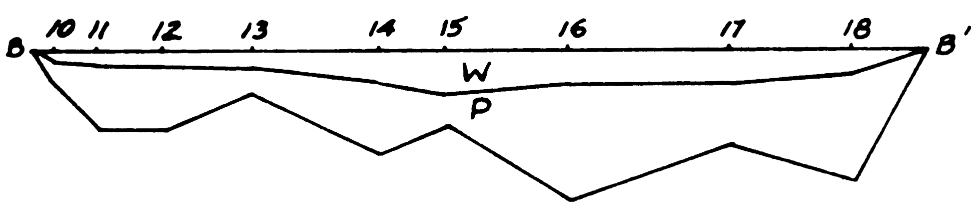
Map 4

Head Lake

Sec. 8 & 9, T2N, R2W.
97 Acres
6 Ft.-Max. Depth
Scale 1 in. = 450 Ft.







W-Water
P-Peat
Vert. Scale 1 in. = 20 Ft.

Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Depth	4	3	4	2	5	6	1	2	1	2	2	2	3	5	6	5	5	3
Original Depth	5	17	20	16	23	21	19	23	7	4	12	12	6	16	11	23	14	20
Pondweed	—	✓	✓	✓	✓	✓	✓	✓	—	✓	✓	✓	✓	✓	✓	✓	✓	✓

Marl was not recovered at any station but it was observed in a spoil pile left from dredging in the southeast part of the lake.

Guernsey Lake

Guernsey Lake (Map 5) consists of two basins, "Big Guernsey" (the western basin) and "Little Guernsey." A dredged channel connects the two basins and replaces a natural, vegetation clogged channel. Water flows east through the channel. An outlet flows most of the year.

The drainage area is about 825 acres with maximum relief of about 100 feet. The drainage area is composed of unsorted sandy gravel, boulders, and clay. Cattle are pastured on part of the drainage area. About 25 cottages and a trailer park have been built leaving additional space for development. A boat livery on Big Guernsey provides access.

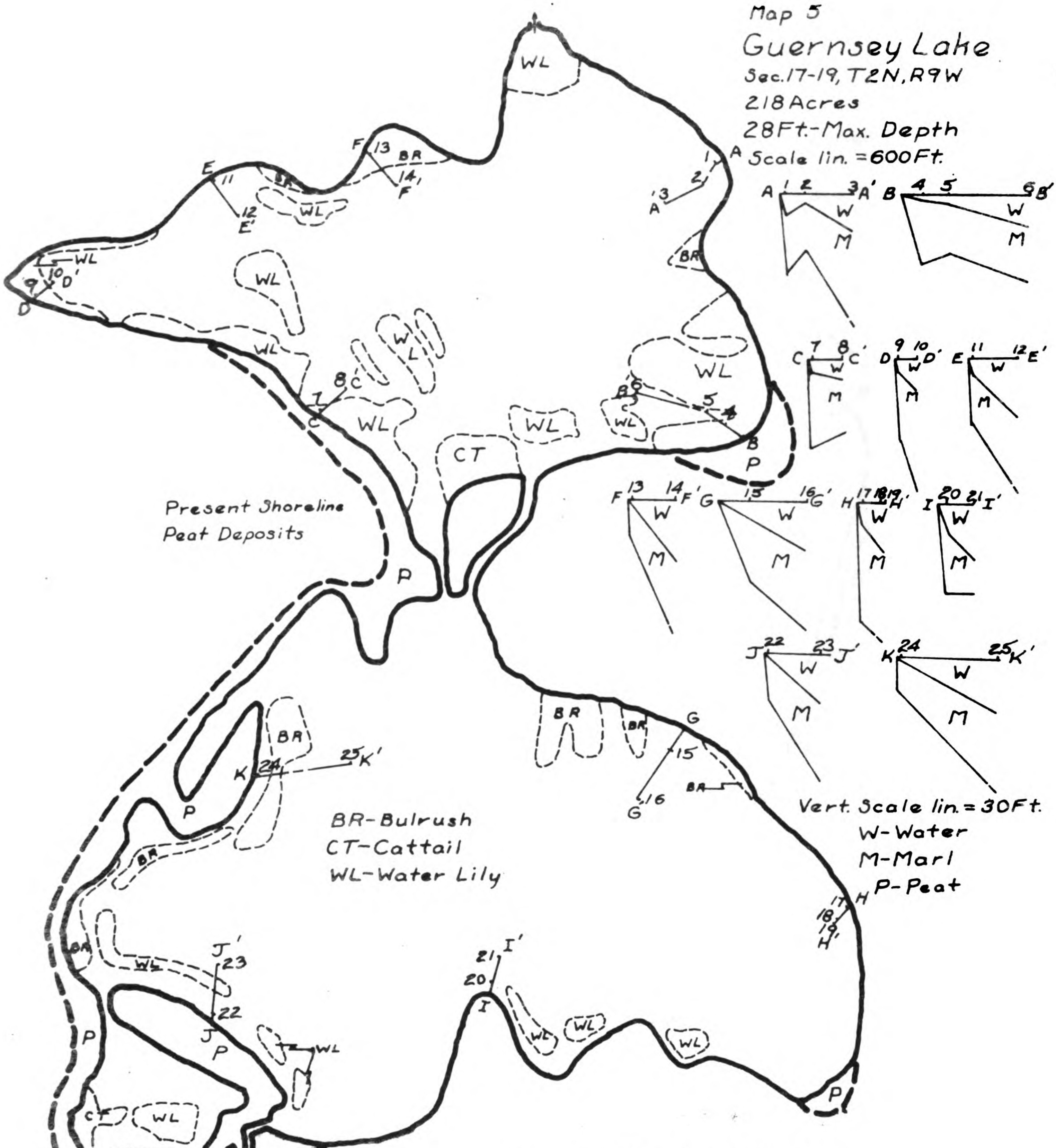
The original bottom slopes lakeward at 19 to 58 degrees with a mean of 37.5 degrees for six measurements. Chalky to organic gray marl is deposited on the original bottom. The organic gray color is characteristic in areas of abundant aquatic vegetation. A marl shelf has developed along the east and south sides of Big Guernsey. The lakeward edge of the shelf dips at 35 to 40 degrees. A wide marl beach occurs along the northern side of Big Guernsey.

Pondweed, water lily, arrowhead, and bulrush were the attached aquatic vegetation growing in 1964. Pondweed grew at depths of three feet. Cattail flourished on peat deposits bordering the lake at depths of a few inches.

Daggett Lake

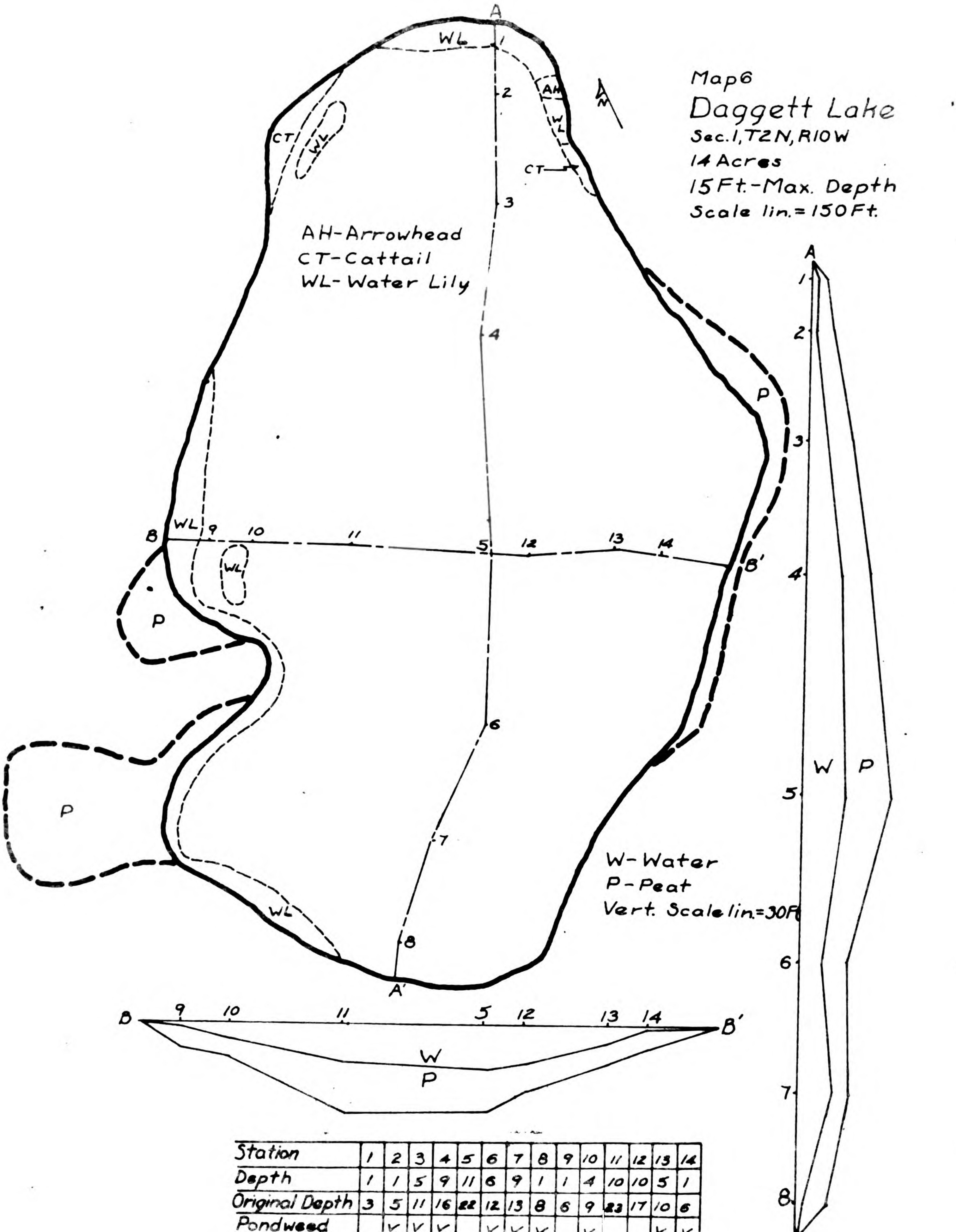
Daggett Lake (Map 6) is in public ownership with a campground and bathing beach on the east shore. The drainage area is 385 acres with maximum relief of about 120 feet. The drainage area is composed of unsorted gravelly sand, boulders, clay, and sorted sand.

The lake level declined about three feet from summer 1962 to summer 1965, with a four-inch decline occurring during the latter summer. The



Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Depth	5	2	8	1	2	7	3	4	3	7	3	13	1	13	4	11	5	10	11	6	12	1	11	1	12
Original Depth	18	13	31+	15	13	20	20	16	18	30	14	31+	9	30+	18	29	27	31+	31+	20	20	11	29	9	30+
Pondweed	—	✓	✓	—	✓	✓	✓	✓	✓	✓	—	—	—	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	—	✓



Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Depth	1	1	5	9	11	6	9	1	1	4	10	10	5	1
Original Depth	3	5	11	16	22	12	13	8	6	9	23	17	10	6
Pondweed		✓	✓	✓		✓	✓	✓		✓			✓	✓

surface area and maximum depth decreased from 15 acres and 18 feet to 14 acres and 15 feet.

The original bottom slopes lakeward at 7 to 11 degrees. Dark brown to yellow-brown, pulpy peat is deposited over the original bottom.

Pondweed, water lily, and arrowhead were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to nine feet. Water lily grew at a depth of two feet. Arrowhead grew at a depth of one foot. Cattail, marsh grass and sedges were common on peat deposits bordering the lake.

Long Lake

Long Lake (Map 7) is in public ownership and development is limited to a state park day camp on the eastern shore where part of the lake basin is dredged to make a swimming area. The drainage area is 207 acres with maximum relief, about 60 feet. The drainage area is composed of unsorted sand, boulders and clay, and deep sorted sand.

The lake level rose three inches from early August to late September 1965. The outlet of Long Lake is dammed.

The original bottom slopes lakeward 3 to 16 degrees. Marl was deposited over the original bottom and peat deposited over the marl. The marl is chalky to organic gray containing seed cases. The organic gray cast is darkest where the overlying peat is three or more feet thick. The peat is dark brown and pulpy, reaching a maximum thickness to six feet.

Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed grew at various places; water lily grew along the north shore. Bulrush was most prolific, covering large areas.

Little Payne Lake

The drainage area of Little Payne Lake (Map 8) is 25 acres with maximum relief of about 10 feet and composed of deep sorted sands. The upland is undeveloped. Access is over a county road within a few feet of the east shore.

Map 7

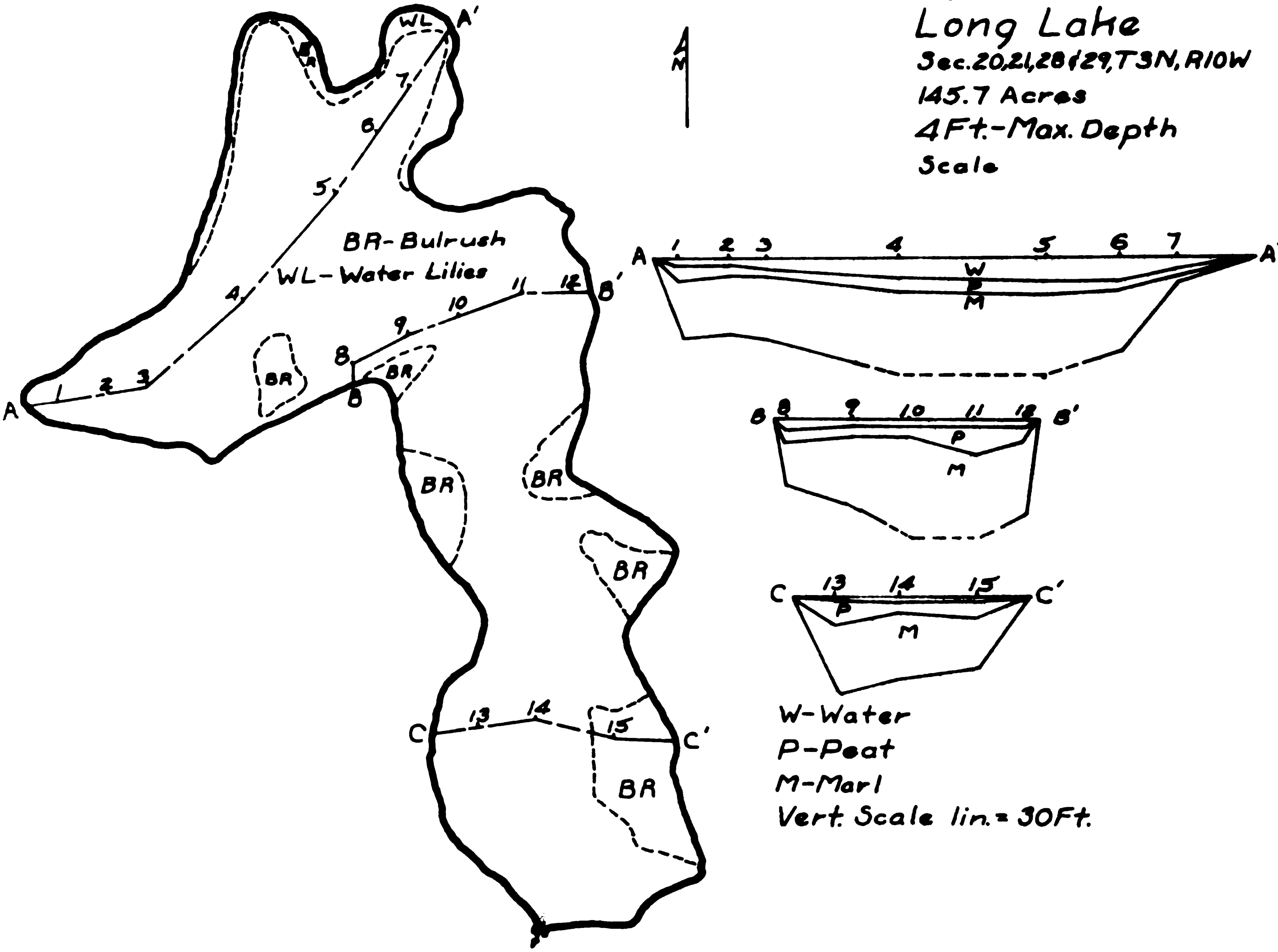
Long Lake

Sec. 20, 21, 28 & 29, T3N, R10W

145.7 Acres

4 Ft.-Max. Depth

Scale



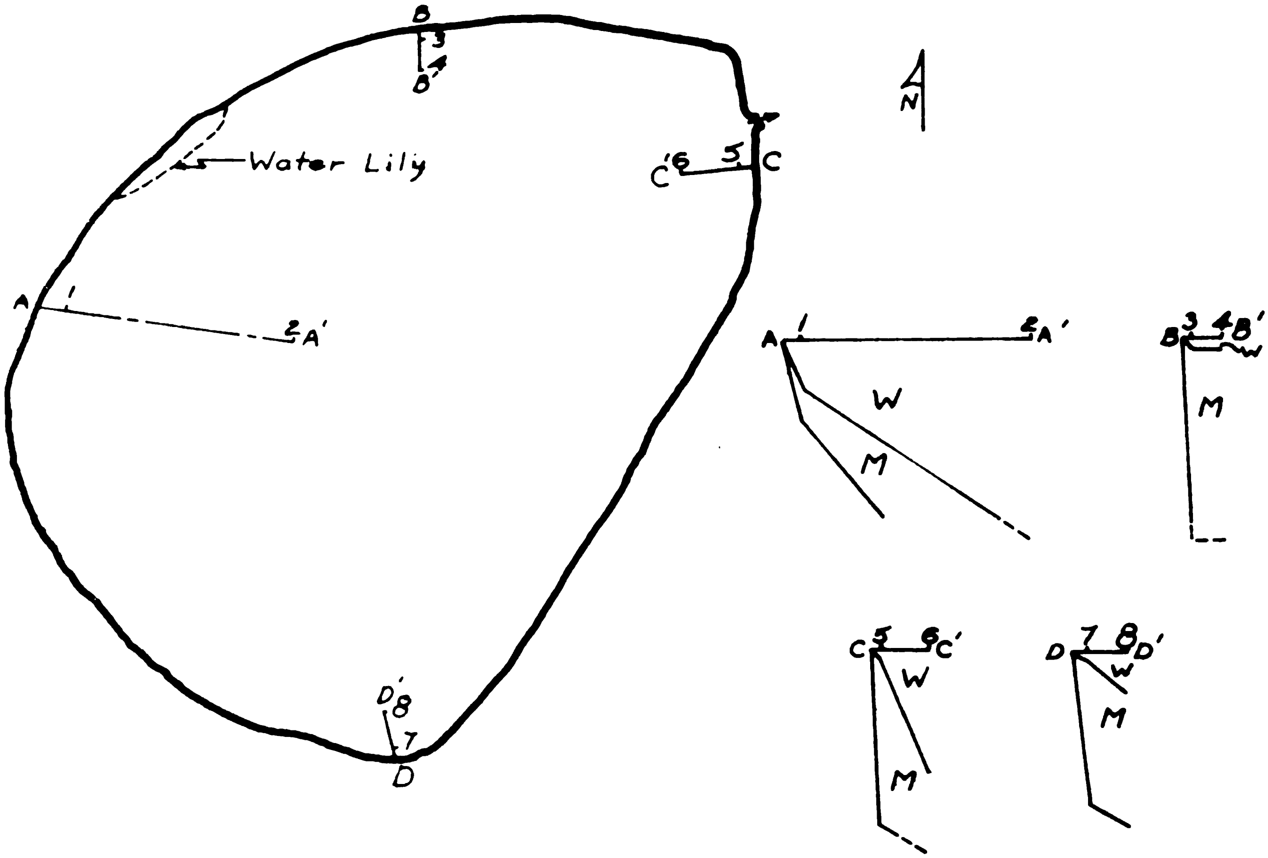
Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depth	1	1	2	3	4	4	2	2	1	1	1	1	1	1	1
Peat (Feet)	4	3	3	6	6	6	3	4	3	3	7	4	5	3	4
Original Depth	14	13	14	21+	21+	17	5	12	16	21+	21	17	17	15	13
Pondweed				✓		✓								✓	✓

Map 8

Little Payne Lake

Sec. 19, T3N, R10W
10 Acres
27 Ft.-Max. Depth
Scale 1in.=200Ft.



W-Water
M-Marl
Vert. Scale 1in.=20Ft.

Sounding Rod Record

Station	1	2	3	4	5	6	7	8
Depth	5	21+	1	1	1	13	1	4
Original Depth	8	21+	21+	21+	18	21+	16	18
Pondweed								

The original bottom slopes lakeward at 39 to 73 degrees. Chalky gray marl is deposited over the original bottom. Calcium carbonate in solution gives the water an emerald blue cast. Attached aquatic vegetation is limited to a few minor areas occupied by water lily and bulrush. A narrow thin peat deposit surrounds the shoreline of the lake.

Carr Lake

The drainage area of Carr Lake (Map 9) is 102 acres with maximum relief of 25 feet. The drainage area is composed of unsorted clay, gravel, and boulders. A woody peat underlain by dark brown, pulpy peat is adjacent to all but the west shore. The peat deposits have limited development of the lake to one cottage and a mobile home. A boat livery on the west shore provides access.

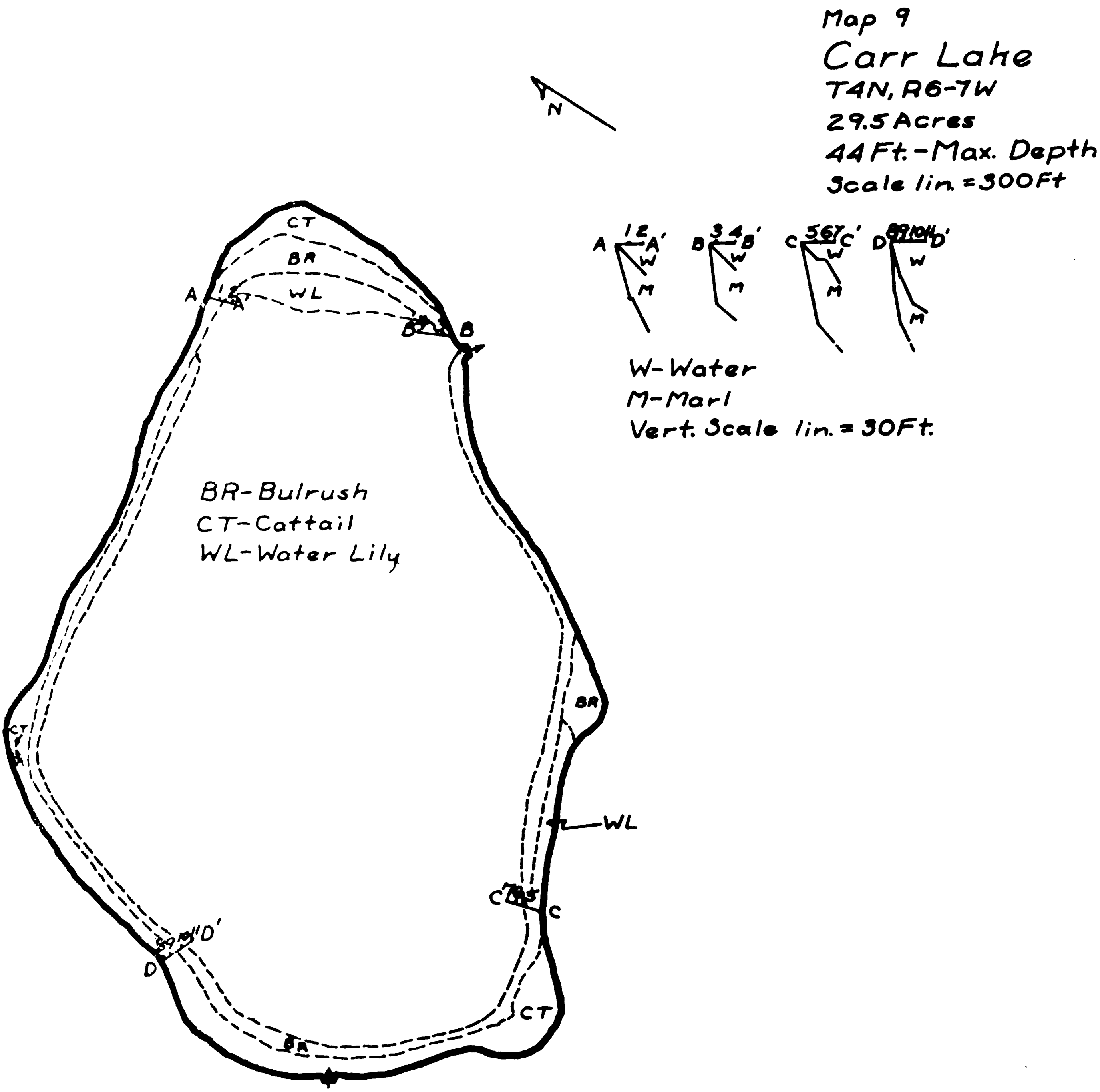
The original bottom slopes lakeward at 28 to 73 degrees with chalky gray marl deposited over it. A marl shelf on the west side dips lakeward at 33 degrees. Calcium carbonate in solution gives the lake an emerald blue cast.

Pondweed, muskgrass, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed and muskgrass grew at depths to eight feet, water lily to four feet. Bulrush grew sparse to dense between the water lily and shore. Cattail grew on the moist peat deposits out to depths of a few inches.

Osceola County

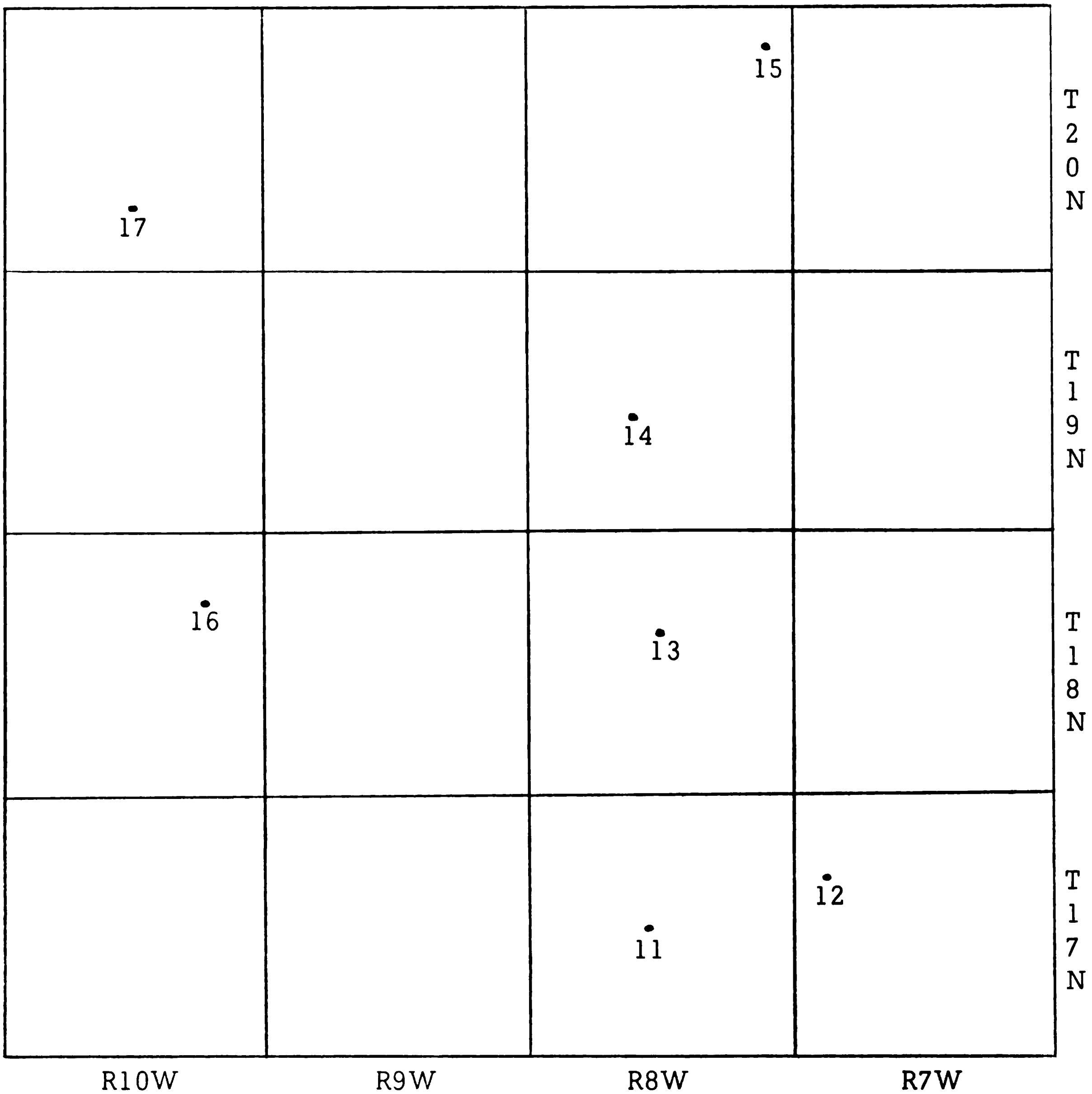
Seven lakes were studied in Osceola County (Map 10). Glacial drift thickness was 500 feet or more in the vicinity.

Osceola County, and surrounding counties, experienced drought conditions that resulted in a 6.99-inch precipitation deficiency from 1960-1964 (Michigan Water Resources Commission, p. 6, 1965) and a 5.31-inch precipitation deficiency from January 1963 to June 1964 (Michigan Water Resources Commission, 1964). Drought conditions ended early in 1965.



Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11
Depth	3	6	1	5	3	3	8	1	7	12	14
Original Depth	11	17	12	15	16	18	21↑	10	16	21↑	21↑
Pondweed	—	—	—	✓	✓	✓	✓	—	—	—	—



11. Alexander Lake
12. Big Lake
13. Myrtle Lake
14. Hicks Lake
15. Park Lake
16. Austin Lake
17. Hewitt Lake

Map 10. Osceola County

Alexander Lake

The drainage area of Alexander Lake (Map 11) is 102 acres with maximum relief of 70 feet. The drainage area is composed of unsorted gravelly sand, boulders and clay. Parts of the drainage area are used for agriculture. A swamp surrounding the lake had limited upland development until recently. In 1965, a channel was dredged through the swampy peat deposits and cottage lots were plotted on the channel. Access is gained from a county road adjacent to the west shore.

The lake level has risen about one foot within the past ten years killing some upland vegetation growing on the peat deposits. The lake level rise is probably due to the county road being built higher at the lake outlets. The culverts conveying water away from the lake may also be higher than the natural outlets.

The original bottom slopes lakeward at one to three degrees with dark brown pulpy peat deposited over it.

Pondweed, water lily, and arrowhead were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 12 feet, water lily to five feet. Arrowhead commonly grew with pondweed at depths less than four feet.

Big Lake

The drainage area of Big Lake (Map 12) is about 950 acres with maximum relief of 70 feet. The drainage area is composed of unsorted clay, gravel and boulders. Parts of the drainage area are under cultivation. Numerous cottages have been built on Big Lake, but additional lake frontage is available. Peat deposits have limited development along the south shore. Access may be gained through a county park and at several boat liveries.

Big Lake is served by an outlet and intermittent inlet. The lake level was about six inches below normal in August 1964.

The original bottom slopes lakeward at 5 to 10 degrees. Chalky to

Map 11

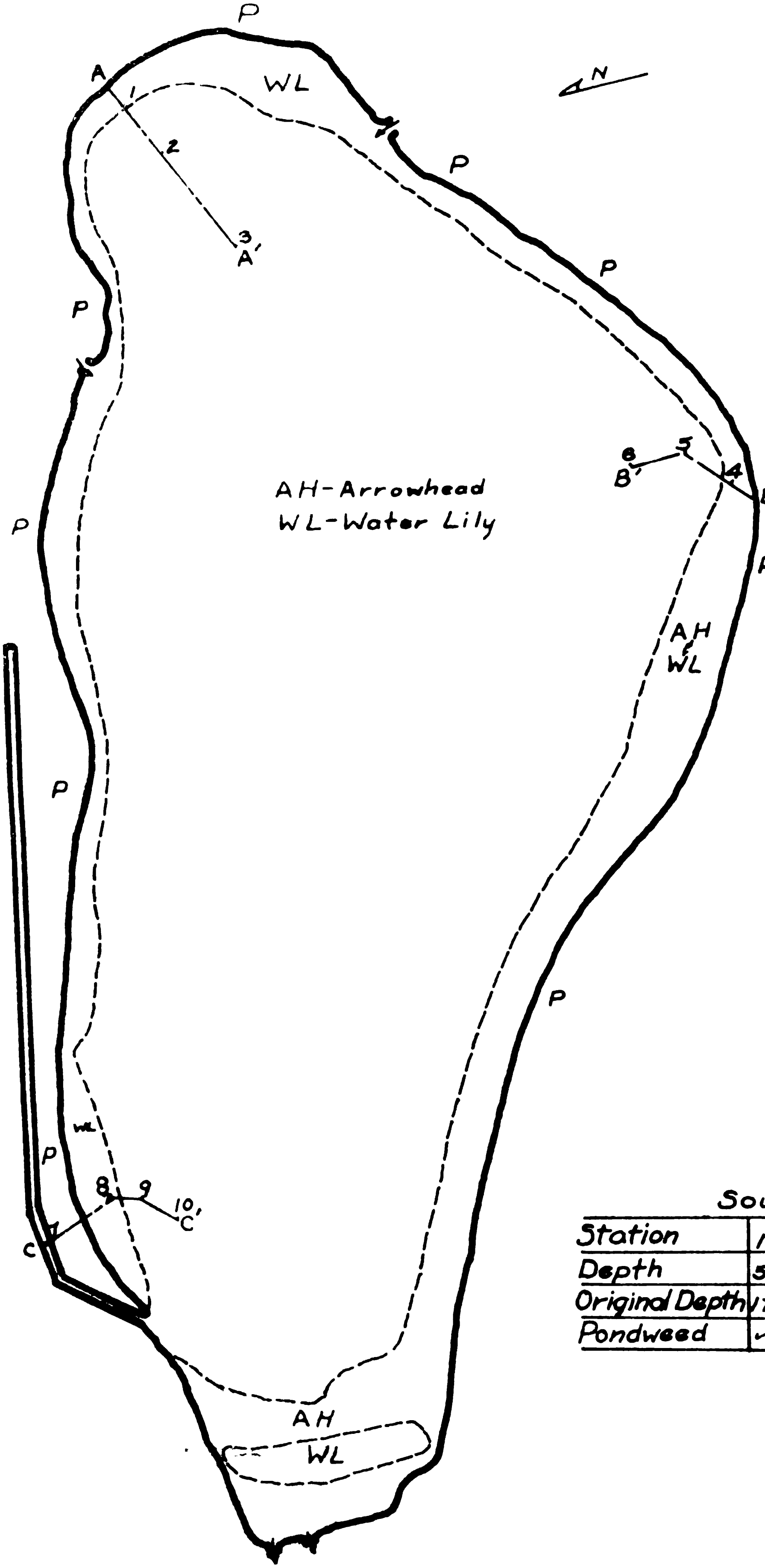
Alexander Lake

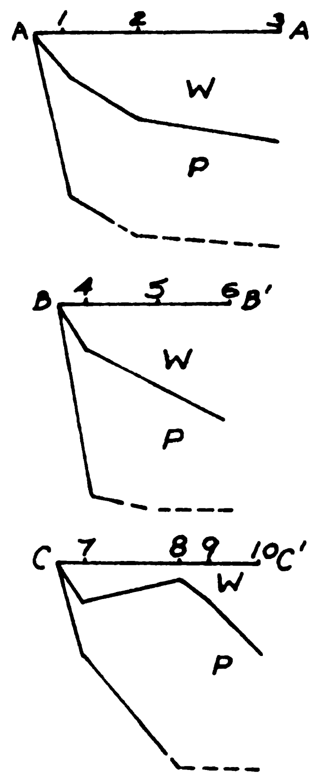
Sec. 22, T17N, R8W

5.7 Acres

17 Ft.-Max. Depth

Scale 1in.=100Ft.





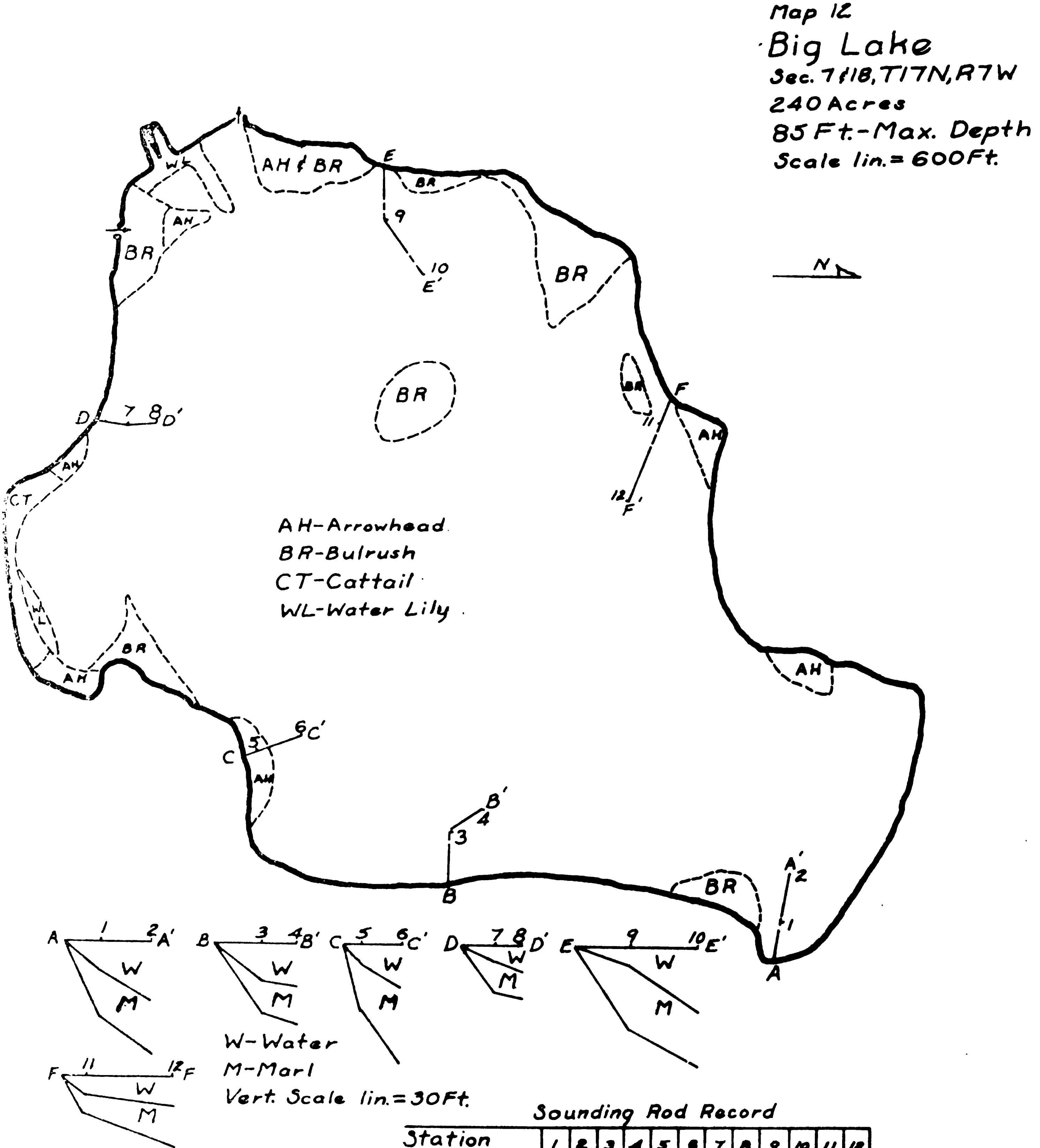
W-Water

P-Peat

Vert. Scale 1in.=20Ft.

Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10
Depth	5	9	11	5	9	12	4	2	4	9
Original Depth	17	21↑	21↑	20	21↑	21↑	9	21↑	21↑	21↑
Pondweed	✓	✓	✓	✓	✓	✓	—	—	✓	✓



Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12
Depth	6	13	8	9	4	9	3	5	4	14	4	6
Original Depth	16	28	15	17	14	28	10	11	13	28	8	15
Pondweed	✓	✓	✓	✓	✓	✓	—	[illegible]	[illegible]	✓	✓	✓

organic gray marl containing seed cases is deposited over the original bottom. The organic gray marl occurred in areas of abundant aquatic vegetation. The marl forms a shelf from shore with the lakeward side dipping about 40 to 55 degrees. Deposits adjacent to south shore consist of dark brown, woody to pulpy peat reaching a maximum thickness of about three feet at the lakeshore.

Pondweed, water lily, arrowhead, and bulrush were the attached aquatic vegetation growing in 1964. Pondweed grew at depths to 16 feet. Water lily grew at depths to three feet. Arrowhead grew at depths to two feet. Bulrush grew alone and in association with arrowhead, to depths of two feet. The attached aquatic vegetation was limited in its lakeward migration by the abrupt lakeward edge of the marl shelf.

Myrtle Lake

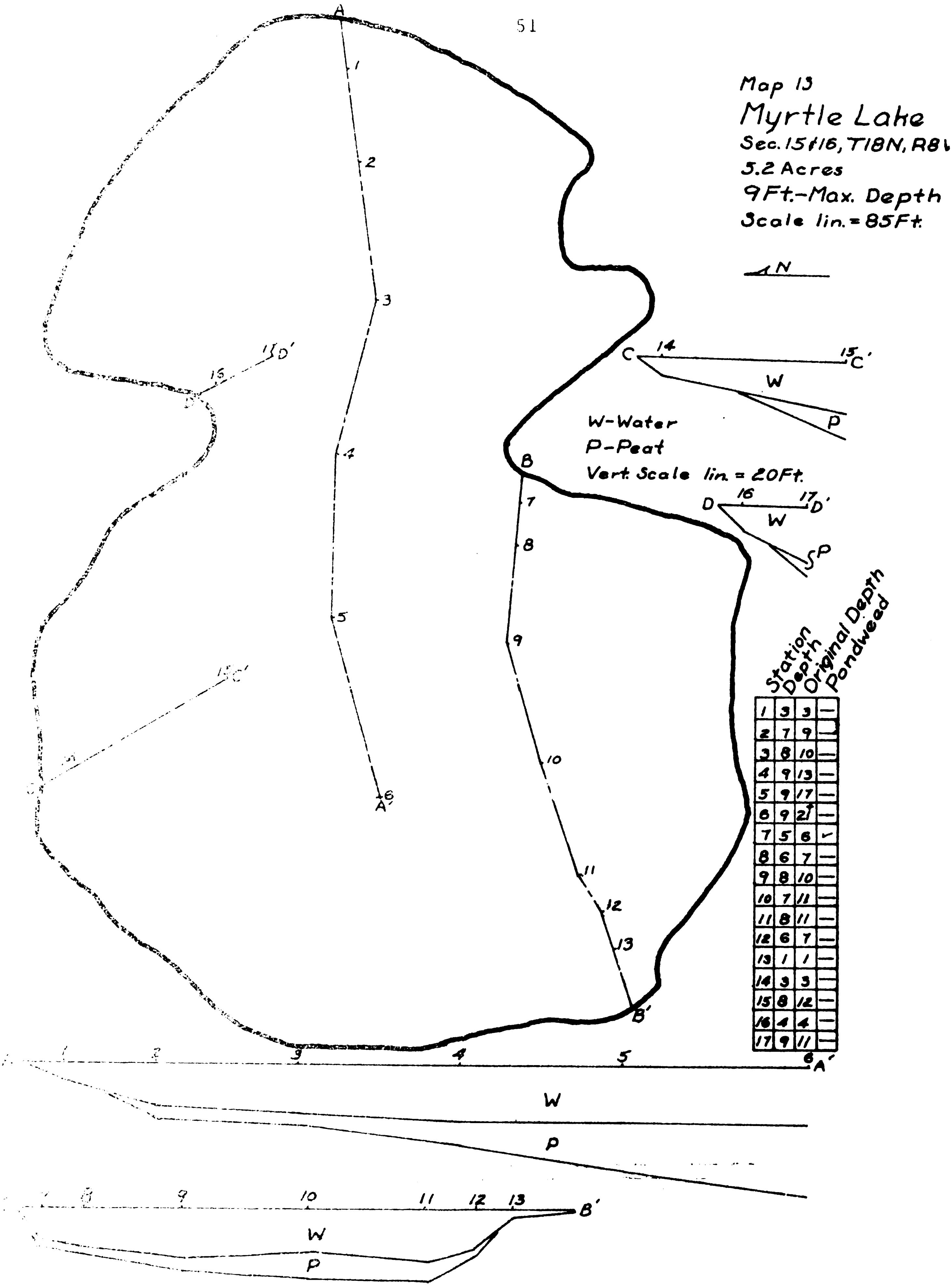
Myrtle Lake (Map 13) is undeveloped but part of the drainage area is used for pasturing cattle. The drainage area is about 410 acres with maximum relief of about 55 feet. The drainage area is composed of unsorted gravelly sand, boulders and clay, and deep, sorted sand. Access is by a county road near the eastern shore.

The recent lake level history is that of a declining lake level for 13 years, until spring 1965. By late August 1964 the surface area had declined from 5.2 to 2.5 acres. Woody upland vegetation, mainly willows, encroached rapidly before being halted by a lake level rise of about three and one-half feet during the spring and summer 1965. The lake level rise covered the base of willows with three feet of water.

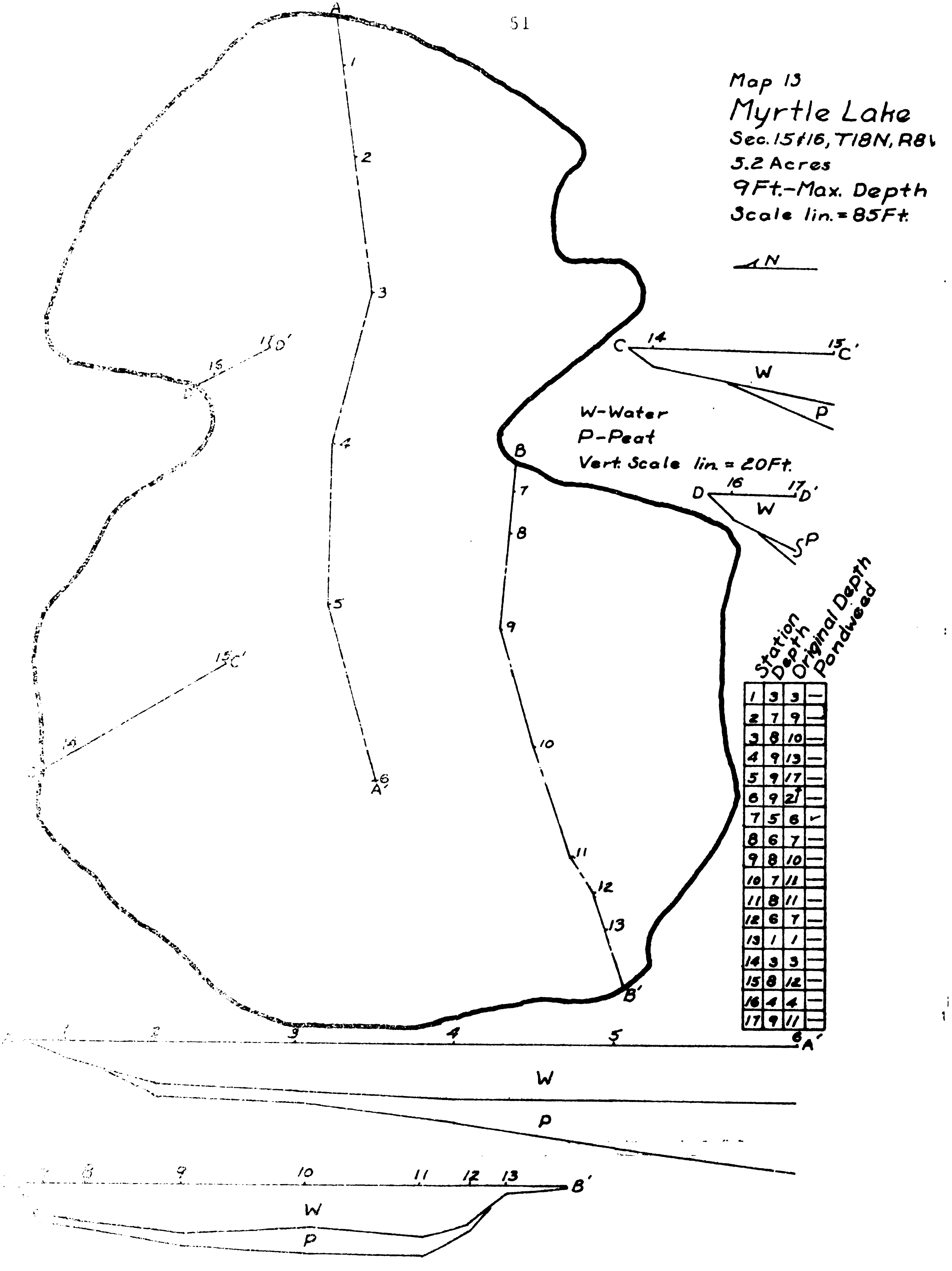
Attached aquatic vegetation is nearly nonexistent with pondweed being observed at only one station. Absence of attached aquatic vegetation may reflect the sudden lake level rise or the rich organic brown color of the water that allows light to penetrate only one and one-half to two feet.

Hicks Lake

Hicks Lake (Map 14) is in a drainage area of about 480 acres with

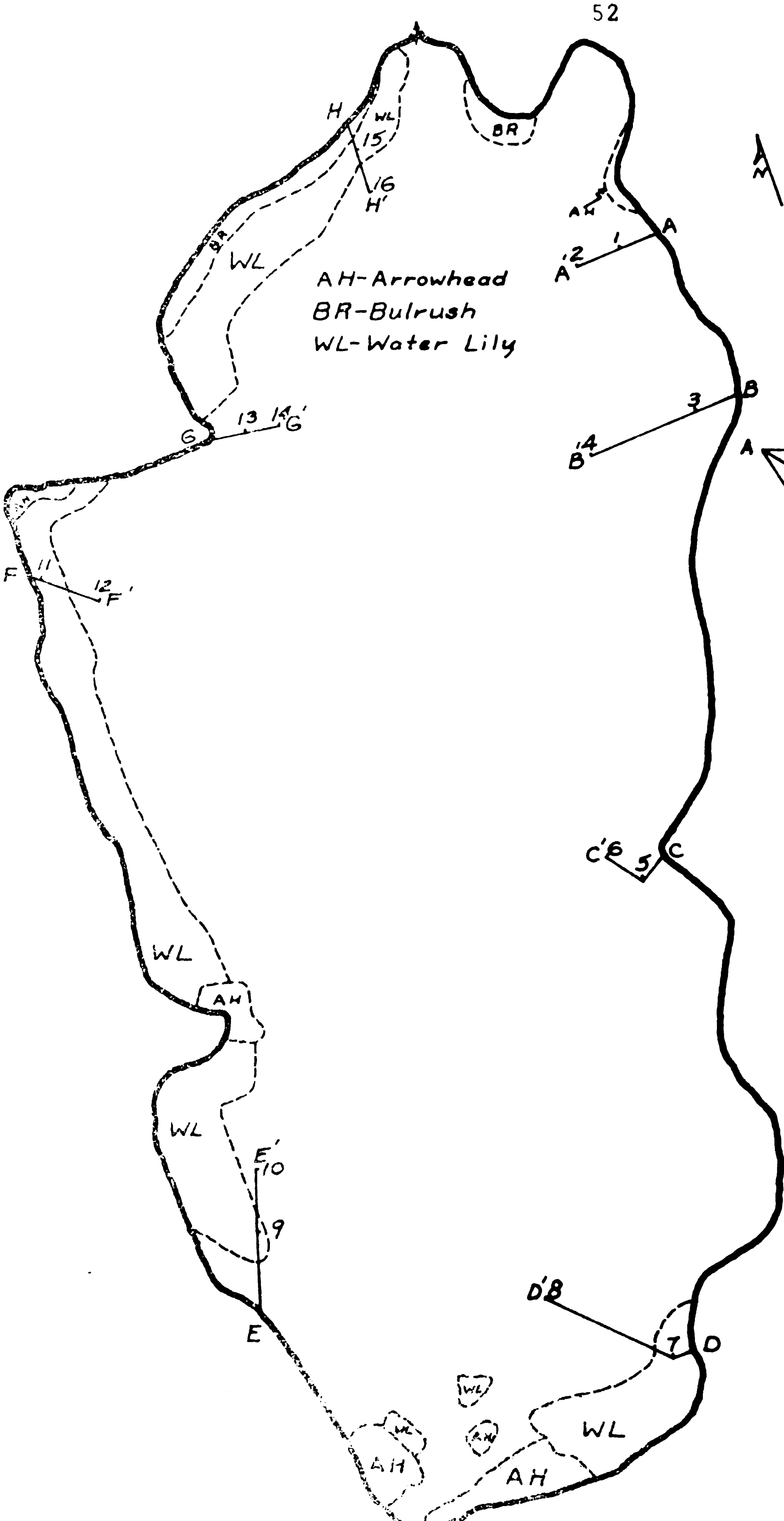


Station	Depth	Original Depth	Pondweed
1	3	3	—
2	7	9	—
3	8	10	—
4	9	13	—
5	9	17	—
6	9	21+	—
7	5	6	✓
8	6	7	—
9	8	10	—
10	7	11	—
11	8	11	—
12	6	7	—
13	1	1	—
14	3	3	—
15	8	12	—
16	4	4	—
17	9	11	—

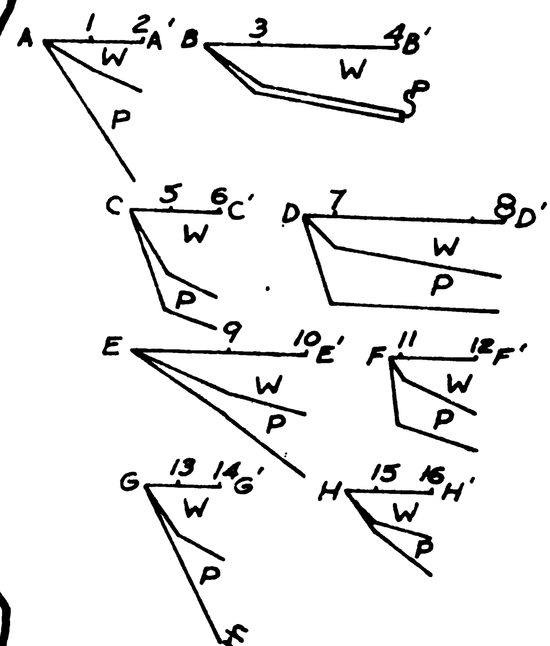


Station	Depth	Original Depth	Pondweed
1	3	3	—
2	7	9	—
3	8	10	—
4	9	13	—
5	9	17	—
6	9	21	—
7	5	6	✓
8	6	7	—
9	8	10	—
10	7	11	—
11	8	11	—
12	6	7	—
13	1	1	—
14	3	3	—
15	8	12	—
16	4	4	—
17	9	11	—

Map 14
Hicks Lake
Sec. 20 & 21, T19N, R8W
155 Acres
33 Ft.-Max. Depth
Scale 1in. = 450 Ft.



W-Water
P-Peat
Vert. Scale 1in. = 30 Ft.



Station	Depth	Original Depth	Pondweed
1	5	11	✓
2	8	22	✓
3	6	7	✓
4	10	11	✓
5	10	16	✓
6	14	19	✓
7	5	14	✓
8	8	14	✓
9	6	10	✓
10	9	19	✓
11	3	11	✓
12	8	14	✓
13	8	10	✓
14	12	25	✓
15	5	6	✓
16	[illegible]	[illegible]	[illegible]

maximum relief of about 90 feet. The drainage area is composed of unsorted clay, sand, gravel and boulders. Parts of the drainage area are used for pasture. Peat deposits surround all but the eastern shore, the site of numerous cottages. A public access site is on the northeast corner of the lake. The lake level was nine inches below normal in July 1964.

The original bottom slopes lakeward at one to four degrees. Dark brown, pulpy peat was deposited over the original bottom.

Pondweed, water lily, arrowhead, and bulrush were the attached vegetation growing in 1964. Pondweed grew at depths to 16 feet, water lily to five feet. Arrowhead was growing with water lily at depths of a few inches to about one foot. Bulrush grew at depths to three feet and cattails grew over part of the moist peat deposits and out into water a few inches deep.

Park Lake

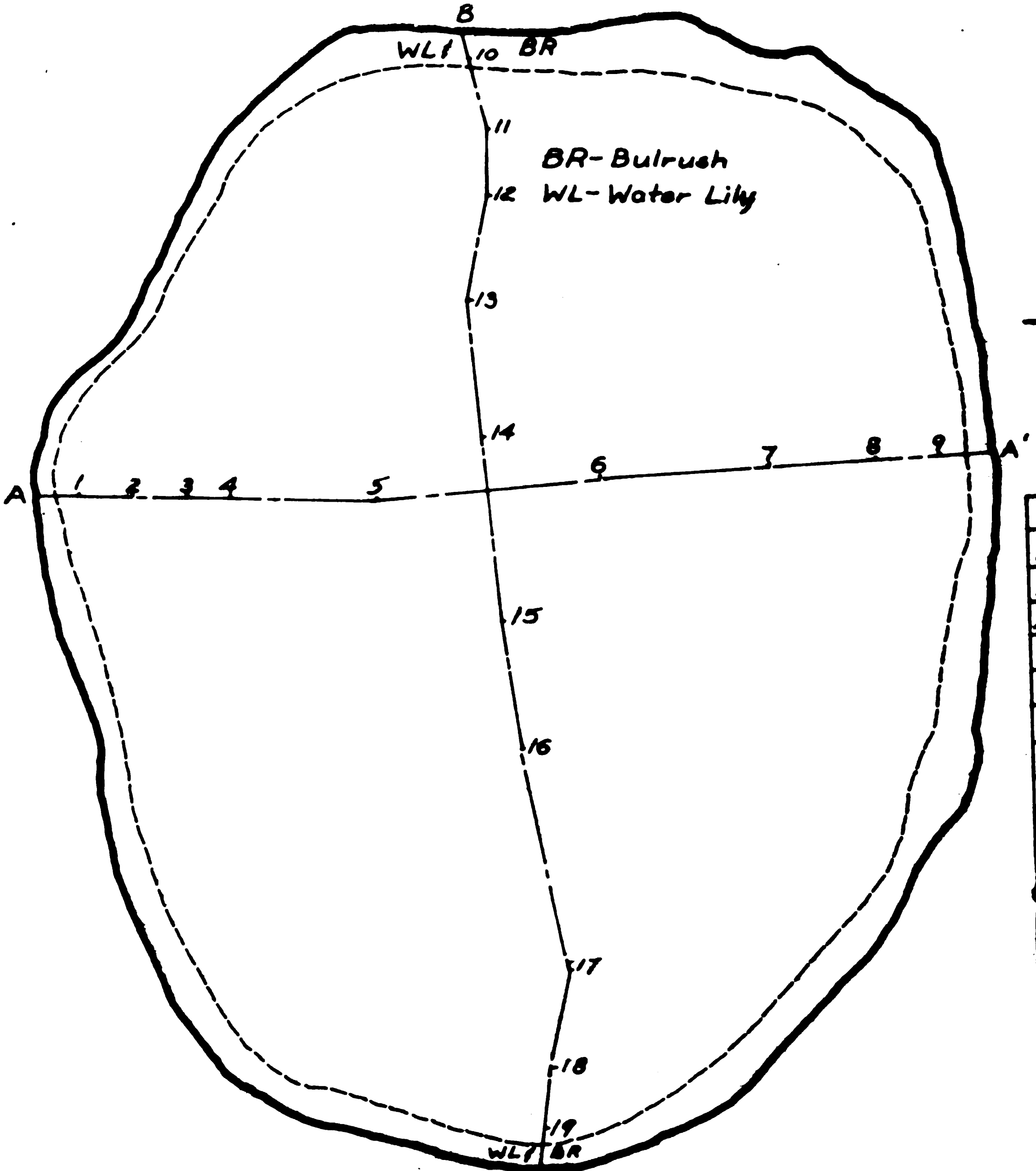
Park Lake (Map 15) is in a drainage area of about 70 acres with maximum relief of about 50 feet. The drainage area is composed of unsorted sandy clay, gravel and boulders, and deep sorted sand and is under cultivation. Park Lake is in private ownership but access was permitted by the owner.

The original bottom slopes lakeward at 6 to 12 degrees and is covered with dark brown pulpy peat.

Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed had nearly covered the present bottom at depths to nine feet, and was observed at all but two stations. Water lily and bulrush grew sparse and intermingled adjacent to all shores at depths of one and one-half feet or less.

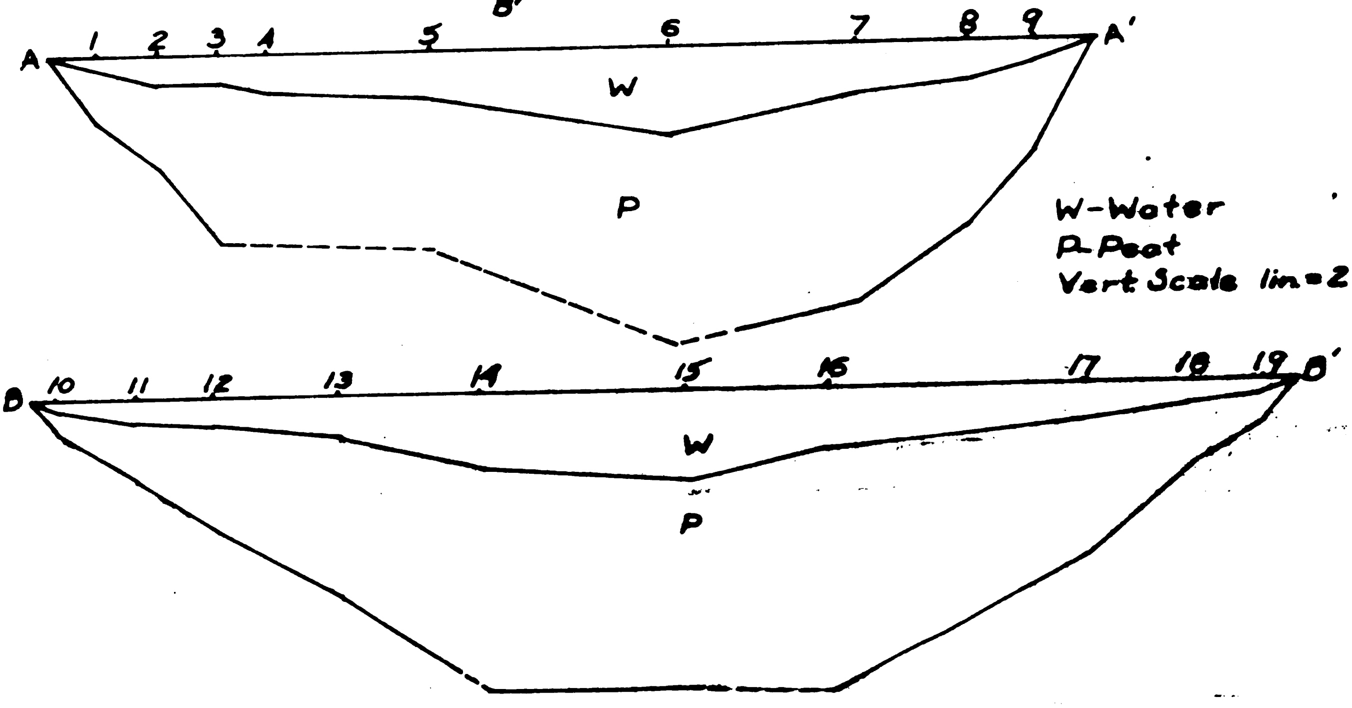
Austin Lake

Austin Lake (Map 16) is in a drainage area of about 540 acres with maximum relief of 70 feet. The drainage area is composed of unsorted sandy gravel, and clay and boulders. Peat deposits surround all but a

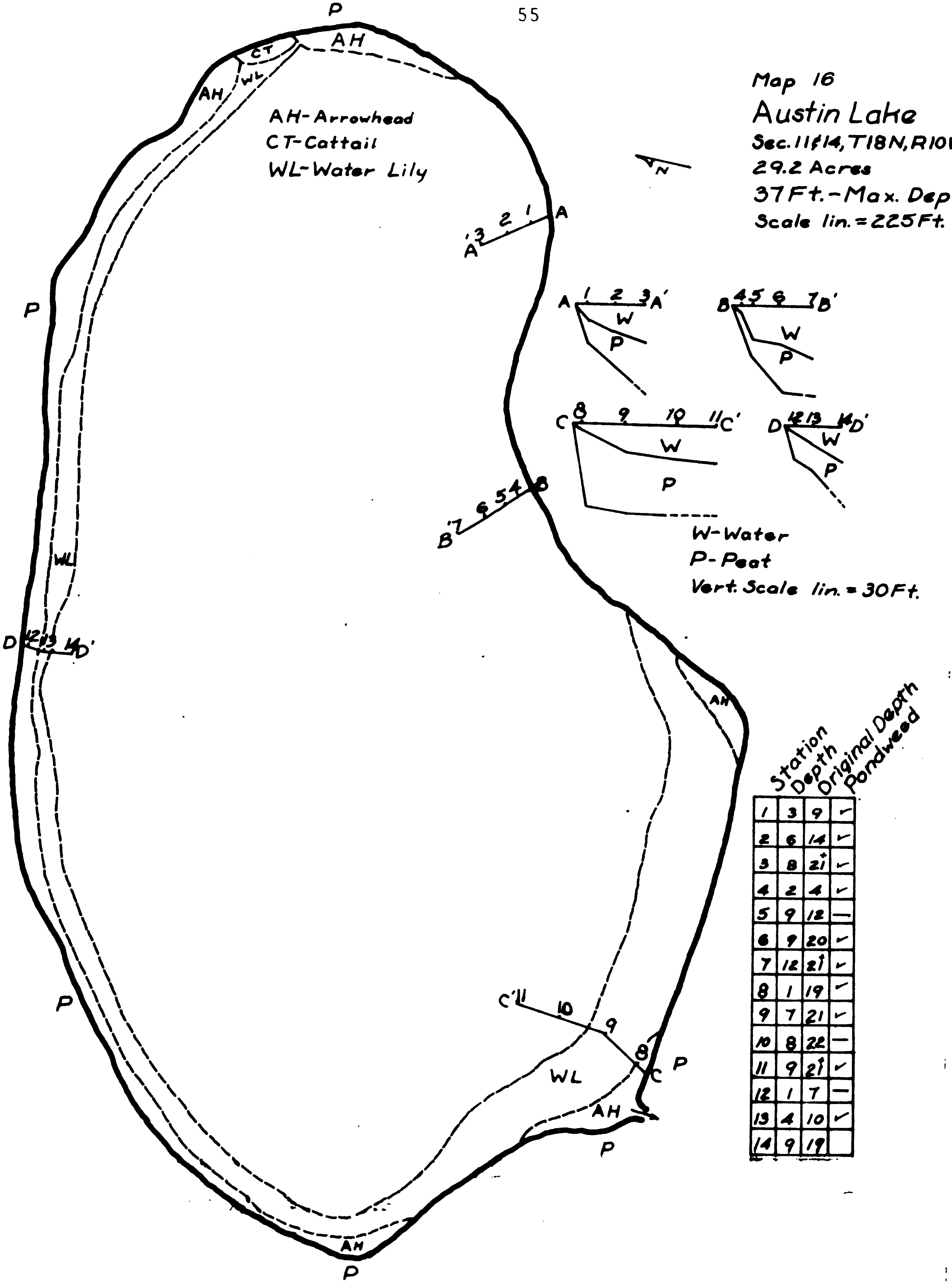


Map 15
Park Lake
Sec. 1 & 12, T20N, R8W
8.2 Acres
9 Ft.-Max. Depth
Scale 1in.= 125 Ft.

Station	Depth	Original Depth	Pondweed
1	2	7	✓
2	3	18	✓
3	4	21+	—
4	5	21+	✓
5	5	21+	✓
6	9	31+	✓
7	5	27	✓
8	4	19	✓
9	2	11	✓
10	1	3	—
11	2	8	—
12	3	14	✓
13	4	21	—
14	8	31+	—
15	9	31	—
16	6	31+	✓
17	3	17	✓
18	2	8	✓
19	1	4	✓



W-Water
P-Peat
Vert. Scale 1in.=20Ft.



Station	Depth	Original Depth	Pondweed
1	3	9	✓
2	6	14	✓
3	8	21+	✓
4	2	4	✓
5	9	12	—
6	9	20	✓
7	12	21+	✓
8	1	19	✓
9	7	21	✓
10	8	22	—
11	9	21+	✓
12	1	7	—
13	4	10	✓
14	9	19	

small part of the east shore where most of the ten cottages on this lake are located. The lake level was normal in August 1965.

The original bottom slopes lakeward at one to seven degrees. Dark brown, pulpy peat is deposited over the original bottom. Pondweed, water lily, and arrowhead were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 12 feet and water lily at depths to seven feet. Arrowheads grew at depths to one foot in isolated patches. Cattails grew on the peat deposits and lakeward to depths of a few inches.

Hewitt Lake

Hewitt Lake (Map 17) is in a drainage area of about 79 acres with maximum relief of about 75 feet. The drainage area is composed of unsorted sandy gravel, clay and boulders, and deep sorted sand. Parts of the drainage area are used for pasture. Farm buildings and a barnyard are about 100 feet from the south shore of the lake where a boat livery is operated. Eleven cottages are along the shore.

The original bottom slopes lakeward at 9 to 11 degrees with dark brown, pulpy peat deposited over it.

Clastic sediments, mainly sand, were deposited in a small area near the north shore. This is from soil erosion on the adjacent upland. The clastic sediments displaced peat previously deposited at that point. Pondweed, water lily, and arrowheads were the attached aquatic vegetation present in 1965. Pondweed grew at depths to 11 feet, water lily at depths to five feet and arrowheads to one foot.

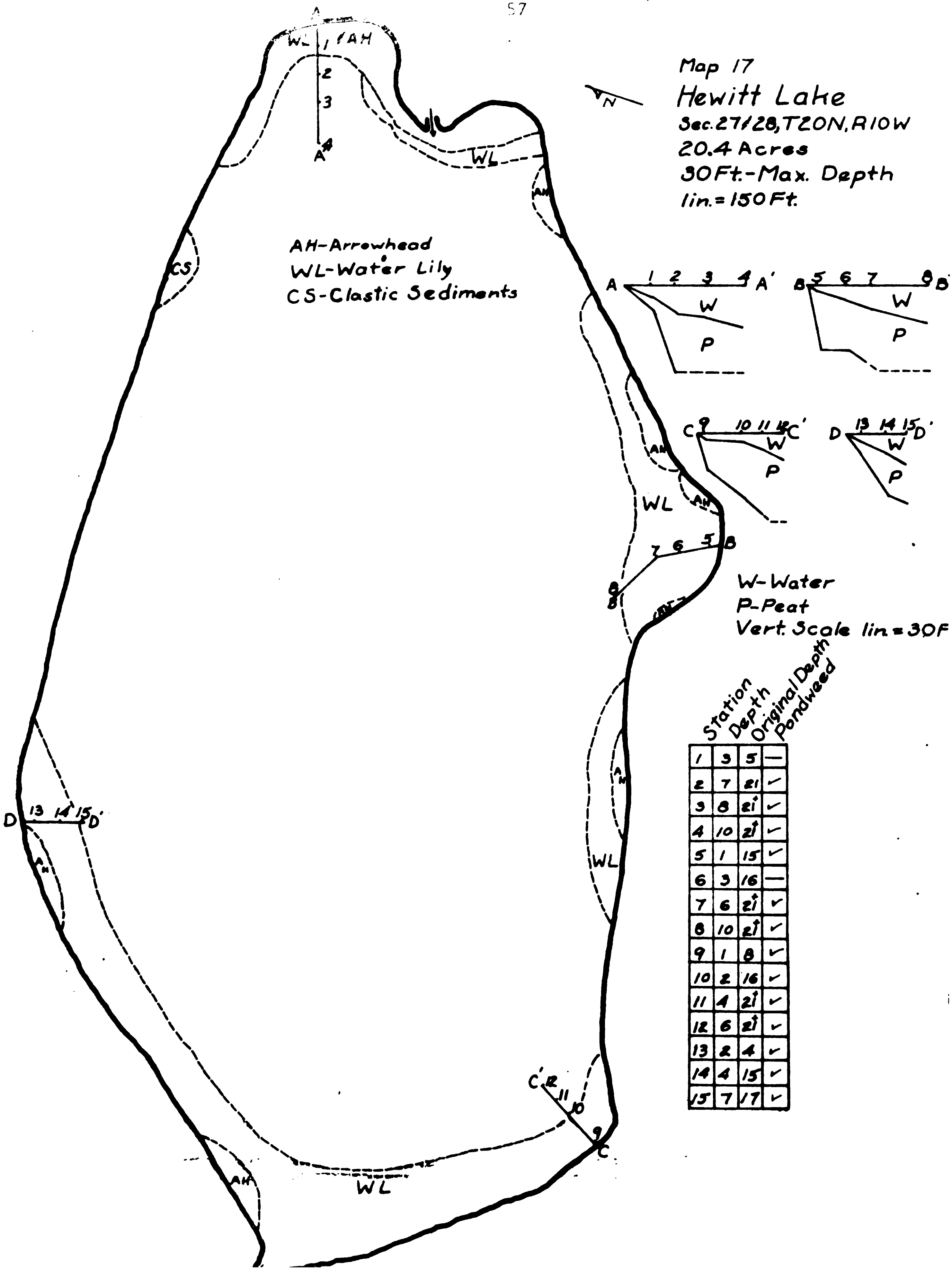
Clare County

Pike Lake was studied in Clare County (Map 18). Glacial drift in its vicinity is over 500 feet thick.

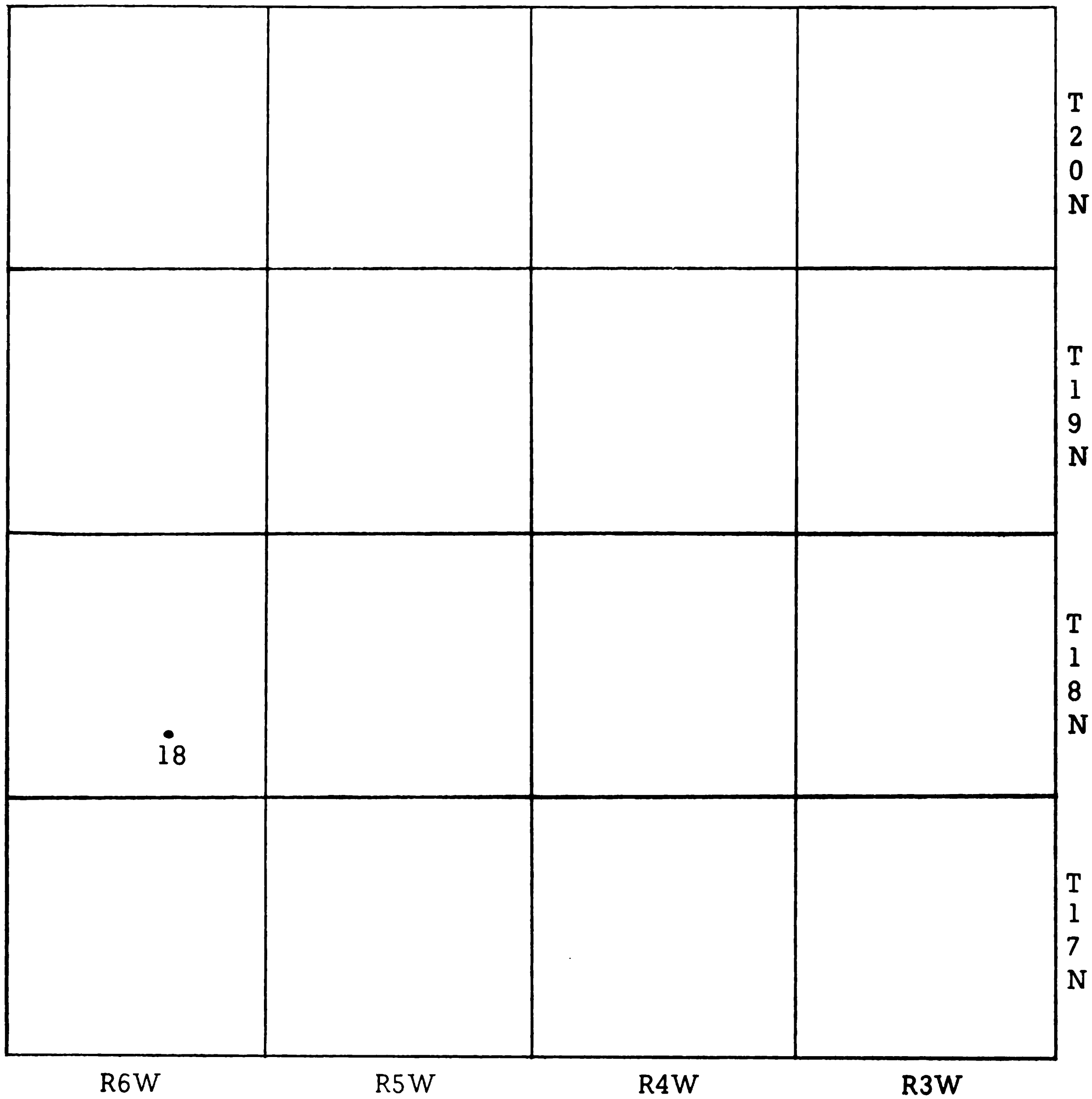
Drought conditions in Clare County are the same as in Osceola County, described on page 44.

Pike Lake

Pike Lake (Map 19) is in a drainage area of about 179 acres with maximum

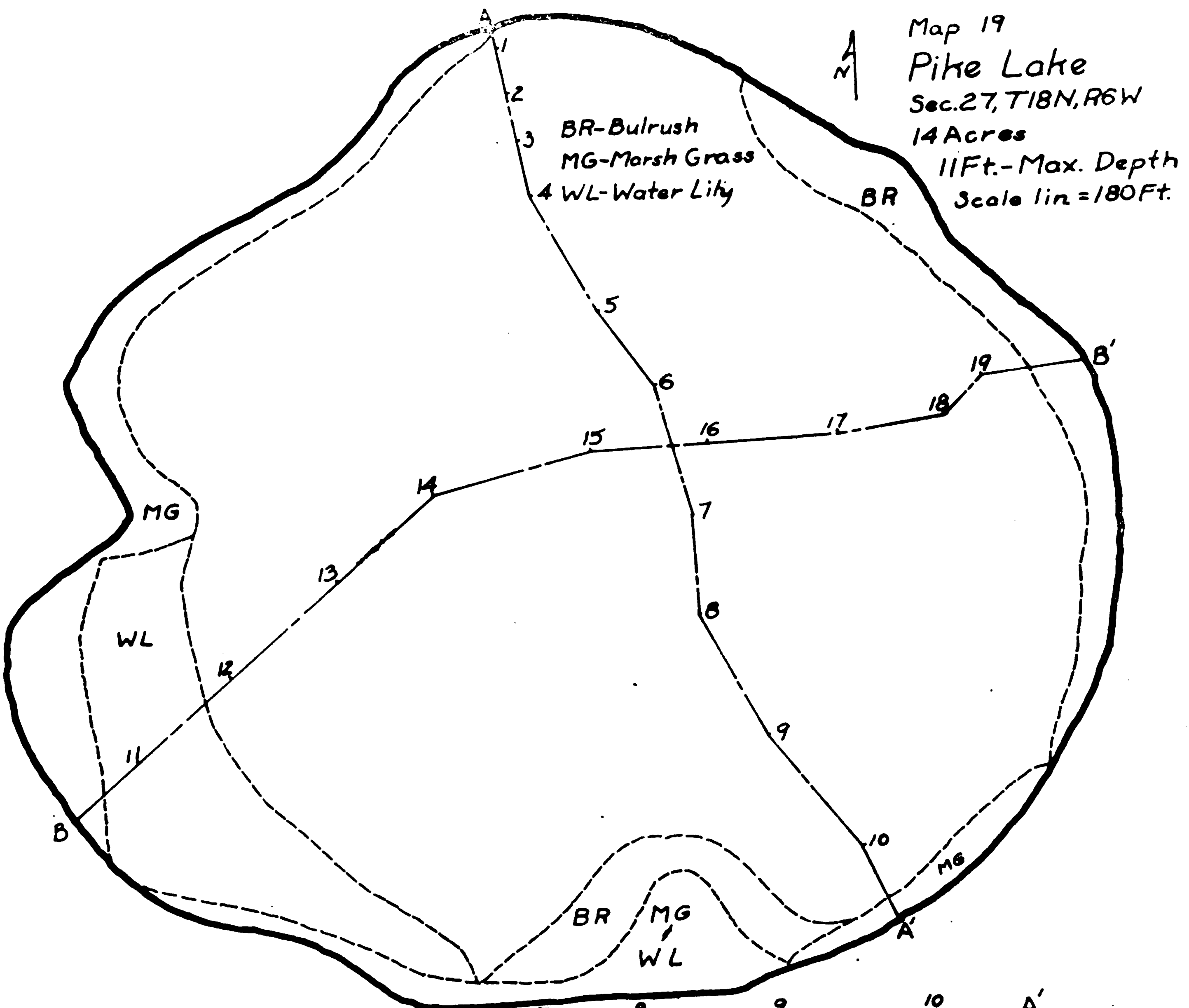


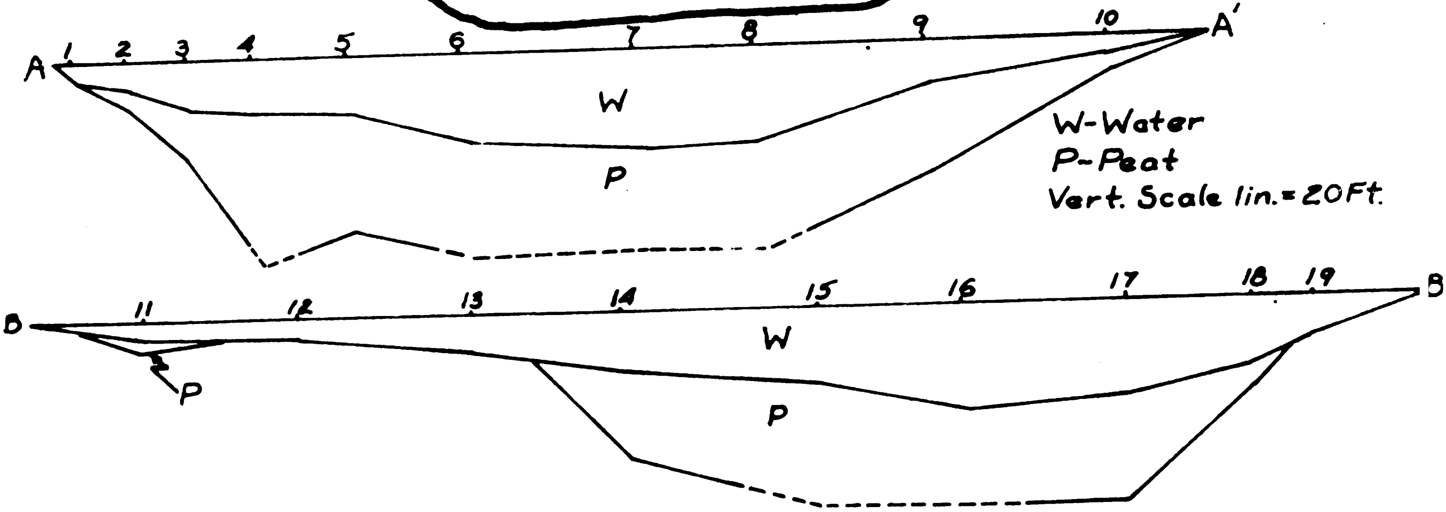
Station	Depth	Original Depth	Pondweed
1	3	5	—
2	7	21	✓
3	8	21+	✓
4	10	21+	✓
5	1	15	✓
6	3	16	—
7	6	21+	✓
8	10	21+	✓
9	1	8	✓
10	2	16	✓
11	4	21+	✓
12	6	21+	✓
13	2	4	✓
14	4	15	✓
15	7	17	✓



18. Pike Lake

Map. 18. Clare County





Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Depth	2	3	5	5	6	9	10	10	4	2	2	2	4	7	8	11	10	7	4
Original Depth	2	4	10	21+	18	21+	21+	21+	13	3	3	2	4	16	21+	21+	21	9	4
Pondweed	—	✓	✓	✓	✓	—	—	✓	✓	✓	✓	—	✓	✓	✓	—	—	✓	—

relief of about 10 feet. The drainage area is composed of deep sorted sand. Pike Lake is in public ownership and the east shore is a popular roadside campground.

The lake level declined about two and one-half feet during the ten years prior to spring 1965. Woody upland vegetation rapidly advanced over the former bottom. However, the lake level rose about two feet during the spring and summer, 1965, covering vegetation that had advanced.

The original bottom slopes lakeward at two to four degrees and is under a cover of dark brown, pulpy peat.

Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 10 feet. Water lily grew sparse at depths to two feet. Bulrush grew at depths to three feet. Marsh grass grew abundantly on the western side of the lake and sparsely with water lily at depths to two feet.

Wexford County

Two lakes were studied in Wexford County (Map 20). Glacial drift in the vicinity of the lakes is over 700 feet thick.

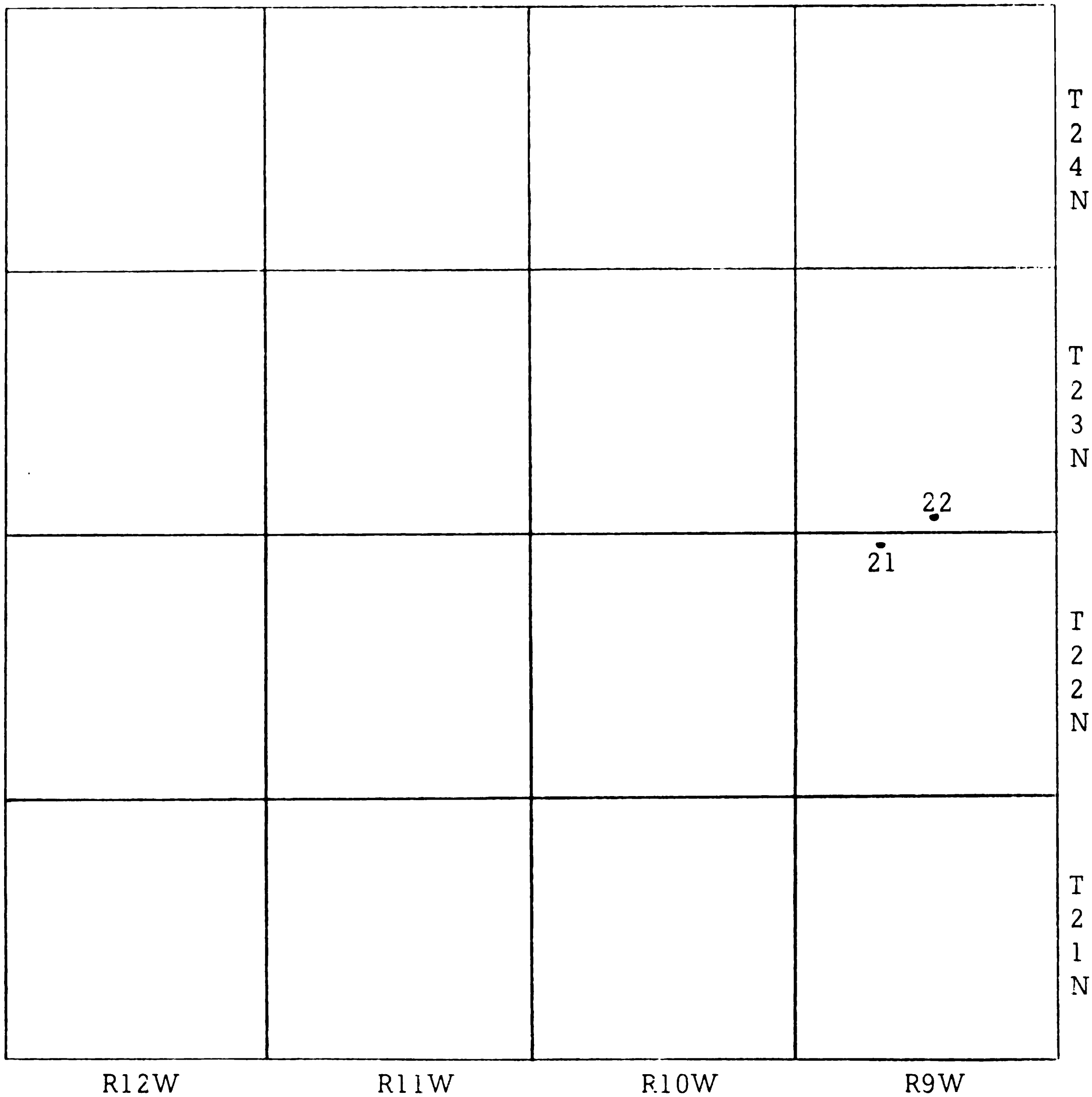
Drought conditions in Wexford County are the same as in Osceola County described on page 44. Most lake levels were below normal.

Unnamed Lake

This lake (Map 21) is in a drainage area of 21 acres with maximum relief of about 30 feet. The drainage area is composed of unsorted gravelly sand, boulders and clay, and was recently cutover for pulpwood. The lake is undeveloped. Access is possible from a trail adjacent to the north shore. The lake level was about four inches below normal in August 1965.

The original bottom slopes lakeward at 5 to 13 degrees with dark brown, pulpy peat deposited over it.

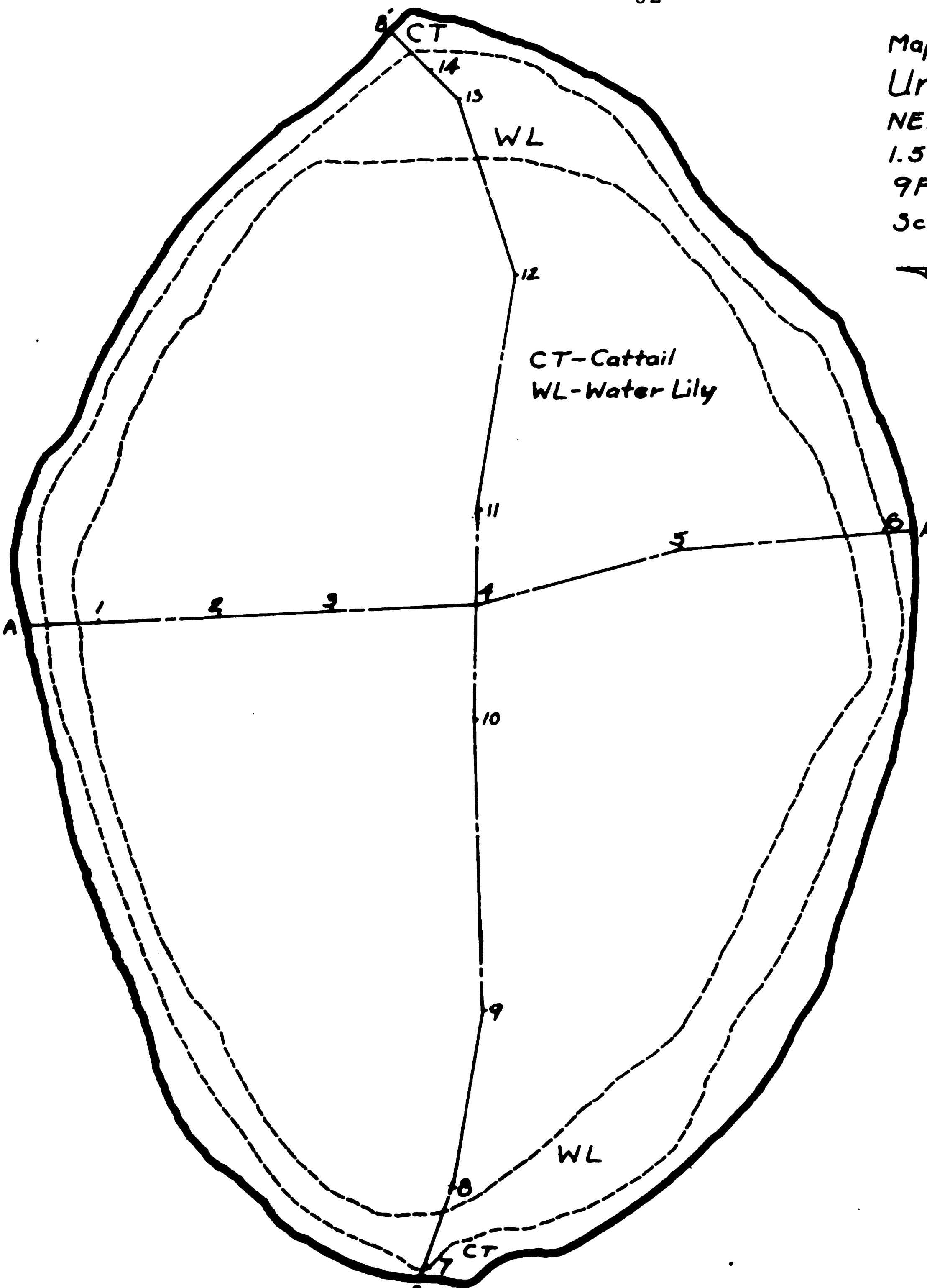
Pondweed and water lily were the attached aquatic vegetation growing in 1965 with pondweed at depths to 10 feet and water lily to four feet. Marsh grass and cattail grew at the waters edge.



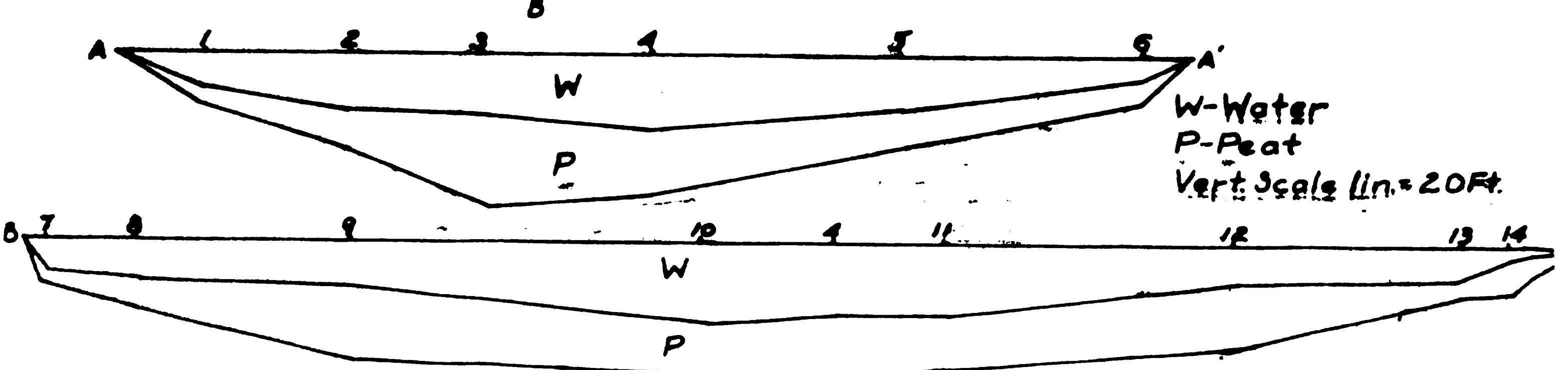
21. Unnamed Lake
22. Meady Lake

Map 20. Wexford County

Map 21
Unnamed
NE¼, Sec. 5, T22N, R9W
1.5 Acres
9 Ft.–Max. Depth
Scale 1in. = 60 Ft.



Station	Depth	Original Depth	Pondweed
1	4	5	✓
2	6	10	✓
3	7	16	✓
4	8	15	✓
5	6	10	✓
6	3	5	✓
7	3	4	✓
8	4	10	✓
9	5	13	✓
10	9	18	✓
11	8	14	✓
12	4	11	✓
13	4	5	✓
14	1	5	✓



Meady Lake

Meady Lake (Map 22) is in a drainage area of about 103 acres with maximum relief of about 70 feet. The drainage area is composed of unsorted sandy gravel, boulders and clay, and deep sorted sand. The lake is surrounded by a narrow margin of peat giving it a bog appearance. The peat is dark brown and pulpy, but is black, woody, and leavy at the surface where it is overgrown by leatherleaf. The lake is in public ownership and undeveloped. Access is possible from a trail passing within one-tenth mile of the lake.

The original bottom slopes lakeward at 8 to 20 degrees and dark brown pulpy peat was deposited over it. Attached aquatic vegetation was limited to pondweed observed at one station.

Missaukee County

Four lakes were studied in Missaukee County (Map 23). Glacial drift thickness in the vicinity of lakes studied exceeds 500 feet.

The Missaukee County area experienced a precipitation deficiency of 6.31 inches from January 1962 to June 1964 (Michigan Water Resources Commission, 1964). However, in 1964 accumulated precipitation was 0.1 inch above normal (Michigan Water Resources Commission, 1965, p. 6). Most lake levels in this county were below normal.

Lake Missaukee

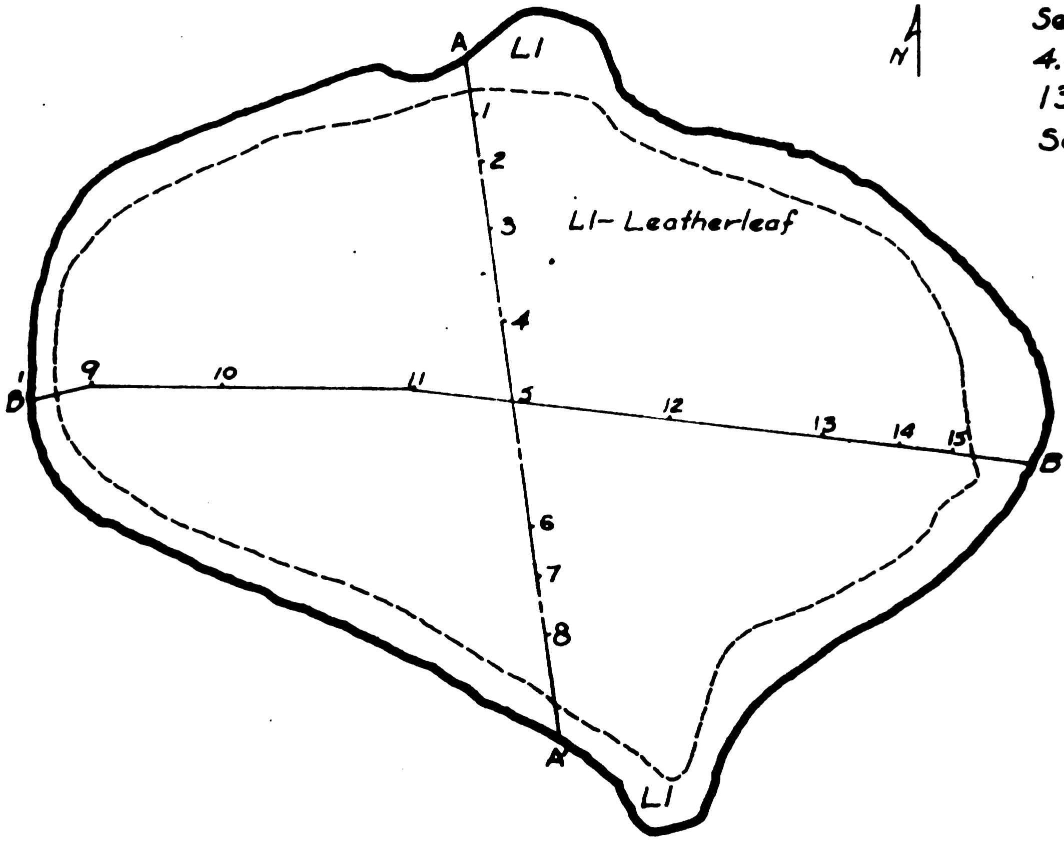
Lake Missaukee (Map 24) is in sections 1, 2, 3, 10, 11, and 12, T22N, R8W, and sections 6 and 7, T22N, R7W. The drainage area is composed of unsorted gravelly sand and sandy clay, and deep sorted sands. The lakeshore is extensively developed with several hundred cottages, resorts, marinas, a county campground and beach, and Lake City.

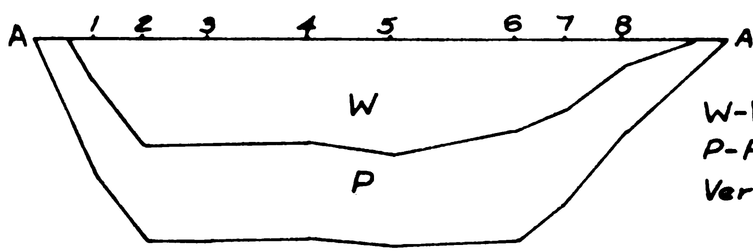
The lake level has declined since the mid-1920's when Lake Missaukee was served by outlets flowing from nearby Goose and Crooked Lakes. By the late 1930's, the inlets were no longer flowing, causing local residents to fear the lake level decline was due to the city removing 640 gallons of

Map 22

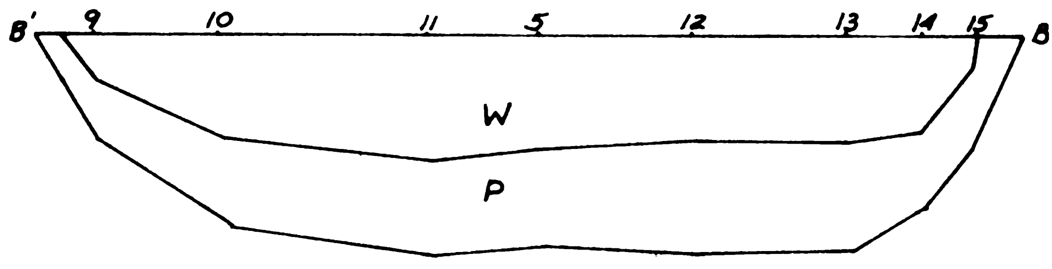
Meady Lake

Section 34, T29N, R9W
4.5 Acres
13 Ft.-Max. Depth
Scale 1in.=100Ft.



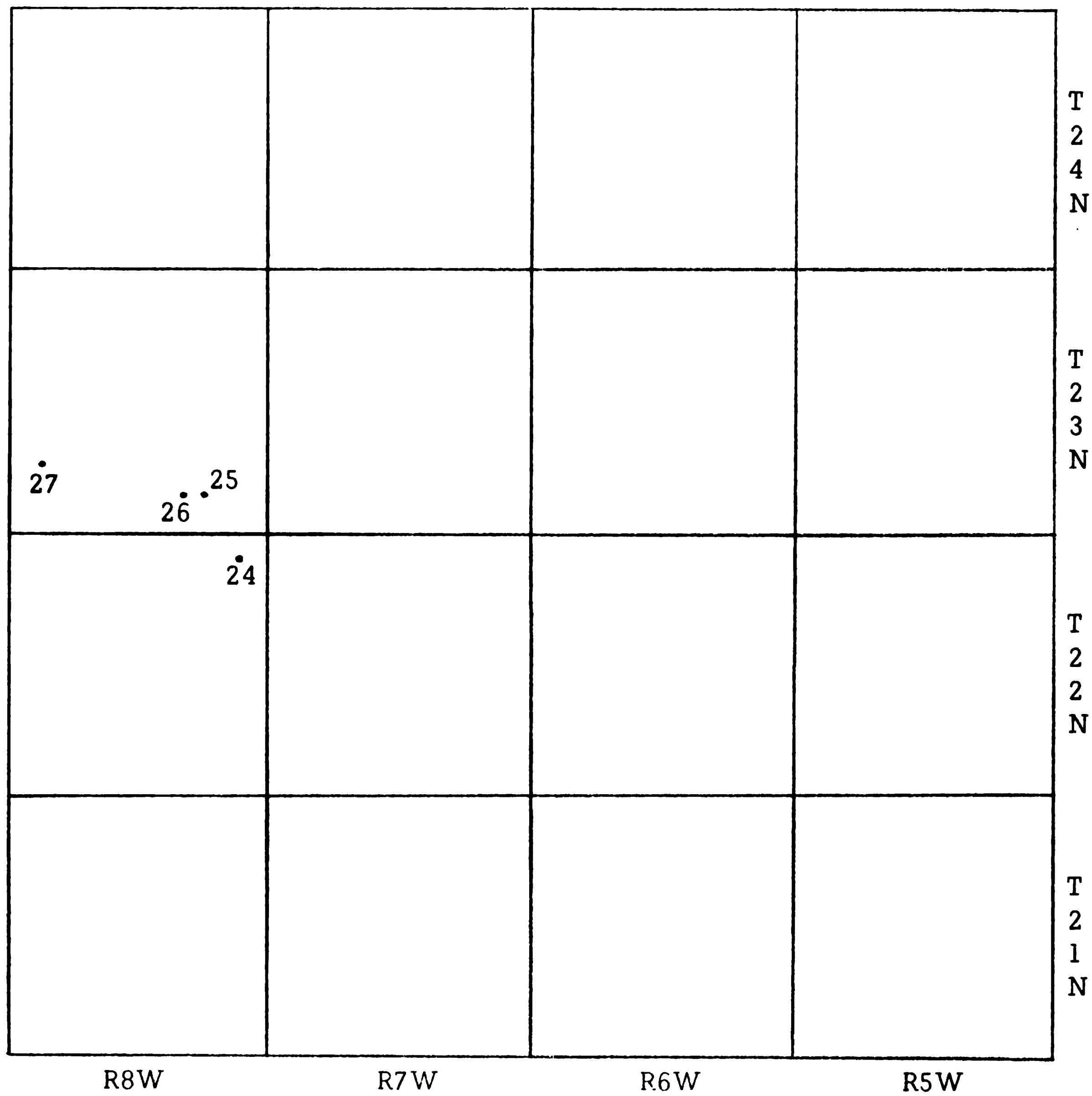


W-Water
P-Peat
Vert. Scale 1in.=20Ft.



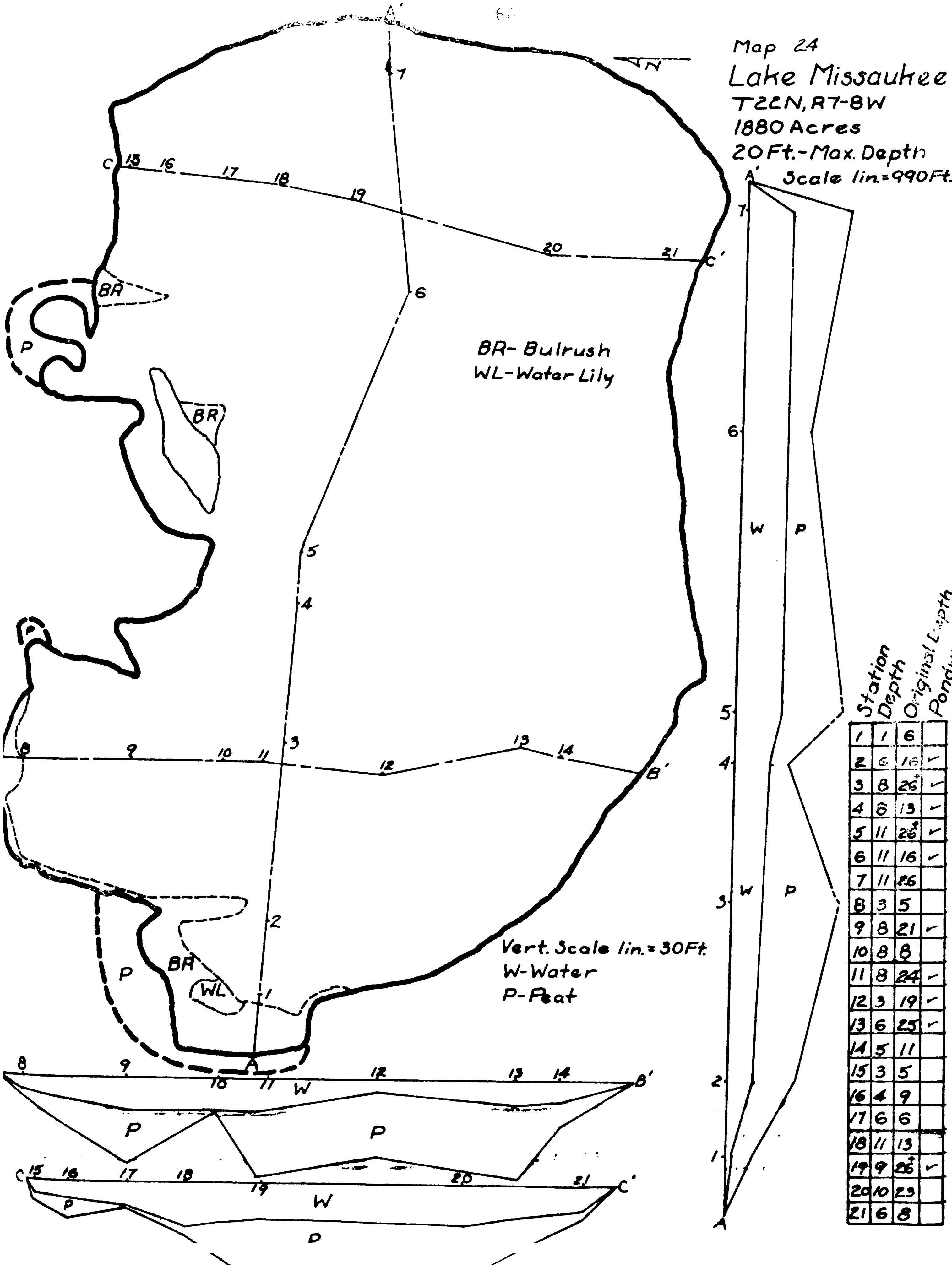
Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depth	4	11	11	11	12	10	7	3	5	11	13	11	11	10	4
Original Depth	14	21	21	21	22	21	17	10	11	20	23	23	22	18	18
Pondweed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



24. Lake Missaukee
25. Goose Lake
26. Long Lake
27. Whitlock Lake

Map 23. Missaukee County



Station	Depth	Original Depth	Pondweed
1	1	6	
2	6	18	✓
3	8	26+	✓
4	6	13	✓
5	11	26+	✓
6	11	16	✓
7	11	26	
8	3	5	
9	8	21	✓
10	8	8	
11	8	24	✓
12	3	19	✓
13	6	25	✓
14	5	11	
15	3	5	
16	4	9	
17	6	6	
18	11	13	
19	9	26+	✓
20	10	23	
21	6	8	

water a minute from a shallow nearby well. The well was later discontinued but the lake level continued to decline from a maximum depth of 27 feet in 1941 to 20 feet in 1964. The lake level was three feet lower in August 1964 than in June 1955, the highest level in recent years.

The original bottom slopes lakeward at one to three degrees. Dark brown, pulpy peat is deposited over the original bottom.

Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1964. Pondweed flourished at depths to 12 feet. Water lily grew sparse at depths to three feet. Bulrush grew at depths to two feet.

Goose Lake

Goose Lake (Map 25) is in a drainage area of about 180 acres with maximum relief of about 15 feet. The drainage area is composed of deep sorted sand. The lake is undeveloped with the exception of the public-owned northern shore, which includes a campground.

The lake level has declined since the 1930's when an outlet flowed into Lake Missaukee. The surface area and maximum depth have declined from 100 acres and 14 feet in 1940 to about 85 acres and 12 feet in 1965, surrounding the lake with peat deposits. The lake level declined over one foot from 1963 to August 1965.

The original bottom slopes lakeward at two to seven degrees with dark brown, pulpy peat deposited over it. Peat may also be yellow-brown to light brown and contains vegetative parts in areas of prolific water lily growth.

Pondweed and water lily were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 11 feet. The water lily grew prolifically to depths of five feet. Marsh grass and cattails grew on surrounding peat deposits.

Long Lake

Long Lake (Map 26) is in a drainage area of about 304 acres with

Map 25

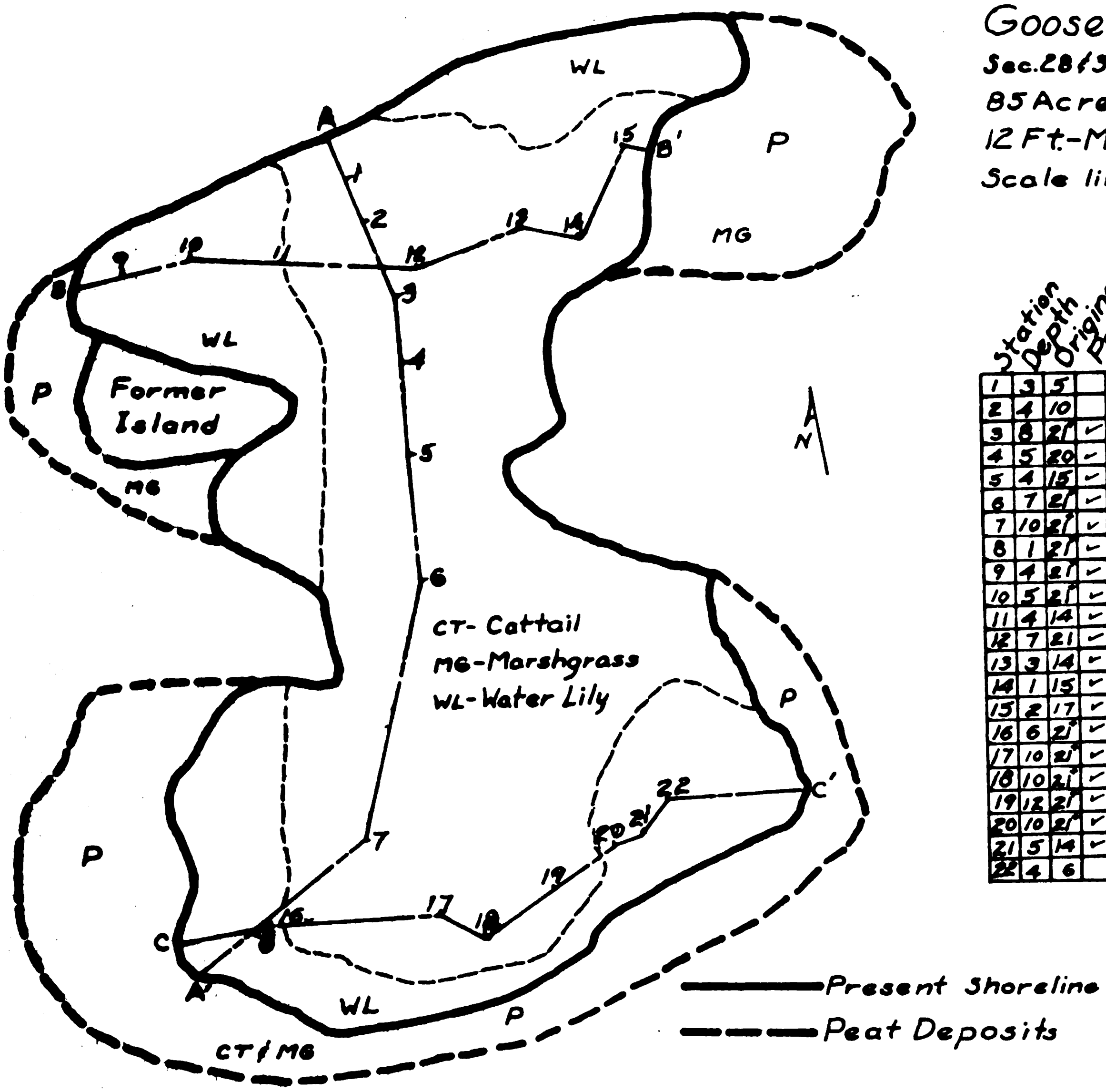
Goose Lake

Sec. 28 & 35, T23N, R8W

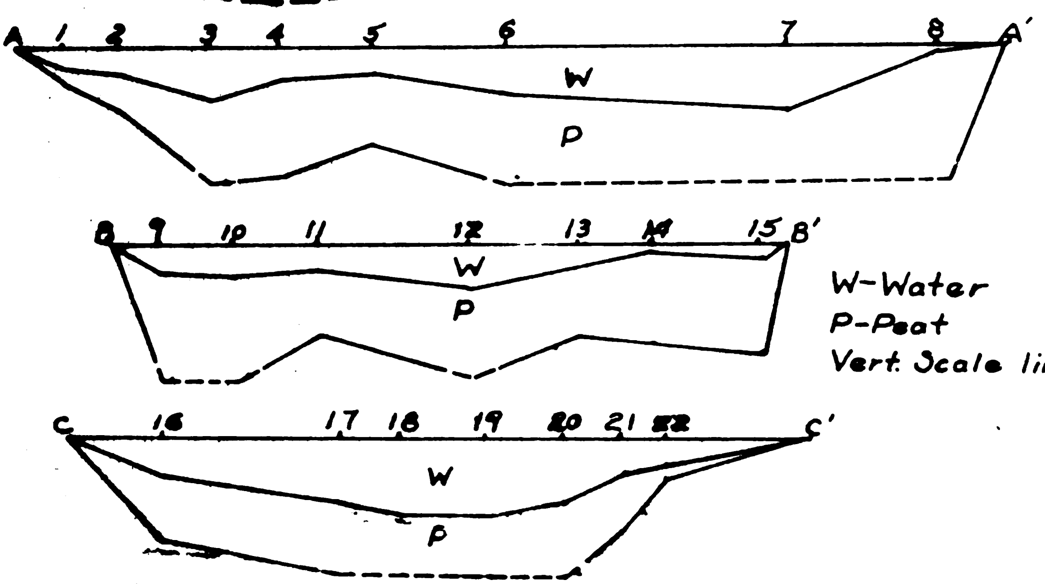
85 Acres

12 Ft.-Max. Depth

Scale 1in. = 460 Ft.



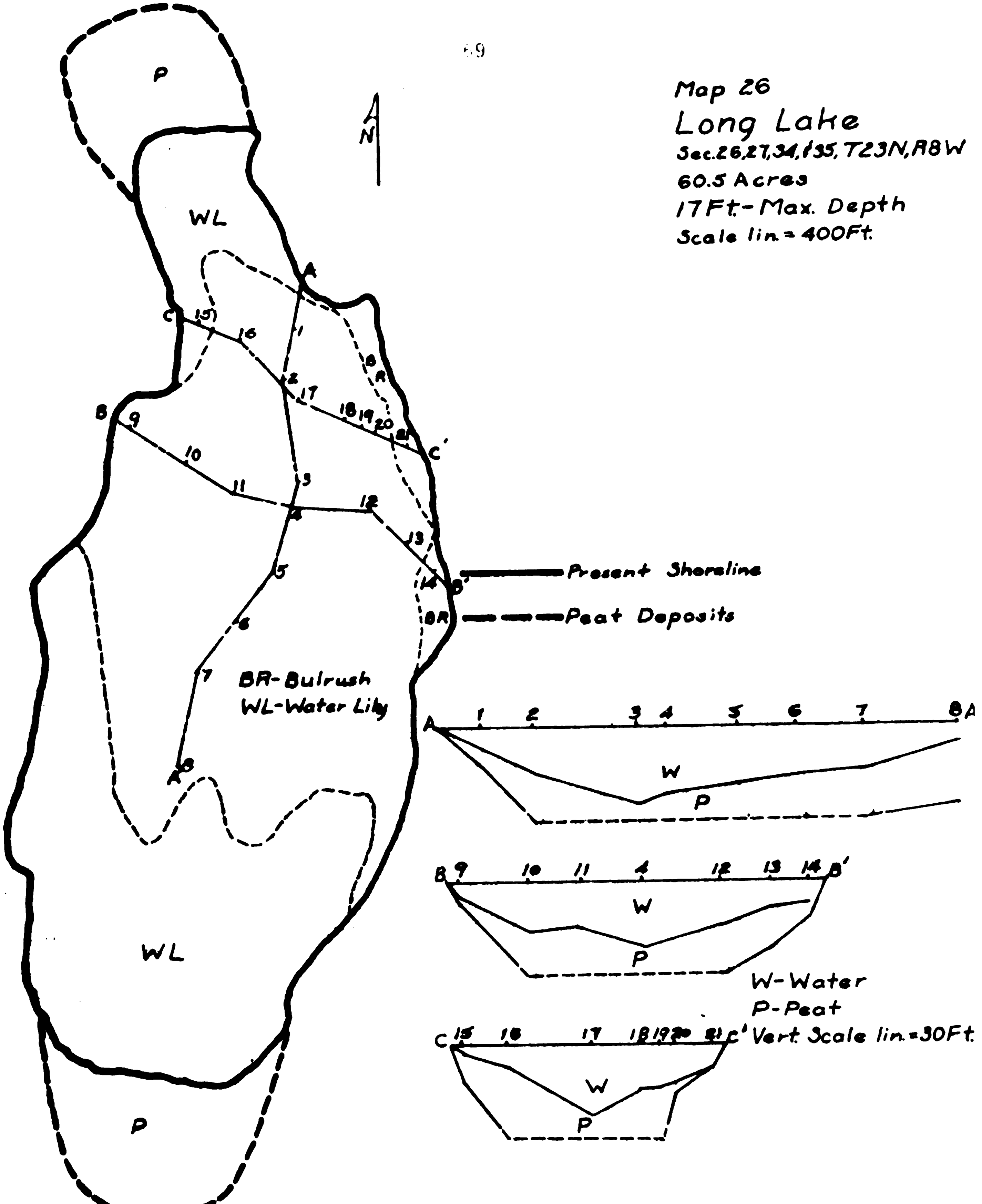
Station	Depth	Original Depth	Pondweed
1	3	5	
2	4	10	
3	8	21	✓
4	5	20	✓
5	4	15	✓
6	7	21	✓
7	10	21	✓
8	1	21	✓
9	4	21	✓
10	5	21	✓
11	4	14	✓
12	7	21	✓
13	3	14	✓
14	1	15	✓
15	2	17	✓
16	6	21	✓
17	10	21	✓
18	10	21	✓
19	12	21	✓
20	10	21	✓
21	5	14	✓
22	4	6	



W-Water

P-Peat

Vert. Scale 1in. = 30 Ft.



Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Depth	5	10	17	15	13	11	10	4	3	11	10	10	6	5	2	5	16	10	9	9	5
Original Depth	9	21	21	21	21	21	21	18	5	21	21	21	15	8	8	21	21	21	21	11	0
Pondweed	✓	✓			✓	✓	✓			✓		✓	✓	✓	✓	✓		✓	✓	✓	

maximum relief of about 40 feet. The drainage area is composed of deep sorted sand. The lake is in public ownership and a campground is on the eastern shore. The lake level has declined for several years, about three feet during the past five years (1965).

The original bottom slopes lakeward at two to five degrees. Yellow-brown to dark brown pulpy peat is deposited over the original bottom. Yellow-brown peat has some dead vegetation still visible in areas of prolific water lily growth. Most of the peat is dark brown.

Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 13 feet, water lily to five feet and bulrush grew at depths to two feet. Marsh grass grew on the surrounding peat deposits.

Whitlock Lake

Whitlock Lake (Map 27) is in a drainage area of about 370 acres with maximum relief of about 135 feet. The drainage area is composed of unsorted sandy gravel, boulders and clay, and deep sorted sand. Dark brown peat deposits occur on all lakeshores. The lake is in public ownership and undeveloped. Cattails growing at depths of nine inches suggest the lake level rose about six inches recently (July 1965).

The original bottom slopes lakeward at 2 to 10 degrees and dark to yellow-brown pulpy peat is deposited over it. The yellow-brown peat occurs in areas of prolific water lily growth where there is also parts of partially decomposed leaves.

Pondweed and water lily were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to 10 feet. Water lily grew prolifically to depths of five feet.

Kalkaska County

Two lakes were studied in Kalkaska County (Map 28). Glacial drift thickness in the vicinity is over 500 feet.

Precipitation deficiency was similar to Missaukee County, page 63.

Map 27

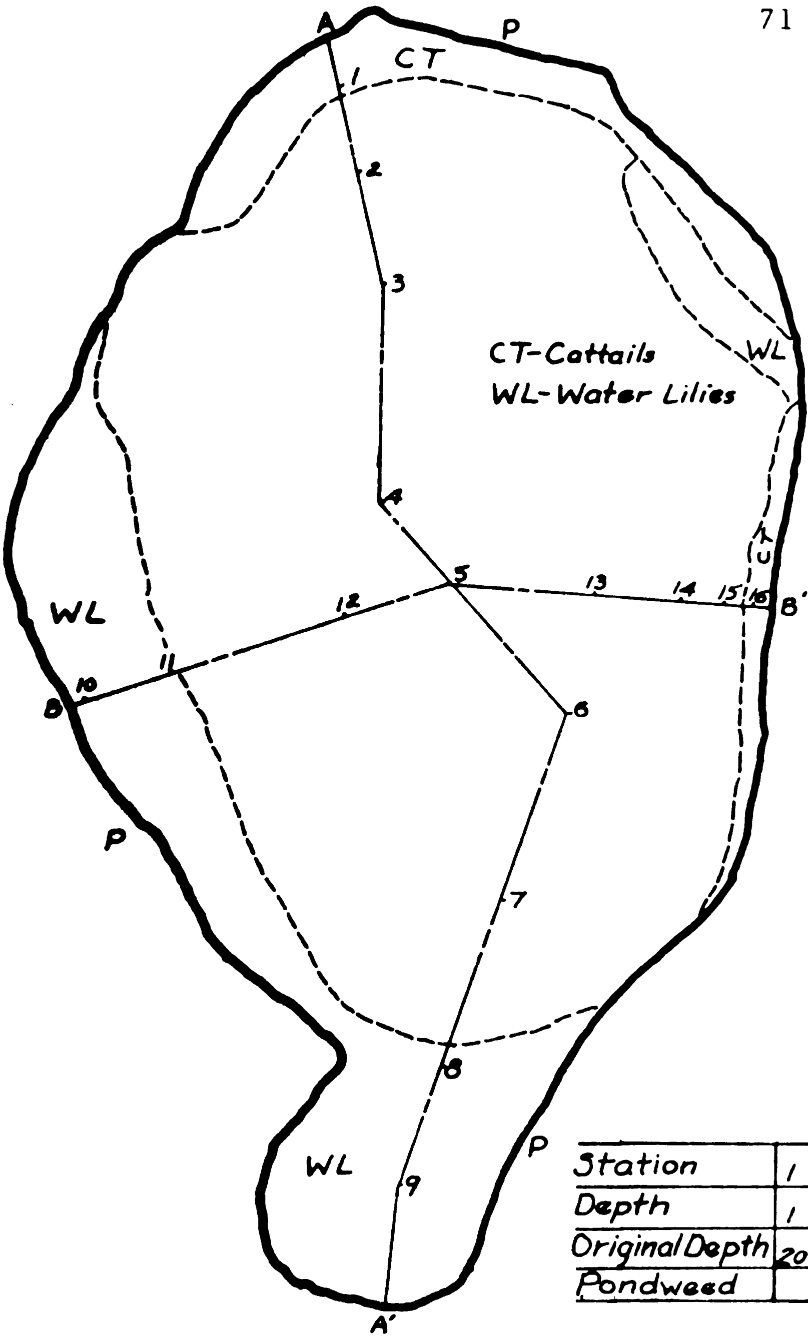
Whitlock Lake

Sec. 30, T23N, R8W

13 Acres

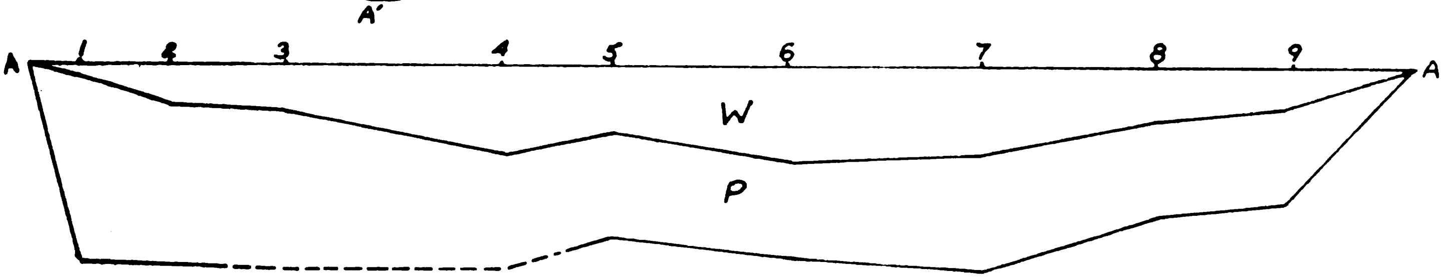
11 Ft.-Max. Depth

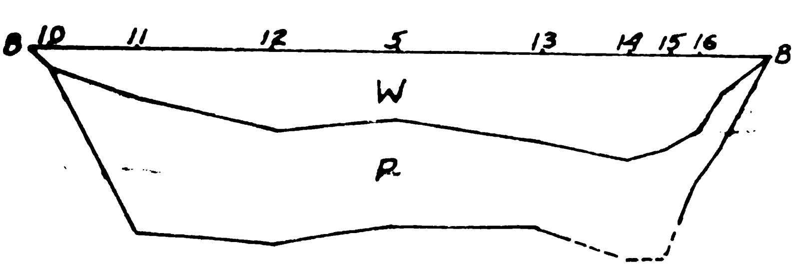
1in. = 250 Ft. (Scale)



Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth	1	4	5	9	7	10	9	5	4	1	5	8	9	11	10	8
Original Depth	20	21	21+	21+	18	20	21	15	19	0	19	20	18	21+	21+	13
Pondweed		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓			✓

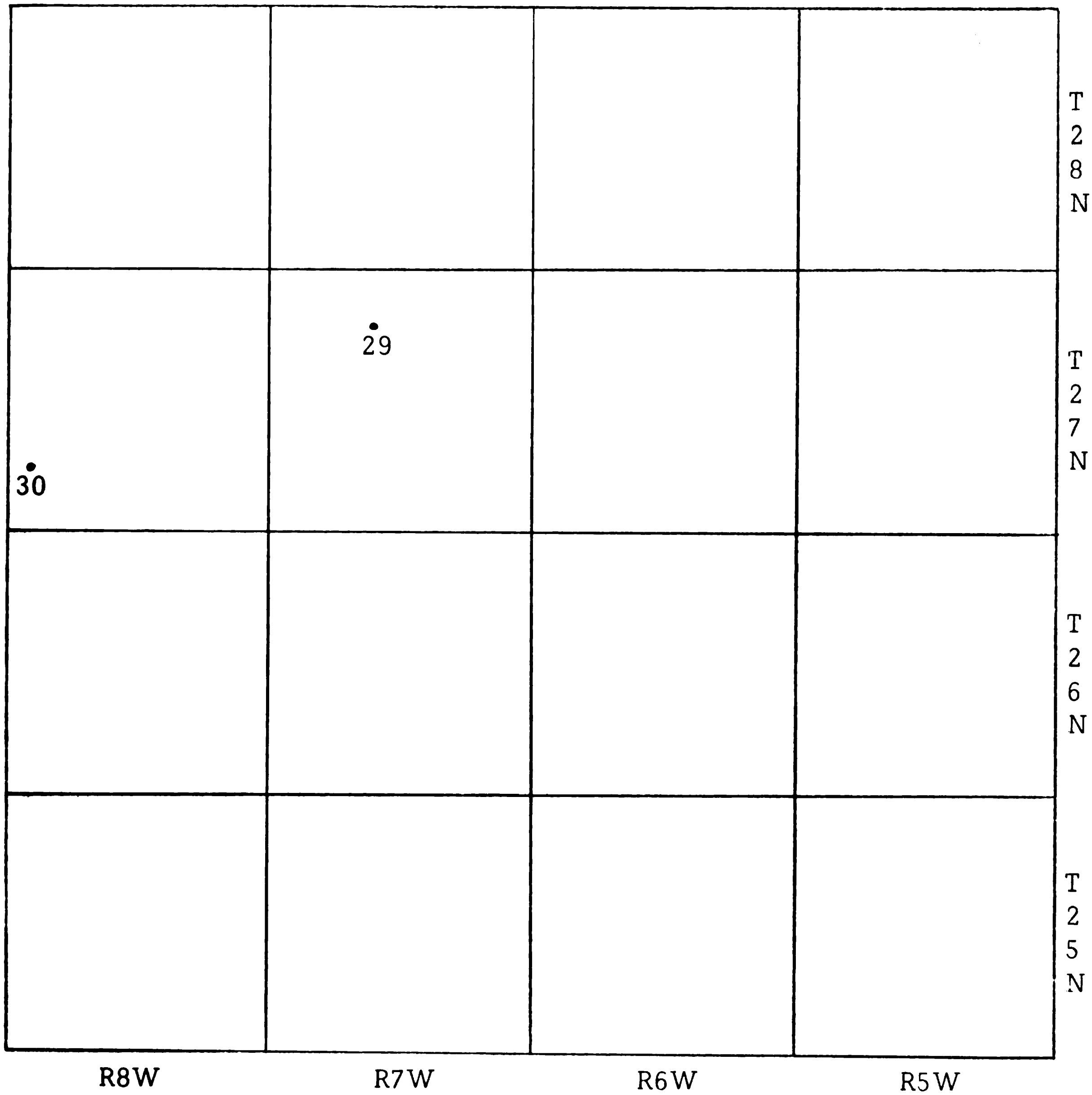




Vert. Scale 1in. = 20 Ft.

W-Water

P-Peat



29. Blue Lake
30. Guernsey Lake

Map 28. Kalkaska County

Many lake levels in Kalkaska County were the lowest in the memory of local residents.

Blue Lake

Blue Lake (Map 29) is in a drainage area of about 91 acres with maximum relief of some 13 feet. The drainage area is composed of deep sorted sand. Blue Lake is the site of six cottages with the northern shore in public ownership. The lake level was six inches below normal in August 1965.

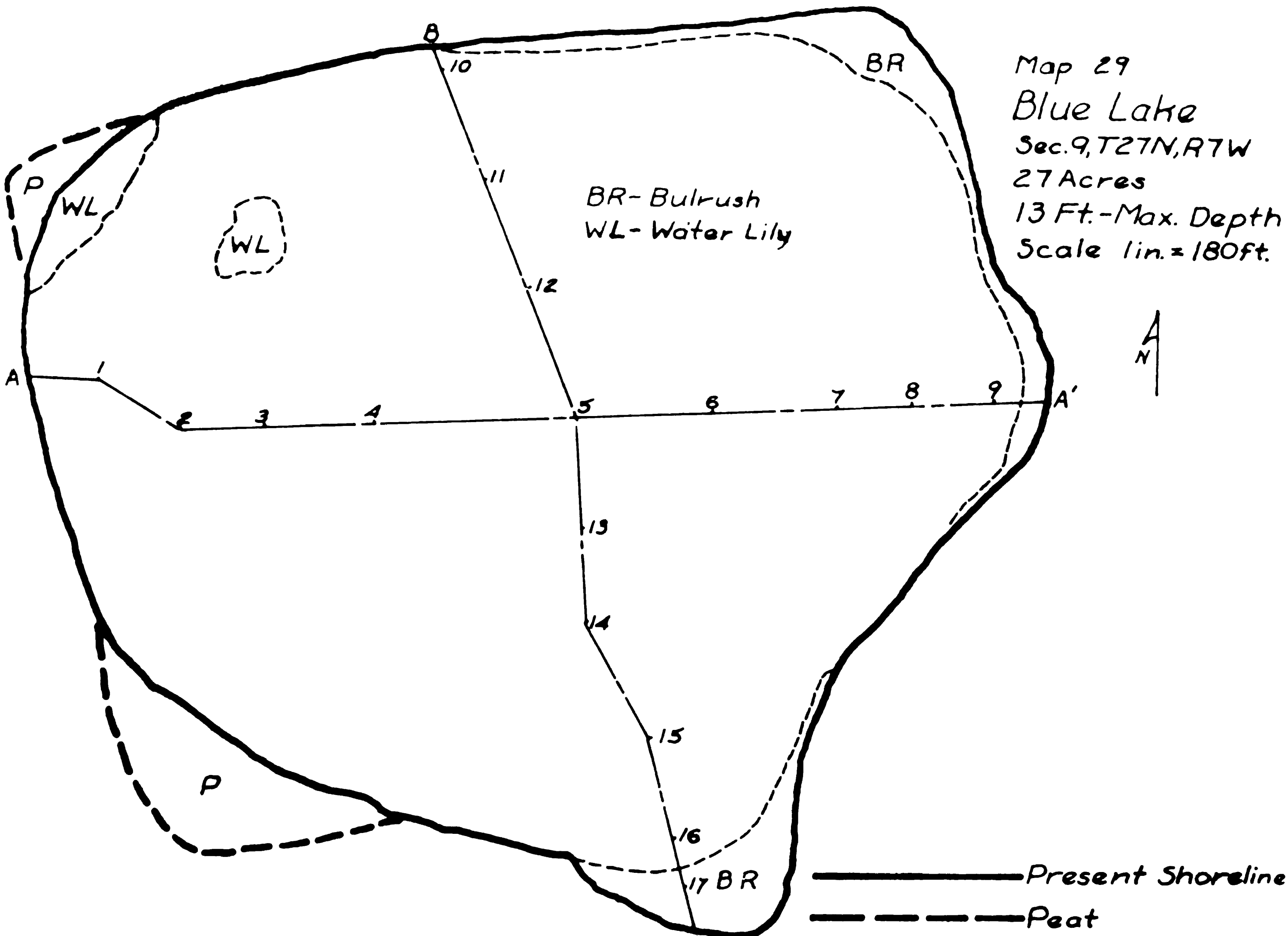
The original bottom slopes lakeward at 2 to 17 degrees. Marl and peat were deposited on it and chalky to organic gray marl overlies a small area of the original bottom. The marl is overlain by dark brown, pulpy peat, the dominant sediment over most of the original bottom, and continues to be deposited.

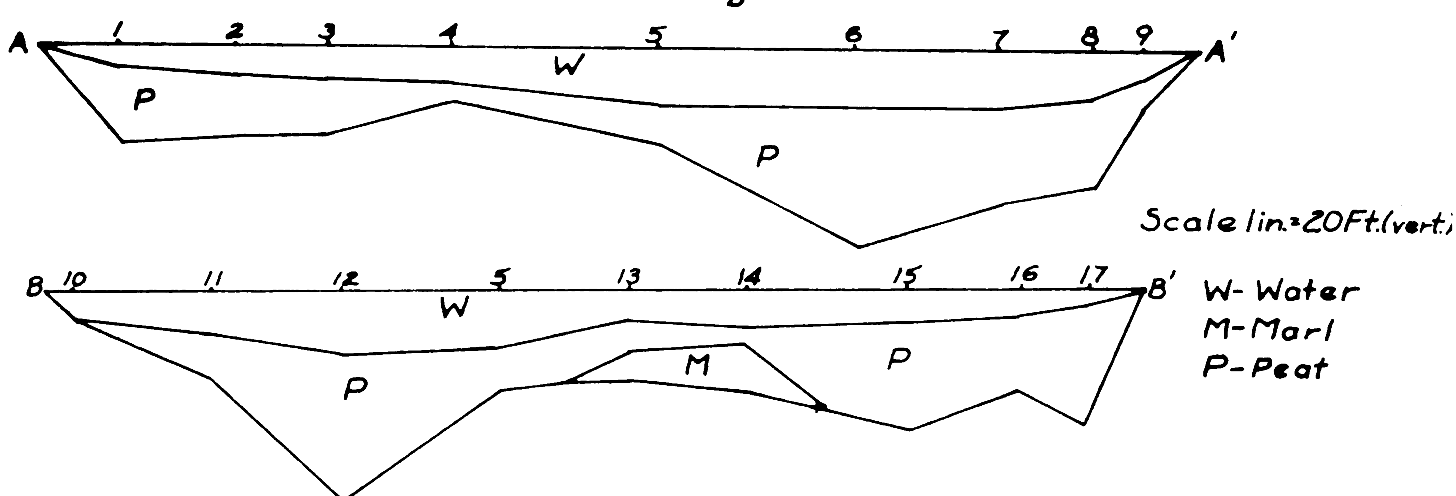
Pondweed, water lily, and bulrush were the attached aquatic vegetation growing in 1965. Pondweed grew at depths to five feet, water lily at depths to four feet, and bulrush to depths of two feet.

Guernsey Lake

Guernsey Lake (Map 30) is in a drainage area of about 73 acres and maximum relief of about 45 feet. The drainage area is composed of unsorted gravelly sand, boulders, and clay. Guernsey Lake is in public ownership with a campground and improved beach on the northern shore. The lake level has declined about three feet in the past five to eight years (1965) with the surface area declining from 31 to 27 acres.

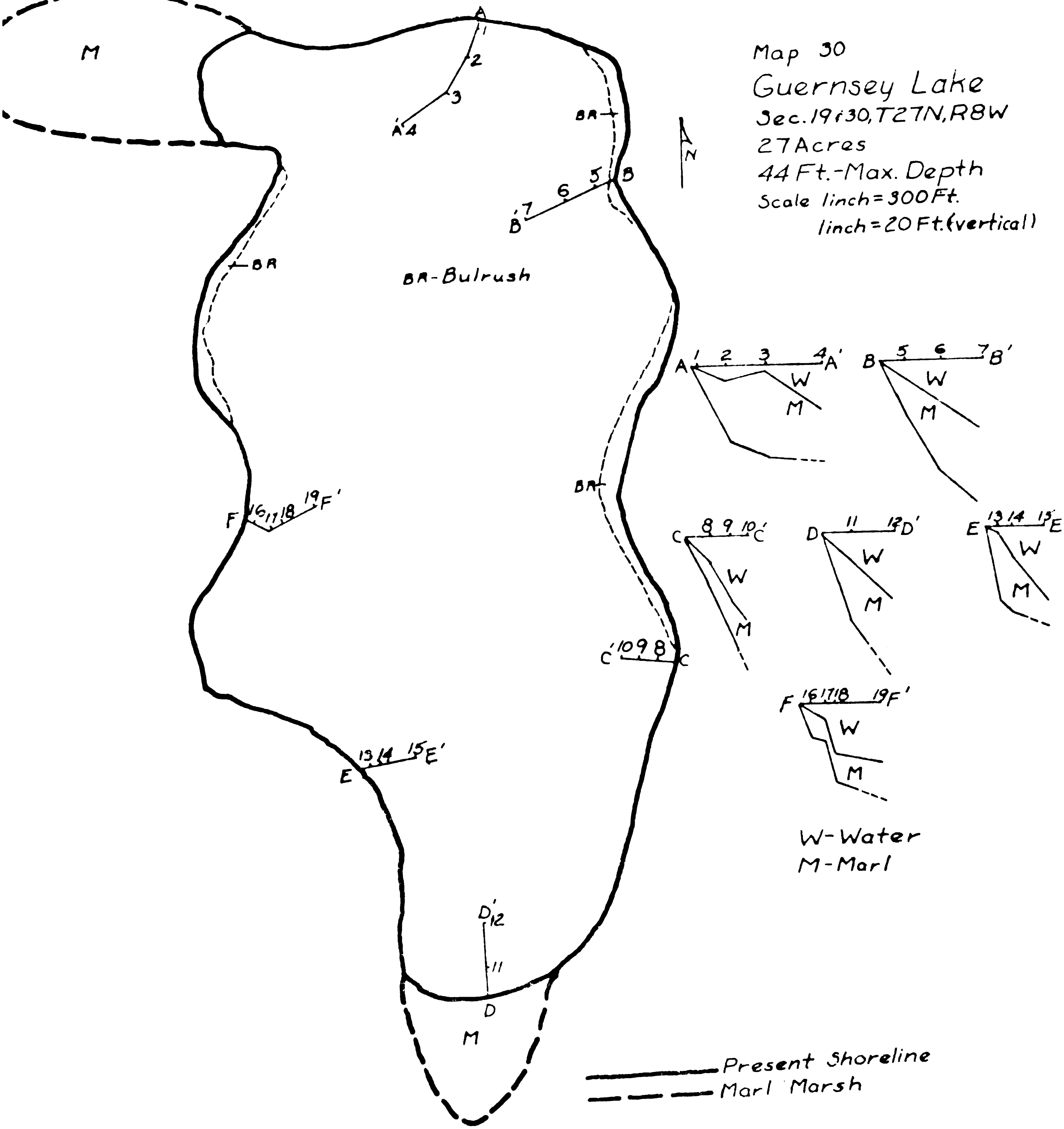
The original bottom slopes lakeward at 10 to 19 degrees. Chalky gray marl was deposited over the original bottom. A marl shelf was built lakeward from the north and east shores. The lakeward edge of the shelf dips 40 to 45 degrees and calcium carbonate in solution gives the water an emerald blue cast. Attached aquatic vegetation was limited to bulrush growing at depths to three feet.





Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Depth	2	3	3	4	6	6	5	5	3	2	4	6	3	4	3	2	1
Original Depth	10	9	10	5	10	21	16	14	6	0	8	21	9	10	14	10	14
Marl (Feet)	—	—	—	—	—	—	—	—	—	—	—	—	3	5	—	—	—
Pondweed				✓			✓										



Sounding Rod Record

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Depth	1	3	1	10	3	6	10	4	10	12	4	17	1	5	11	1	4	11	13
Original Depth	0	16	20	21+	13	16	21+	7	17	21+	12	21+	11	13	15	7	8	17	21+
Pondweed																			

CHAPTER V

SUMMARY

Data collected from the 23 lakes studied in detail is summarized in Table 1. It is obvious from Table 1 and the lake basin profiles that all of the lake basins have been modified by sediments, but size and shape of the lakes, size and relief of the drainage areas have little bearing on the relative resistance of the lake to senescence and extinction.

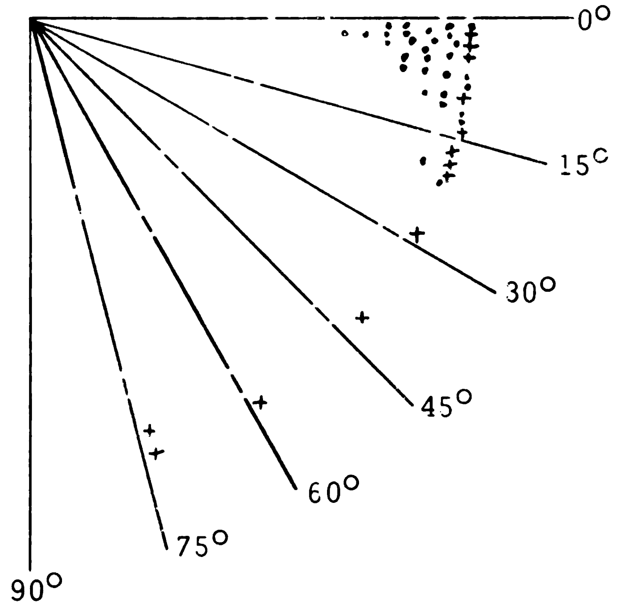
An interesting relationship exists between the slope of the original bottom and the dominant type of sediment deposited on it, summarized in Figure 4. Original bottoms usually dip at 13 degrees or less in lakes where peat dominates, but 14 degrees or more where marl is the dominant sediment. Since all of the lake basins in this study intercepted the groundwater table, the following hypothesis is advanced: calcium carbonate may be carried into any lake basin intersecting the groundwater table but is deposited as marl only where acids do not exist in quantities capable of neutralizing calcium carbonate. The most favorable environment for marl deposition would be in lakes with steep original bottoms that limit the growth and migration of attached aquatic vegetation. If the growth of aquatic vegetation is limited, there would only be limited amounts of decomposing and acid-producing vegetation.

Shallow and deep lakes, and parts of lakes, may be defined on the basis of the original bottom angle dipping in a lakeward direction and the dominant sediment. Deep lakes have an original bottom dipping 14 degrees or more and/or marl is the dominant sediment. Shallow lakes have an original bottom dipping 13 degrees or less and/or peat is the dominant sediment.

Deep lakes remain relatively deep and are less prone to senescence

Table 1. Summary of Lake Data

Lakes	Size	Depth	Original Bottom Slope	Dominant Sediment	Drainage Area	Relief
Barry County						
Cloverdale	12	30	3	Peat	400	47
Long	289	48	14 to 18	Marl	1150	115
Head	97	6	2 to 4	Peat	403	100
Guernsey	218	28	19 to 58	Marl	825	100
Daggett	14	15	7 to 11	Peat	385	120
Long	145.7	4	3 to 16	Marl & Peat	207	60
Little Payne	10	27	39 to 73	Marl	25	10
Carr	29.5	44	28 to 73	Marl	102	25
Osceola County						
Alexander	5.7	17	1 to 3	Peat	102	70
Big	240	85	5 to 10	Marl	950	70
Myrtle	5.2	9	1 to 9	Peat	410	55
Hicks	155	33	1 to 4	Peat	480	90
Park	8.2	9	6 to 12	Peat	70	50
Austin	29.2	37	1 to 7	Peat	540	70
Hewitt	20.4	30	9 to 11	Peat	79	75
Clare County						
Pike	14	11	2 to 4	Peat	179	10
Wexford County						
Unnamed	1.5	9	5 to 13	Peat	21	30
Meady	4.5	13	8 to 20	Peat	103	70
Missaukee County						
Missaukee	1880	20	1 to 3	Peat	2600	250
Goose	85	12	2 to 7	Peat	180	15
Long	60.5	17	2 to 5	Peat	305	40
Whitlock	13.1	11	2 to 10	Peat	370	135
Kalkaska County						
Blue	27	13	2 to 17	Peat	91	13
Guernsey	127	44	10 to 19	Marl	73	45



The least and greatest angles of the original bottom

+ Marl dominates
· Peat dominates

Figure 4. Slopes of the Original Bottom

and extinction, because the growth of attached aquatic vegetation is limited by depth and marl. For attached aquatic vegetation to migrate lakeward within the depth and light limitation of the species, sediments must be deposited to reduce the depth. Marl will be the dominant sediment deposited, but most attached aquatic vegetation cannot grow as well on marl as on clay or peat. The growth of attached aquatic vegetation will also be retarded by wave action. Cooler water, characteristic of deep lakes, will evaporate slower than warm water.

Shallow lakes become shallower and are more prone to senescence and extinction because attached aquatic vegetation can root and migrate more readily. Dead vegetation decomposes to form peat which makes the lake even shallower resulting in greater aquatic vegetation migration and control. There is also less wave action in shallow water to hinder the growth of aquatic vegetation and exchange warm surface water, with deeper, cooler water.

All lakes contained pondweed, but it grows most prolifically in the peat lakes. In Myrtle Lake, Osceola County; Blue Lake, Kalkaska County; and Meady Lake, Wexford County; a near absence of pondweed may be due to ecological imbalances.

A topographic sheet and soils map study of over 3,000 extinct lakes, Greenwood peat deposits, in 18 Michigan counties indicates that extinct lakes can occur at any elevation, on and in association with moraines, till plain, outwash plain, glacial drainageways and lake plain in almost any type of soil. Extinct lakes also occur in every geographic region and physiographic province of Michigan. No correlation exists between the number of extinct lakes and relative age of the region they occur in.

A soils map study of several thousand lakes in 18 Michigan counties indicates that peat deposits are most common adjacent to west shores where wave action is usually minimum. However, peat deposits are not restricted to the west shore, but may occur wherever shallow water exists and wave action is minimum.

Drought will affect shallow lake levels more severely than deep lake levels. Lake levels are lowered more readily on shallow lakes due to greater evapotranspiration losses not immediately replenished. Lower lake levels also mean vegetation can migrate more rapidly lakeward, due to reduced depths. The shallow lake shoreline will recede more rapidly enabling upland vegetation to encroach.

Minor amounts of clastic sediments, mainly clay in solution, gave the water a cloudy appearance in areas of active shore erosion, and runoff from the adjacent upland. Sand had eroded from the upland displacing peat previously deposited, in Hewitt Lake, Osceola County.

No evidence of accelerated aquatic vegetation growth due to effluent was found, despite riparian dependence on septic tanks, chemical toilets and outhouses. Agricultural fertilizers and manures had not visibly affected the lakes.

Conifers growing in the vicinity of lakes studied in Kalkaska, Missaukee, and Wexford counties may have affected lake levels during the recent drought. Several local residents noted that lake levels have declined almost continuously since the 1930's. Most of the trees were planted close together in the 1930's. However, recent vegetation on the shores of these lakes is usually a volunteer growth of poplar less than 10 years old.

The study could have been improved by recovering a continuous core of sediments from each lake. A core study could have shed light on cyclic deposition due to climatic pulsations.

Senescent lakes too shallow and weedy for swimming and waterskiing may be an ideal habitat for bass, ducks, fishermen and hunters. Senescent lakes, too shallow for power boats, may be ideal locations for nature groups and others who would rather hear loons than see lunatics tearing around.

Extinct lakes are a source of peat and marl, habitat for wild animals, and a site for peat farming. Peat bogs usually contain an autobiography of climatic and flora information of the region in the form of plant spores and pollen, as cores may reveal.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The original basin of each of 23 lakes studied in detail had been modified by sediments.
2. Dark brown, pulpy peat is the dominant sediment in lakes with original bottoms dipping lakeward at 13 degrees or less. Peat lakes are shallow lakes, more fertile, and more prone to senescence and extinction, than deep marl lakes.
3. Marl is the dominant sediment in lakes with original bottoms dipping lakeward at 14 degrees or more. Marl lakes are deep lakes.
4. All lakes show some degree of senescence and/or extinction. Senescence is exhibited in shallow areas controlled by attached aquatic vegetation where wave action is non-existent or slight at the most. Extinction is shown by peat and marl deposits adjacent to the present water area.
5. Extinction may occur in lakes at any elevation, in association with moraines, till plains, outwash plains, glacial drainageways, and lake plain in almost any type of soil.
6. Extinct lakes occur in every geographic region and physiographic province of Michigan.
7. Peat deposits are most common adjacent to west shores where wave action is usually minimum.
8. Peat deposits may occur wherever shallow water exists and wave action is usually minimum.
9. Practically all inland lakes contain pondweed, growing most prolifically over peat deposits between shore and depths of 10 feet. A lack

of pondweed may indicate an ecological imbalance, or the lake has been treated to rid it of this aquatic nuisance.

10. Attached aquatic vegetation is most prolific in areas of peat deposits covered by shallow water. Marl is a less favorable soil for vegetation growth. The lakeward migration of attached aquatic vegetation is retarded by abrupt slopes at the edge of marl shelves.
11. Wave action, waterskiers, and swimmers retard the growth of attached aquatic vegetation.
12. There is a direct relationship between the growth of attached aquatic vegetation, the depth of water and available light. There is also a relationship between the present shoreline and upland vegetation encroachment on the lake.
13. Calcium carbonate is carried into lake basins intersecting the groundwater table in glacial drift but marl will be deposited only if acids do not exist in quantities that may neutralize the calcium carbonate.
14. Calcium carbonate in solution gives the lake an emerald-blue cast.
15. Marl is less indurated and easier to penetrate with a sounding rod in the more northern lakes (Kalkaska County) than in southern lakes (Barry County).
16. Deep lakes and deep parts of a lake can usually be located because of vigorous wave action when the wind is blowing, and a lack of attached aquatic vegetation.
17. Lower lake levels are common during periods of prolonged drought. Lake levels usually rise when precipitation returns to normal.
18. Reforestation projects may have a long-range effect on the groundwater table and lake levels, where trees are planted close together.
19. The size and shape of the lake, and the size and relief of the drainage area has little if any bearing on the resistance of the lake to senescence and extinction.
20. No correlation exists between the number of extinct lakes and the relative age of the region they occur in.

21. Each lake must be considered on its individual merits.
22. Cores of lake sediments would provide information about cyclic deposition in response to climatic pulsations.
23. Senescent lakes may be an ideal habitat for wild fowl and bass.
24. Senescent lakes may be of value to hunters, fishermen, and nature groups.
25. Extinct lakes are habitat for wild animals.
26. Extinct lakes may be of value to peat and marl producers, peat farmers, and palynologists.
27. Artificial lakes should be designed to allow a minimum of area between the shoreline and a depth of 10 feet.

Recommendations for Additional Studies

1. Develop a simple coring device and coring technique that could be used from a small rowboat.
2. Take one core from each of 100 or more lakes from the Indiana-Michigan boundary line to Lake Superior. Study and correlate sediments, pollen and spores.
3. A chemical and physical analysis of lake sediments recovered as cores. Analyses may reflect the geological and limnological history of the lake and drainage basin.
4. The origin of lakes versus their resistance to senescence and extinction. The discussion in Chapter II shows that lakes may originate in different ways. A study may indicate that lakes of a particular origin are more prone to senescence and extinction than lakes of a different origin.
5. A comprehensive revision of Michigan Geological Survey Publication 30, "Inland Lakes of Michigan" by I. D. Scott, 1921. Hydrographs, lake studies, and glacial geology studies have resulted in new information about lakes and the regions they occur in. This information would aid not only in revising Scott's interpretations but also in

expanding the number of lakes described. With so much emphasis being placed on the recreational value of water, this out-of-print publication is again needed.

6. Investigate groundwater quality and lake water quality versus senescence and extinction. A connection exists between quality; salts, organic matter, pH, acids, alkalines; and senescence and extinction, but is there a combination of water constituents that predominate in senescent and extinct.
7. Study fish, animals, insects, and flora associated with senescent and extinct lakes and areas of lakes. Perhaps a species or its behavior indicates senescence or extinction.
8. A comparison between lake development and property evaluation adjacent to areas exhibiting senescence and extinction. The value of recreational property should be less in areas of senescence and extinction than in other areas of the lake not displaying these characteristics.
9. Develop an easy to use checklist for prospective riparians.
10. Develop a method or technique for determining the distance to the original bottom without having to use a sounding rod or take a core.

CHAPTER VII

CONTROL OF AQUATIC VEGETATION

Aquatic vegetation may be controlled by mechanical and chemical methods, and manatees, a weed-eating sea animal. Mechanical weed control includes dredging, a mowing machine arrangement adapted to operating underwater, and a set of bed springs. A permit from the Michigan Department of Conservation is needed for each dredging project. Dredging removes the weeds and the soil they grew on but it also leaves spoil piles on shore and an artificial appearance. A mowing machine is manufactured and marketed by a Wisconsin firm. The success and use of this machine is unknown. A set of rusty bedsprings attached to a power boat by rope was used to restrict aquatic weed growth on part of Hicks Lake, Osceola County. Mechanical methods must be repeated annually but do not kill or endanger animal life as chemical methods may.

Chemical methods vary with the type of vegetation and lake characteristics. Several chemical companies have developed aquatic herbicides. Each compound has its own characteristics and application. Due to danger to animals and humans, a permit is required from the Michigan Department of Conservation for applying some chemicals. More information can be found in "Aquatic Weeds and Their Control in Michigan," available from the Publications Room, Michigan Department of Conservation, Lansing, Michigan 48926.

The manatee loves aquatic vegetation, clearing 100 cubic yards of vegetation-clogged water or 100 pounds of vegetation a day. They have been experimented with in Florida where they would rather eat than reproduce, and sometimes die from respiratory ailments during cold snaps. For these reasons, they would not be an efficient way of eliminating aquatic vegetation in Michigan.

Man-made lakes may be constructed so there is a minimum opportunity for attached aquatic vegetation to live. The shores could be designed so the bottom slopes steeply lakeward to depths greater than 10 feet. Periodically the water should be drained, so aquatic vegetation and peat deposits may be scraped away. Another solution is an asphalt or cement strip surrounding the lake from shore to a depth of 10 to 12 feet. Periodically, this strip should be scrubbed, to eliminate aquatic veteta-tion that may find a means of growing.

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APPENDIX A

POINTS TO CONSIDER WHEN BUYING LAKE PROPERTY

Any depression holding water is a potential site of lakefront property in Michigan. Many good sites remain on natural lakes but abandoned gravel pits are being cleaned up, and small streams are being dammed to provide additional "lake frontage." While investigating senescence and extinction, I talked to many riparians, sportsmen, realtors, and lake-lot promoters. The writer's interpretation of riparians views, pitfalls, and advice is summarized as follows:

1. Never buy property sight unseen, even on the advice of a friend or relative. If you are unable to visit the site forget about it until you can make personal inspections.
2. Visit the site at different times of the year. Are the neighbors noisy? Is the lake infested with aquatic vegetation? Is the trip to this lake too long, especially in the winter? Most of all, does the lake and area offer the comforts and conveniences you are looking for or already take for granted?
3. Ask the realtor or salesman about building restrictions on the lake and in the township, taxes, maintenance of the road leading to the property you are interested in, recreation rights and restrictions, visitor and pet restrictions, sewage facilities, rubbish and garbage collection, and health facilities or doctors in nearby towns. Also ask the salesman or promoter about ownership of the lots; do they own the lots or merely have an option on them? Are the lakefront lots zoned against future subdividing, industrial development, and certain types of commercial establishments, such as an amusement facility? Is there a lake association actively engaged in improving the lake?

4. After visiting the lake and talking to a realtor or salesman, gather all the information you can about the lake and area from official sources. See the township assessor for valuation and tax information, the local conservation officer for fishing, hunting, public access, and lake-level stability information. A hydrograph, showing depths and bottom conditions may be available from the Publications Room, Department of Conservation, Lansing, Michigan 48926. The county road commission can tell you about road maintenance. A technician in the U. S. Soil Conservation Service office, usually located at the county seat, can show you the location of peat deposits and other soils that are unfavorable building sites. Also visit a nearby town and look around. While in town inquire about rubbish and garbage pickup at the lake. With this information, the property can be considered more objectively and you can also determine the reliability of the salesman or realtor.
5. If you are still interested in the property, go back for a serious second look. Try to talk with people who have been there for some time and also try to go out on the lake without the salesman or realtor. Is there aquatic vegetation or has it been sprayed to give the lake a more showy weedless appearance? If you are not satisfied, look at other lakes, comparing values, likes and dislikes. There is a great deal of unadvertised lake property available so you can disregard comments about this property being "the last of the good lake frontage available in the county."
6. If the lake level is maintained by a dam inquire about maintenance and liability of the dam. Usually each riparian is responsible.
7. Man-made lakes vary in quality. Some are nothing more than dammed brooks that formerly trickled through a swamp. The swamp is still there except it is now covered by a few feet of water. Stumps and brush may be seen in lakes of poorer quality, giving them a mill pond appearance. Remember, the size and cost of the dam does not guarantee that nature will fill it. Some lake levels must be maintained by water

pumped from deep wells with the riparians sharing the water bill. In Michigan there is no law to prevent the construction of a second dam upstream, thus lowering the lake level of an earlier built man-made lake located downstream.

Most riparians are glad they own a cottage. To the satisfied, a cottage is a relaxed retreat from the fast pace and pressures of daily living, where they can be together as a family. The 400-miles or more round trip that many cover during a weekend is worth it just to get away from the desk and neighbors.

The commonest complaints heard from riparians were in regard to the substantial investment and upkeep of a cottage versus limited use, especially after the children have grown up and left home. Waterskiers and large high-powered boats rate a close second on the complaint list, especially from older people interested in fishing and rest.