

A HYDROLOGIC DESCRIPTION OF LAKE MAGDALENE NEAR TAMPA, FLORIDA

By
J.D. Hunn and R.C. Reichenbaugh

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INTRODUCTION

Urban growth, the value of lakeside property for homesites, the intended use of some lakes as reservoirs for public water supplies and the desire to have controlled lake levels with water suitable for fishing and recreation have brought about an awareness of the need to better understand the hydrology of lakes. Dredging of lake bottoms, drainage of swamps, pumping from aquifers, diversion of water for agricultural use, and inflow containing nutrients and pollutants can, under some circumstances, upset the natural equilibrium of a lake. The results of such an upset can be varied and undesirable.

Lake studies are intended to document the hydrologic and geologic setting of Florida lakes and to determine the existing or impending problems and, when possible, to determine the causes of the problems. This atlas, prepared by the U.S. Geological Survey in cooperation with the Southwest Florida Water Management District, describes the hydrologic and geologic setting of Lake Magdalene. The lake, about 1½ miles north of Tampa (inset on aerial photograph) is one of many lakes in northern Hillsborough County. The lake is used for fishing, swimming, and boating. Residential areas are replacing citrus groves that formerly surrounded the lake.

The level of Lake Magdalene has been below average much of the time since 1965, with a low for the period of record occurring in 1968. The Southwest Florida Water Management District requested the Geological Survey to determine the hydrologic conditions in the lake basin and, if possible, to determine whether the low lake levels were caused by a precipitation deficiency, by drainage of adjacent land, by dredging of the lake bottom, or by large withdrawals from wells in nearby areas.

Data collected during the investigation include: hydrologic and geologic information from test borings, altitude of land surface at test borings and selected ponds, water-level measurements in wells, and lake depth from 63 traverses with an echo sounder and check soundings. The field work was done in the period March-September 1971.

HYDROLOGY OF LAKE MAGDALENE BASIN

Lake Magdalene has a surface area of 0.4 square mile at a stage of 47 feet above mean sea level and a drainage basin area of 1.7 square miles (U.S. Geological Survey, 1971). The lake basin consists of several adjoining natural depressions, most of which probably result from collapse of solution cavities in limestone. The configuration of the lake bottom has been modified in some places by dredging, which, according to local residents, was done mostly during the late 1950's. The lake bottom is sandy along the shores, except for the cove at the south end of the lake. Beginning at a depth of about 4 feet below the lake surface, the sandy bottom grades laterally into black organic clay and silt of unknown thickness. This deposit covers most of the lake bottom that is less than 40 feet above sea level.

Lake Magdalene is a water-table lake hydraulically connected on all sides with a shallow aquifer (fig. 1) that consists of silty fine to medium sand. The slope of the water table in this aquifer near the lake (fig. 2) is from the northwest to the southeast, indicating the general direction of ground-water flow. Immediately southeast of the lake, because of some ground-water mounds, the direction of flow is toward the lake.

The shallow aquifer is underlain by as much as 15 feet of gray to green clay. This clay was found in all test holes drilled during the course of investigation, including one drilled in a sinkhole. Locally, in the lake basin, and where present in sinkholes outside the basin, the clay occurs at altitudes below nearby bedrock (limestone) highs.

The clay, in turn, is underlain by the Floridan aquifer, a thick sequence of limestone and dolomite formations. In the Lake Magdalene area, the contact between the clay and the uppermost limestone of the Floridan aquifer is gradual. Water in the Floridan aquifer is confined chiefly by the clay stratum and in part by the weathered upper few feet of the limestone.

During the investigation, the potentiometric surface in the Floridan aquifer was 7 to 10 feet lower than the water table in the shallow aquifer, indicating that no direct hydraulic connection exists between the two aquifers. However, because of the vertical hydraulic gradient, some water moves from the shallow aquifer into the Floridan aquifer. The shallow aquifer supplies water to many lakes and ponds, some of which are used as sources of water for agriculture. The Floridan aquifer is extensively developed with many irrigation and domestic wells in the vicinity of the lake. Six wells in St. Petersburg's well field, about 2 miles northwest of the lake beyond the area covered by the aerial photograph, supplied about 18 mgd (million gallons per day) of water for municipal use in 1971. Production from the well field began in 1963.

RAINFALL AND LAKE STAGE FLUCTUATION

Rainfall records are available for three stations in the general vicinity of Lake Magdalene. The record from none of these stations extends through the same time span as the stage record for the lake. The record at Bay Lake extends from 1947 to 1962, and during this period annual rainfall ranged from 36.1 to 81.6 inches and averaged 55.6 inches. Annual rainfall at the Tampa Airport ranged from 28.9 to 76.6 inches and has averaged 51.6 inches from 1951 to 1970. Annual rainfall at Starvation Lake ranged from 44.3 to 57.9 inches, 1966-71. The rainfall records at Bay Lake and Starvation Lake are apparently more representative of rainfall at Lake Magdalene than that at Tampa Airport.

Since May 1946 the stage of Lake Magdalene has fluctuated between 42.5 and 51.6 feet above sea level and has been at or above 48 feet more than 50 percent of the time (fig. 3 and 4). During most years, the stage rises about midyear then declines late in the year, a fluctuation pattern that follows the seasonal rainfall patterns. The rainy season ordinarily is from June through September. In most years, rainfall on the lake surface is slightly greater than evaporation (Visser and Hughes, 1969).

The close relation between lake stage and rainfall is demonstrated on figure 3: lake stage recovered sharply in 1957 during 1 year of above-normal rainfall and also in 1969-70 during 2 years of near-normal rainfall at Starvation Lake. Since 1966, lake levels have been below 48 feet much of the time, and the fall at Starvation Lake and at Tampa has been below normal most of the time. Hence, the lower-than-normal lake stage is consistent with the rainfall deficiency.

Above-normal rainfall has caused the lake stage to rise above an altitude of 50 feet in 5 of the years since 1946 (fig. 3). In these years, the annual rainfall has exceeded 62 inches and has been as much as 81.6 inches. Above-normal rainfall in excess of or nearly equal to 62 inches can be expected to recur in the future. If drainage from new urban areas is diverted to the lake, an annual rainfall somewhat less than 62 inches can be expected to cause the lake level to rise above an altitude of 50 feet. For these reasons, buildings constructed on land whose altitude is below about 51 feet will continue to be subject to flooding.

LAKE INFLOW AND OUTFLOW

Lake Magdalene does not have a large perennial inflow and outflow of surface water. A ditch on the northwest side of the lake drains a field and a small pond into the lake. Another ditch leads westward from the lake to Bay Lake (fig. 2). A board dam in this ditch just upstream from Bay Lake was intended to prevent flow from Lake Magdalene to Bay Lake when the stage of Lake Magdalene declines below an altitude of about 48 feet. This ditch has been partly blocked by slump and by growth of brush between Lake Magdalene and the board dam. During the investigation, in the area of the blockage, water stood about 2½ feet higher in the ditch than in Lake Magdalene, and water in the ditch was flowing into Lake Magdalene.

Inflow to the lake is primarily from the shallow aquifer. Most of this inflow enters the lake from the west and northwest (fig. 2). Some ground-water inflow comes from the isolated water-table mounds east and southeast of the lake. These isolated mounds may be drained after prolonged droughts thereby decreasing ground-water seepage to the lake.

Ditching of the land before 1965 for improved drainage and flood control has lowered the water table between Platt Lake (fig. 2) and the Section 21 well field. The ditch probably has decreased the water-level gradient toward Lake Magdalene, and as a consequence, ground-water inflow to the lake has been decreased somewhat.

Outflow from the lake occurs as lateral flow into the shallow aquifer to the northeast and southeast and as vertical seepage into the Floridan aquifer. Appreciable seepage could occur only if the surficial aquifer and the lake have a better hydraulic connection with the Floridan aquifer beneath the lake than the two aquifers have in adjacent areas. In order for a good connection to exist the clay layer must be either very thin, extensively breached or absent beneath the lake.

The vertical leakage was not sufficient to capture the lateral outflow from the lake near the end of the 1970-71 drought. Therefore, the vertical leakage out of the lake is controlled chiefly by the rate of leakage that occurs as a result of movement of water through the confining layer at the base of the shallow aquifer.

Hydraulic properties of the Floridan aquifer and the confining layer in the vicinity of Lake Magdalene have been interpreted from aquifer tests run at St. Petersburg's Section 21 well field (Bredenhoft and others, 1965, and Stewart, 1968). Drawdown in a well about 500 feet northwest of Lake Magdalene was used in the analysis of one of the tests. Based on the interpretation of the tests, a continuous pumping rate of 18 million gallons per day at the well field could cause less than 1 foot of drawdown of the water table per year 2 miles away from the well field and a small annual decline of lake levels—somewhat less than 1 foot per year. Such a fluctuation would be overshadowed by the much greater fluctuations caused annually by rainfall variations.

The difficulty involved in attempting to separate a presumed minor fluctuation in stage from a major fluctuation is demonstrated by an analysis of segments of the record of stage on figure 3. Lakestage declines of equal duration, of similar magnitude, during the same time of year, and from about the same initial altitude occurred in 1948-49 (before intensive pumping from the Floridan aquifer) and in 1966-67 (after 3 years of intensive pumping from the Floridan at the Section 21 well field, the only place where appreciable development of the Floridan had occurred between the two date spans). In 1948-49 the stage declined 3.5 feet in 8 months; rainfall at Bay Lake was 13.58 inches during the decline. In 1966-67 the stage declined 4.0 feet in 8 months; rainfall at Starvation Lake was 12.43 inches during this time. The additional half a foot decline may be attributed to the smaller rainfall, but the difference is too small to definitely relate to cause.

Further, were the pumping at the Section 21 field to produce a continued drawdown of, say, 0.5 foot per year, the net decline from 1963 to 1970 would be 3.5 feet, yet in 1969-70 the seasonal high stage was about 49.5 feet, within about 1 foot of the all-time month-end high stage of mid-1960.

WATER QUALITY

The Florida Air and Water Pollution Control Commission has set criteria for Class III waters, which are those to be used for recreation purposes, including swimming and water skiing, and for the maintenance of a well-balanced fish and wildlife population. Data from the analyses of water samples of Lake Magdalene (table 1) are within established limits for Class III waters. The data also reveal that the dissolved-mineral content of the water is low and the principal constituents are calcium, sodium, sulfate, and chloride.

Organic carbon is one measure of the organic content of a water. Sparse organic carbon data collected in 1970 and 1971 indicate that the total organic carbon content was fairly low and ranged from 7 to 19 mg/l. Bacteriological samples collected during the summer of 1971 show that the water of Lake Magdalene did not exceed established bacteriological limits for Class III waters (LA, Chatwood, Hillsborough County Health Department, oral commun., 1972).

The nutrients that support growth of aquatic vegetation and other aspects of biological productivity in lakes originate in the surrounding drainage basin and enter the lake chiefly with surface runoff. The enrichment of a lake is known to result in levels of biological productivity that may adversely affect its use. Algal blooms (an overabundance of phytoplankton) are one indication of nutrient enrichment resulting in high biological productivity. Of the essential nutrient elements, carbon, nitrogen, and phosphorus are considered the key elements for phytoplankton production, though the minimum requirements for these and many other nutrients are difficult to determine. In many lakes, when there is an abundance of nitrogen and phosphorus, algal blooms may occur. In Lake Magdalene the concentrations of nitrogen and phosphorus are low, and algal blooms have not been reported.

Samples of sediment were collected from two sites in the lake. (See aerial photograph.) These samples contained dieldrin, chlordane, DDD, and DDE in measurable quantities (table 2). In addition, the analyses revealed the presence of polychlorinated biphenyls (PCB's), a class of environmentally hazardous compounds which have been used for a variety of purposes, such as dielectrics, heat exchangers, and additives to pesticides. Though safe upper limits for all these compounds are not well established for lake sediments, their presence indicates that pesticides have reached the lake in runoff from adjacent land or by atmospheric fallout. These compounds are known to persist in sediments for many years. Consequently, they represent a continuing source to the fauna, and may be concentrated in the systems of living creatures.

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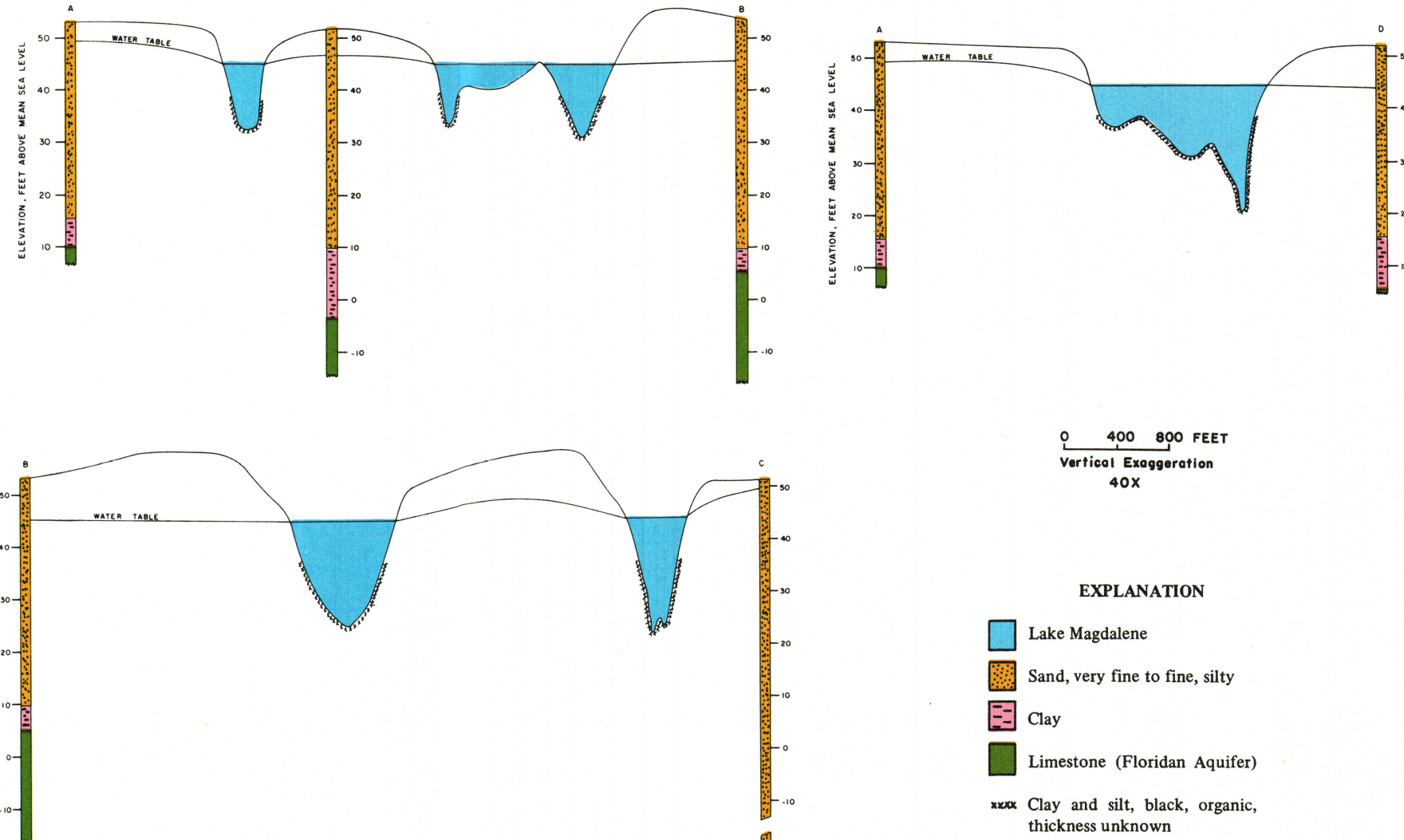


Figure 1. Cross sections showing the relationship of the lake to rock units.

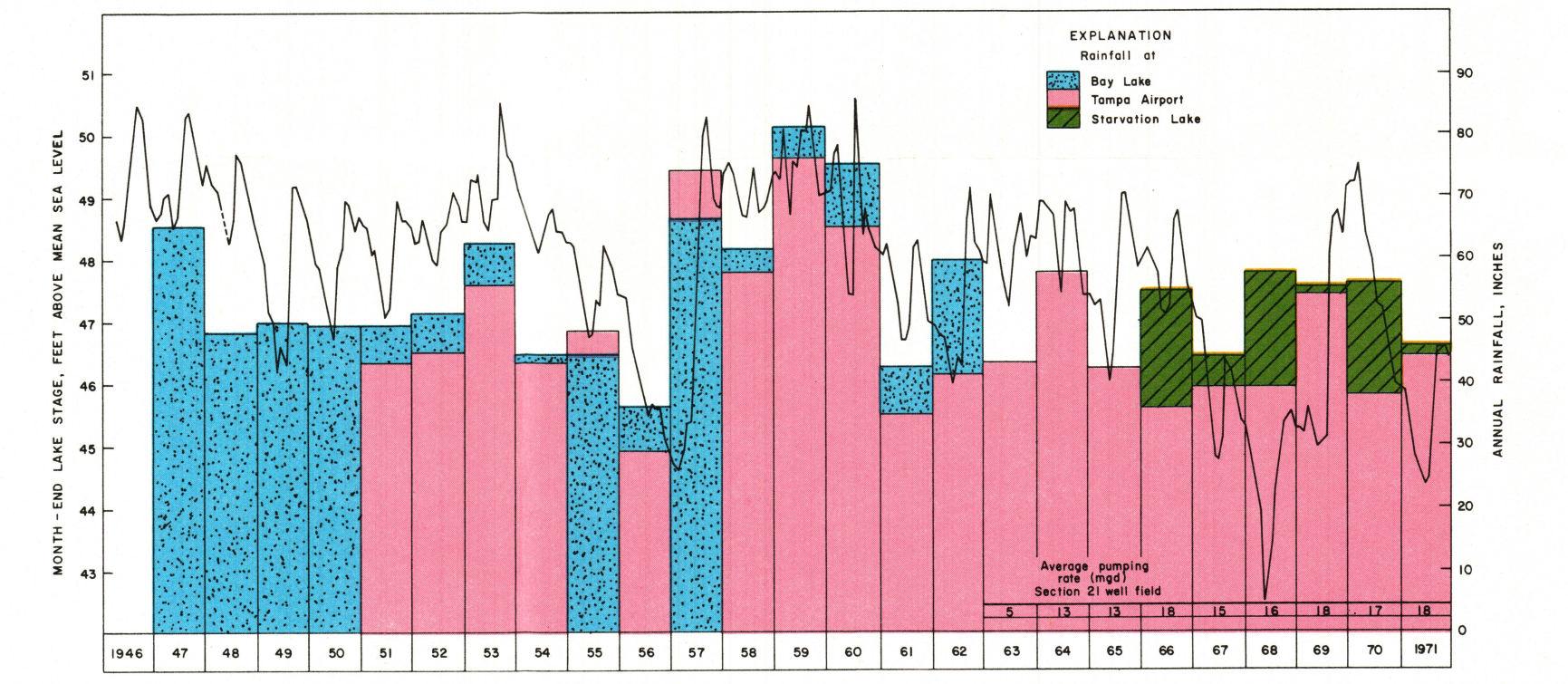


Figure 3. Lake stage compared with rainfall and pumpage from the Section 21 well field. The rain gages at Tampa airport and Starvation Lake near the Section 21 well field, are outside the map area.

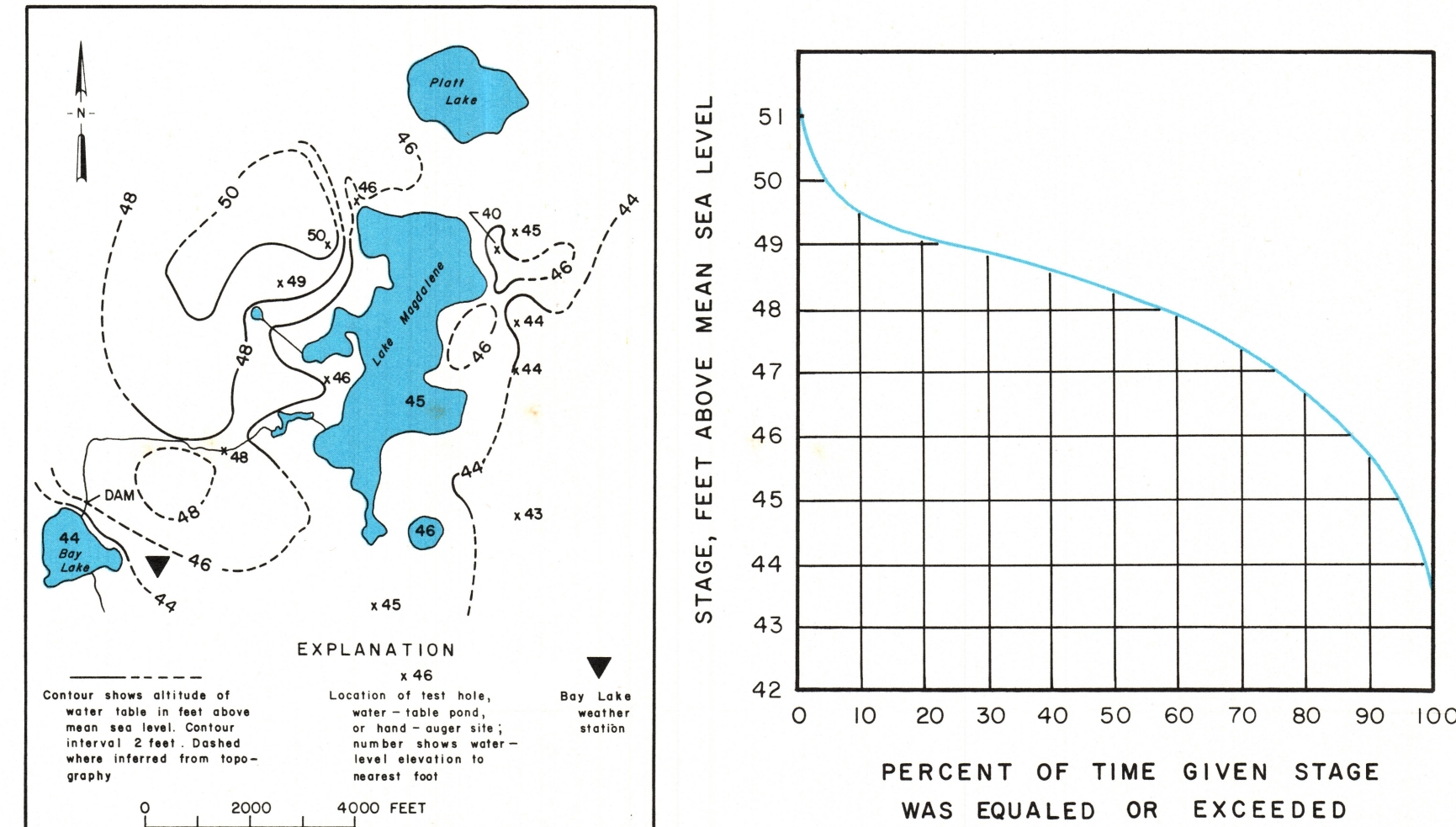


Figure 2. Map showing contours on the water table, August 1-10, 1971.

TABLE 1. CHEMICAL ANALYSES OF WATER IN LAKE MAGDALENE

Water samples taken near staff gage. (See aerial photograph.)		Results in milligrams per liter except as indicated.	
Location	Date	Concentration	Concentration
Site QW 1	5-16-67	45.2	0.0
Site QW 2	5-21-68	43.0	3.8
Site QW 3	5-14-69	44.9	8.3
Site QW 4	5-20-70	48.1	3.6
Site QW 5	10-8-70	46.8	6.2
Site QW 6	4-22-71	44.8	7.0
Site QW 7		44.8	7.0
Site QW 8		44.8	7.0
Site QW 9		44.8	7.0
Site QW 10		44.8	7.0
Site QW 11		44.8	7.0
Site QW 12		44.8	7.0
Site QW 13		44.8	7.0
Site QW 14		44.8	7.0
Site QW 15		44.8	7.0
Site QW 16		44.8	7.0
Site QW 17		44.8	7.0
Site QW 18		44.8	7.0
Site QW 19		44.8	7.0
Site QW 20		44.8	7.0
Site QW 21		44.8	7.0
Site QW 22		44.8	7.0
Site QW 23		44.8	7.0
Site QW 24		44.8	7.0
Site QW 25		44.8	7.0
Site QW 26		44.8	7.0
Site QW 27		44.8	7.0
Site QW 28		44.8	7.0
Site QW 29		44.8	7.0
Site QW 30		44.8	7.0
Site QW 31		44.8	7.0
Site QW 32		44.8	7.0
Site QW 33		44.8	7.0
Site QW 34		44.8	7.0
Site QW 35		44.8	7.0
Site QW 36		44.8	7.0
Site QW 37		44.8	7.0
Site QW 38		44.8	7.0
Site QW 39		44.8	7.0
Site QW 40		44.8	7.0
Site QW 41		44.8	7.0
Site QW 42		44.8	7.0
Site QW 43		44.8	7.0
Site QW 44		44.8	7.0
Site QW 45		44.8	7.0
Site QW 46		44.8	7.0
Site QW 47		44.8	7.0
Site QW 48		44.8	7.0
Site QW 49		44.8	7.0
Site QW 50		44.8	7.0
Site QW 51		44.8	7.0
Site QW 52		44.8	7.0
Site QW 53		44.8	7.0
Site QW 54		44.8	7.0
Site QW 55		44.8	7.0
Site QW 56		44.8	7.0
Site QW 57		44.8	7.0
Site QW 58		44.8	7.0
Site QW 59		44.8	7.0
Site QW 60		44.8	7.0
Site QW 61		44.8	7.0
Site QW 62		44.8	7.0
Site QW 63		44.8	7.0
Site QW 64		44.8	7.0
Site QW 65		44.8	7.0
Site QW 66		44.8	7.0
Site QW 67		44.8	7.0
Site QW 68		44.8	7.0
Site QW 69		44.8	7.0
Site QW 70		44.8	7.0
Site QW 71		44.8	7.0
Site QW 72		44.8	7.0
Site QW 73		44.8	7.0
Site QW 74		44.8	7.0
Site QW 75		44.8	7.0
Site QW 76		44.8	7.0
Site QW 77		44.8	7.0
Site QW 78		44.8	7.0
Site QW 79		44.8	7.0
Site QW 80		44.8	7.0
Site QW 81		44.8	7.0
Site QW 82		44.8	7.0
Site QW 83		44.8	7.0
Site QW 84		44.8	7.0
Site QW 85		44.8	7.0
Site QW 86		44.8	7.0
Site QW 87		44.8	7.0
Site QW 88		44.8	7.0
Site QW 89		44.8	7.0
Site QW 90		44.8	7.0
Site QW 91		44.8	7.0
Site QW 92		44.8	7.0
Site QW 93		44.8	7.0
Site QW 94		44.8	7.0
Site QW 95		44.8	7.0
Site QW 96		44.8	7.0
Site QW 97		44.8	7.0
Site QW 98		44.8	7.0
Site QW 99		44.8	7.0
Site QW 100		44.8	7.0

TABLE 2. PESTICIDE AND PCB ANALYSES, AUGUST 9, 1971

Bottom Sediments										
Results in micrograms per kilogram										
Location (aerial photo)	Adrin	DDD	DDE	DDT	Dieldrin	Endrin	Hepachlor	Lindane	Chlordane estimate	PCB estimate
Site QW 1	0.0	7.9	16	0.0	0.8	0.0	0.0	0.0	80	20
Site QW 2	0.0	12	9.7	0.0	0.0	0.0	0.0	0.0	20	10