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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HYDROLOGIC CONDITIONS IN THE KLATT BOG AREA, ANCHORAGE, ALASKA

By Roy L. Glass

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DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
Water Resources Division
4230 University Drive, Suite 201
Anchorage, Alaska 99508-4664

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CONVERSION TABLE

For readers who may prefer to use metric (International System) units rather than customary U.S. units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.589	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
degree Fahrenheit (°F)	(°F-32)/1.8	degree Celsius (°C)

Other abbreviations in this report are:

mg/L, milligram per liter

µg/L, microgram per liter

µS/cm, microsiemens per centimeter at 25 °C

HYDROLOGIC CONDITIONS IN THE KLATT BOG AREA, ANCHORAGE, ALASKA

by Roy L. Glass

ABSTRACT

Klatt Bog is a 2.3 square-mile wetland in Anchorage, Alaska which provides habitat for many wildlife species but also offers potential sites for residential, commercial, and agricultural developments. Precipitation, the main source of water for the area, averages 15 inches per year; during the 1983 study period, precipitation was 12.16 inches. Estimates of evapotranspiration, considered to be the major component of water outflow, range from 10 to 20 inches. Surface runoff and ground-water outflow during 1983 are estimated to be 2.8 and less than 0.2 inches, respectively. During summer, most of the runoff is derived from ground-water discharge near the upgradient eastern edge of the wetland.

The wetland's aquifer system is composed of fibrous peat which overlies a poorly permeable layer of silt and clay. The aquifer is recharged by infiltration of precipitation and inflow of ground water from upland areas east of the wetland. During 1983 the water table was at or within 3 feet of land surface in most areas and its seasonal fluctuation was less than 2 feet.

Water collected from four shallow observation wells, two ponds, and two sites on a stream had concentrations of dissolved solids that were less than 500 milligrams per liter. Ground-water samples had concentrations of dissolved iron ranging from 2,300 to 6,100 micrograms per liter.

INTRODUCTION

The demand for land for residential, commercial, and recreational uses in Anchorage, Alaska has increased as a result of rapid population growth. As a consequence, increasingly greater parts of Anchorage's wetlands -- the only remaining large "undeveloped" areas -- are being drained and filled. Klatt Bog (fig. 1), a 2.3-mi^2 low-shrub wetland, is an important wildlife habitat and open-space area (Municipality of Anchorage, 1982; Hogan and Tande, 1982), but it also offers potential development sites.

As part of a cooperative agreement with the Municipality of Anchorage, the U.S. Geological Survey did a hydrologic study during 1983 to determine the movement and quality of water in the wetland. The area studied was restricted to drainage areas above five surface-water outlet sites; it is approximately 3.8 mi^2 in area and includes about 1.8 mi^2 (78 percent) of Klatt Bog. The information obtained will be used in planning for and making decisions concerning proposed residential and commercial developments, and other changes in the natural landscape.

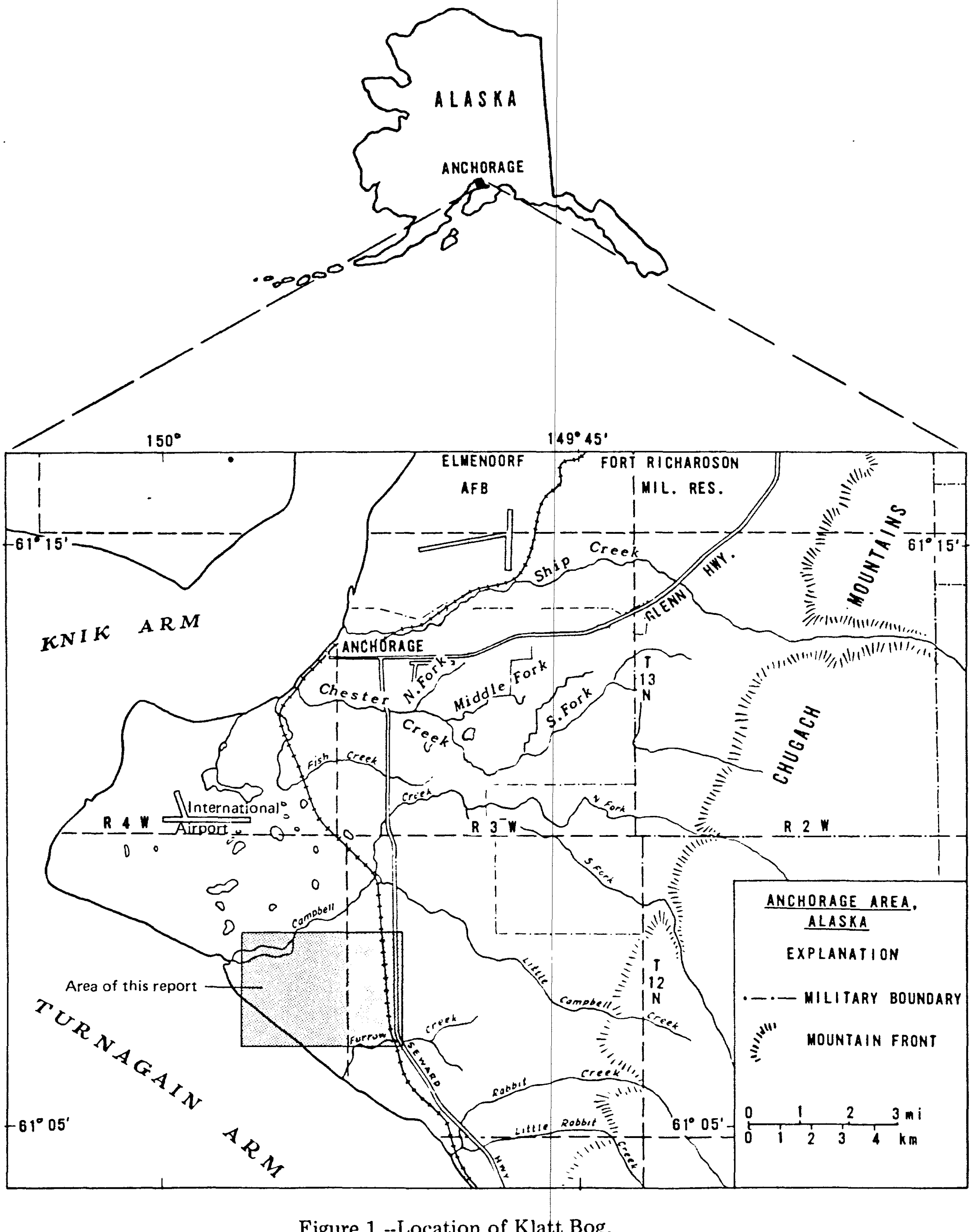
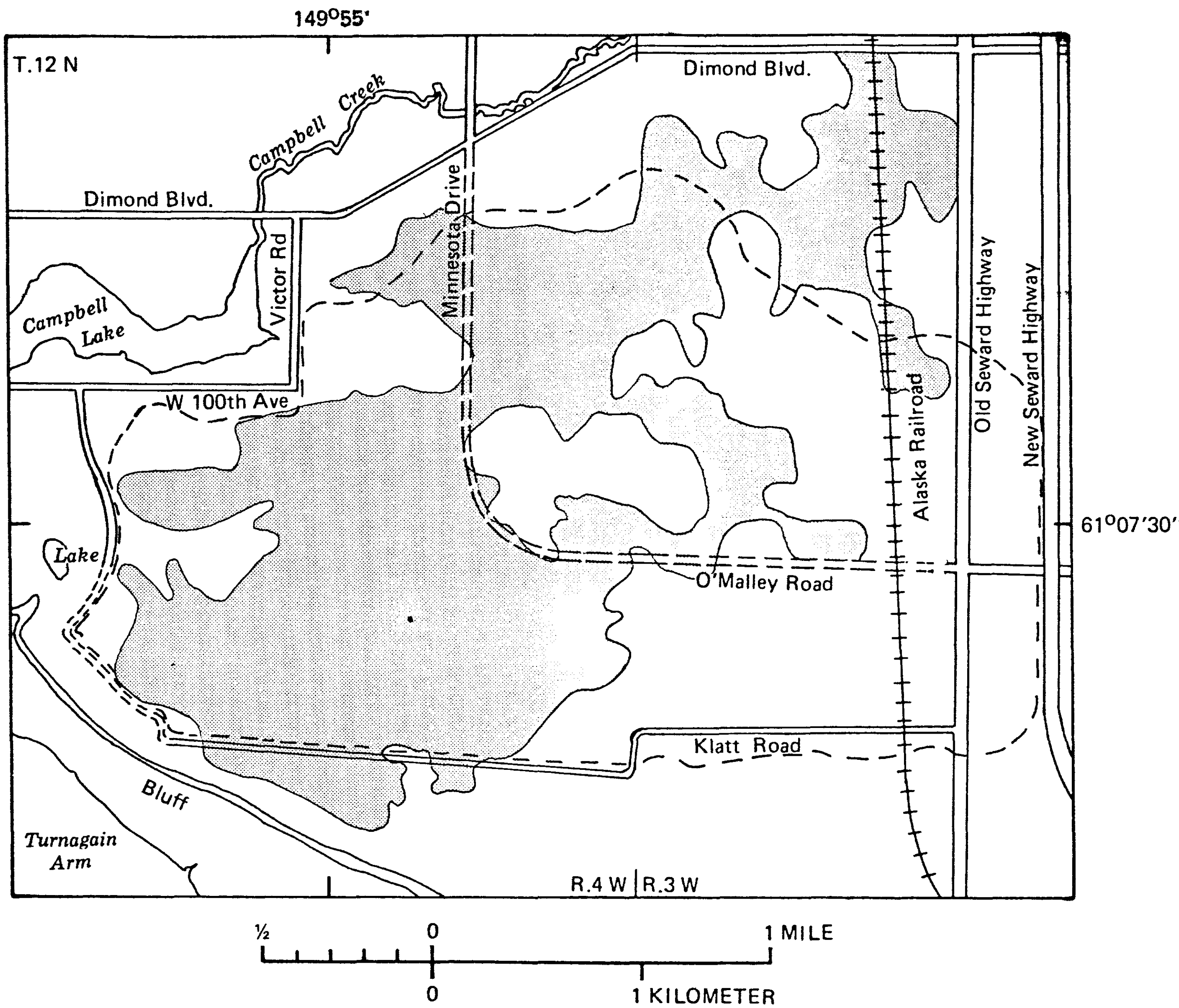


Figure 1.--Location of Klatt Bog.



EXPLANATION

Klatt Bog

Study area boundary

Note: Minnesota Drive and O'Malley Road as shown, were built after the study period.

Figure 1.--Continued.

Much of Klatt Bog is no longer in its natural condition. Extensive reclamation for residential, commercial, and agricultural developments has taken place along the margin of the wetland, and developments near the center of the wetland are proposed. Extensions of major roadways, Minnesota Drive and O'Malley Road, have been built through the wetland.

HYDROLOGIC CYCLE

The chain of events describing the constant circulatory movement of water on earth is called the hydrologic cycle. Water that has evaporated from oceans and from land is lifted and carried in the atmosphere until it falls to earth. After precipitation falls on the earth's surface, part is returned to the atmosphere by evaporation, part runs into streams, ponds, and lakes, and the remainder infiltrates into the ground. Some of the water that enters the ground is held by capillary action and evaporates or is used by plants. The water in excess of the near-surface demand of soil and plants infiltrates downward to the water table.

Ground water moves under the influence of gravity and water-level differences from areas of recharge to areas of discharge. It moves through small openings among grains of soil and rock. This movement is very slow and may be only a few feet per year. Within the study area, ground water may (1) seep into stream and drainage channels and flow out of the area as surface water, (2) seep into a pond where it will evaporate or return to the ground-water system, (3) flow out of the area as ground-water flow, or (4) be absorbed by plant roots and evaporated to the atmosphere (evapotranspiration).

PRECIPITATION AND EVAPOTRANSPIRATION

Precipitation is the main source of water for Klatt Bog. It is measured at International Airport, about 5 mi northwest of the bog, and is reported monthly by National Oceanic and Atmospheric Administration (1943 to 1984). Annual precipitation averages about 15 in., but ranges from 8 to 21 in. About half the precipitation occurs as rain, generally from May through September, and the rest as snow and rain from October through April. Precipitation was 12.16 in. during the 1983 study and was 17.68 in. during 1972.

Estimates of evapotranspiration, which is considered to be the largest component of water outflow, range from 10 to 20 in. (Zenone, 1976). Evapotranspiration data are not available for Klatt Bog or Anchorage, but the pattern of evapotranspiration is expected to be similar to pan evaporation measured at Matanuska Agricultural Experiment Station, about 40 mi northeast of study area. Pan evaporation is measured only during summer and the data are reported by National Oceanic and Atmospheric Administration (1950 to 1984). Pan evaporation during May through September averages about 18 in. It is greatest during May and June (about 4 in. for each month) and decreases through the summer. The temperature at Klatt Bog is slightly cooler than at Matanuska Agricultural Experiment Station, thus evaporation and evapotranspiration are expected to be slightly less at Klatt Bog than at Matanuska Agricultural Experiment Station.

GEOLOGIC SETTING

Klatt Bog lies near the intersection of glacier-carved valleys, Turnagain and Knik Arms. The area has repeatedly been filled with materials deposited by glaciers and by water, resulting in locally highly variable geologic conditions. Figure 2 shows the surface distribution of geologic deposits; figure 3 shows the general vertical arrangement of these deposits. Deposits that have similar characteristics are combined into single units. However, because adjacent units grade into one another and subsurface data are sparse in this relatively undeveloped area, the contacts shown in figures 2 and 3 are only approximate.

Peat in Klatt Bog is composed chiefly of coarse to decomposed sphagnum moss and sedge fibers; woody materials and thin lenses of clay and silt are also present in the peat. Data from 20 shallow wells drilled for this study (fig. 4 and table 1) and from numerous shallow test holes along the alignments of extensions of Minnesota Drive and O'Malley Road and in proposed subdivisions indicate that peat in Klatt Bog is generally more than 5 ft thick. The maximum depth of peat found was 23 ft, in a test hole drilled approximately 100 ft northwest of well 4. The lateral extent of peat is shown in figure 2 by an overprint pattern.

Alluvium (map unit a, fig. 2) is present at the surface near the wetland. It consists chiefly of sand and gravel that were deposited by flowing water in streams and by glaciers.

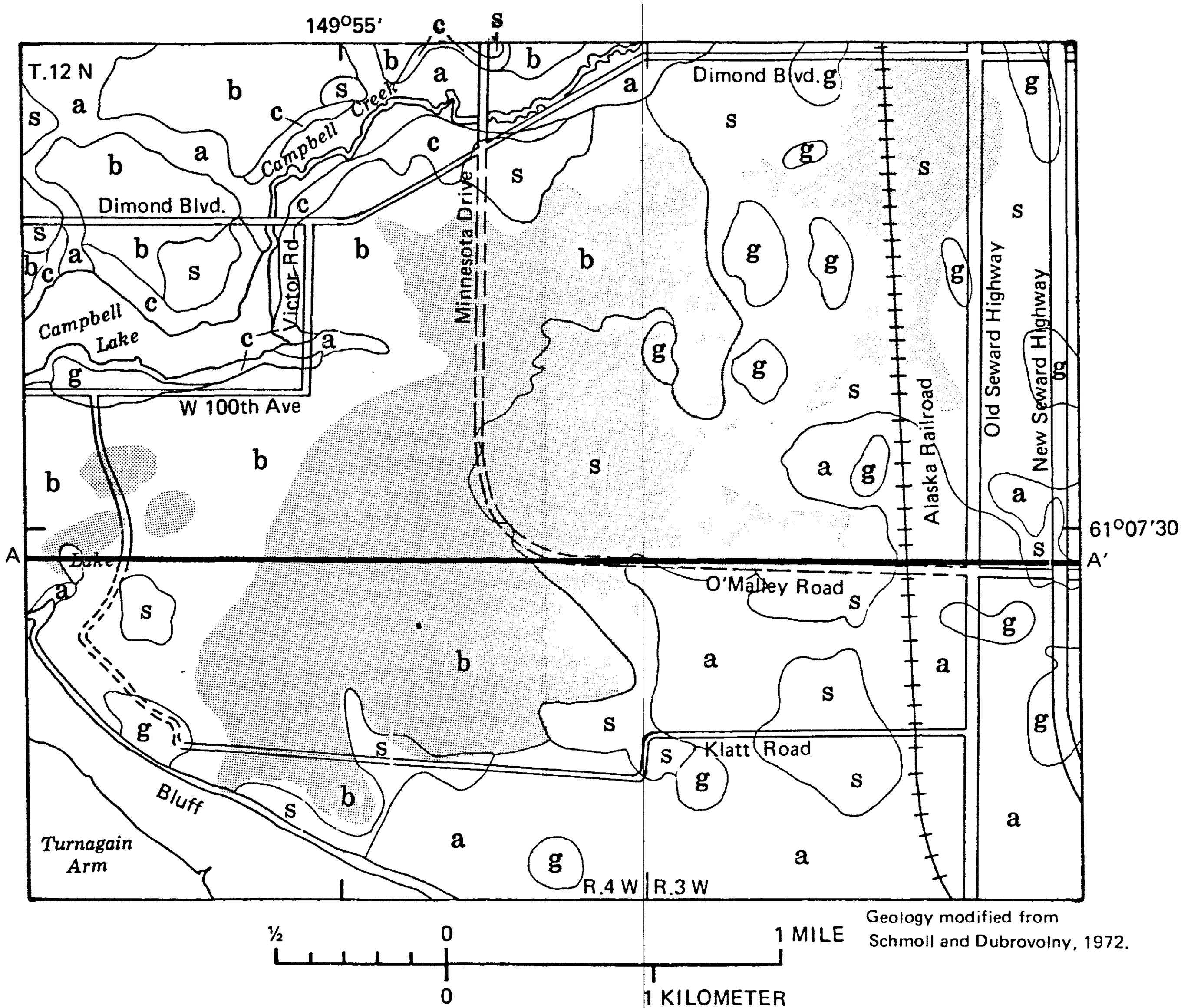
A layer of sand underlies peat in the eastern part of the wetland and occurs at the surface east of the wetland. The sand is generally 20 ft or less in thickness and is complexly interrelated and underlain by a unit composed chiefly of silt and clay (Schmoll and Dobrovolny, 1972), which is known locally as the Bootlegger Cove Formation of Pleistocene age.

The Bootlegger Cove Formation (map unit b, fig. 2) directly underlies peat in the western half of the wetland and occurs at the surface west of the wetland. It is about 100 ft thick near the western edge of the wetland (Ulery and Updike, 1983, pl. 3), but its thickness and extent are poorly defined in other areas. The eastern margin of this unit may merge at depth with material mapped as unit g (Schmoll and Dobrovolny, 1972).

Underlying the Bootlegger Cove Formation and occurring at the surface in hills in and near the wetland are deposits that consist of well-sorted to poorly sorted clay, silt, sand, and gravel (map unit g, fig. 2). The deposits are chiefly of glacial origin but also may contain materials of marine, alluvial, and lacustrine origin (Schmoll and Dobrovolny, 1972). These deposits are several hundred feet thick.

GROUND WATER

Ground water is present in all geologic units. In peat, sand, alluvium, and near-surface glacial deposits, the water is unconfined; in glacial deposits that underlie a poorly permeable layer of silt and clay, it is confined or partially confined.



EXPLANATION

COARSE-GRAINED DEPOSITS

- **a** Alluvium. Chiefly sand and gravel.
- **s** Sand. Well bedded and well sorted.

FINE-GRAINED DEPOSITS

- Peat. Consists chiefly of coarse to decomposed sphagnum moss and sedge fibers but also contains wood and thin lenses of clay, silt, and sand.
- **b** Bootlegger Cove Formation. Chiefly Pleistocene clay and silt.

MIXED COARSE- AND FINE-GRAINED DEPOSITS

- **g** Well-mixed to well-sorted deposits of clay, silt, sand, and gravel. Chiefly of glacial origin, but may also contain materials of marine, alluvial, and lacustrine origin.
- **c** Colluvium (slope deposits). Chiefly clay, silt, and sand. Materials reflect the composition of upslope deposits.

A├───┤A′ Line of cross section (see figure 3)

NOTE: Minnesota Drive and O'Malley Road as shown, were built after the study period.

Figure 2.--Generalized surficial geology of the Klatt Bog area.

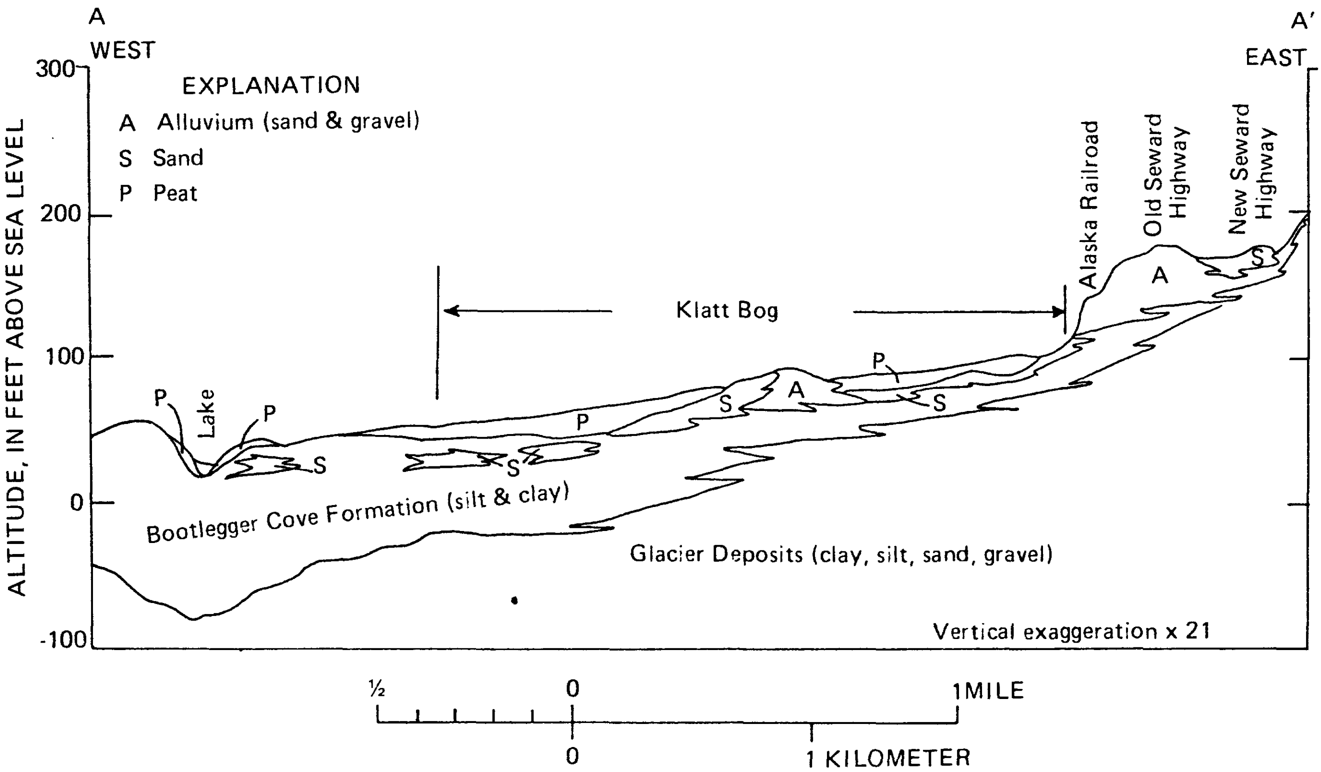


Figure 3.--Generalized geologic section through the Klatt Bog area. (Line of section A-A' in figure 2.)

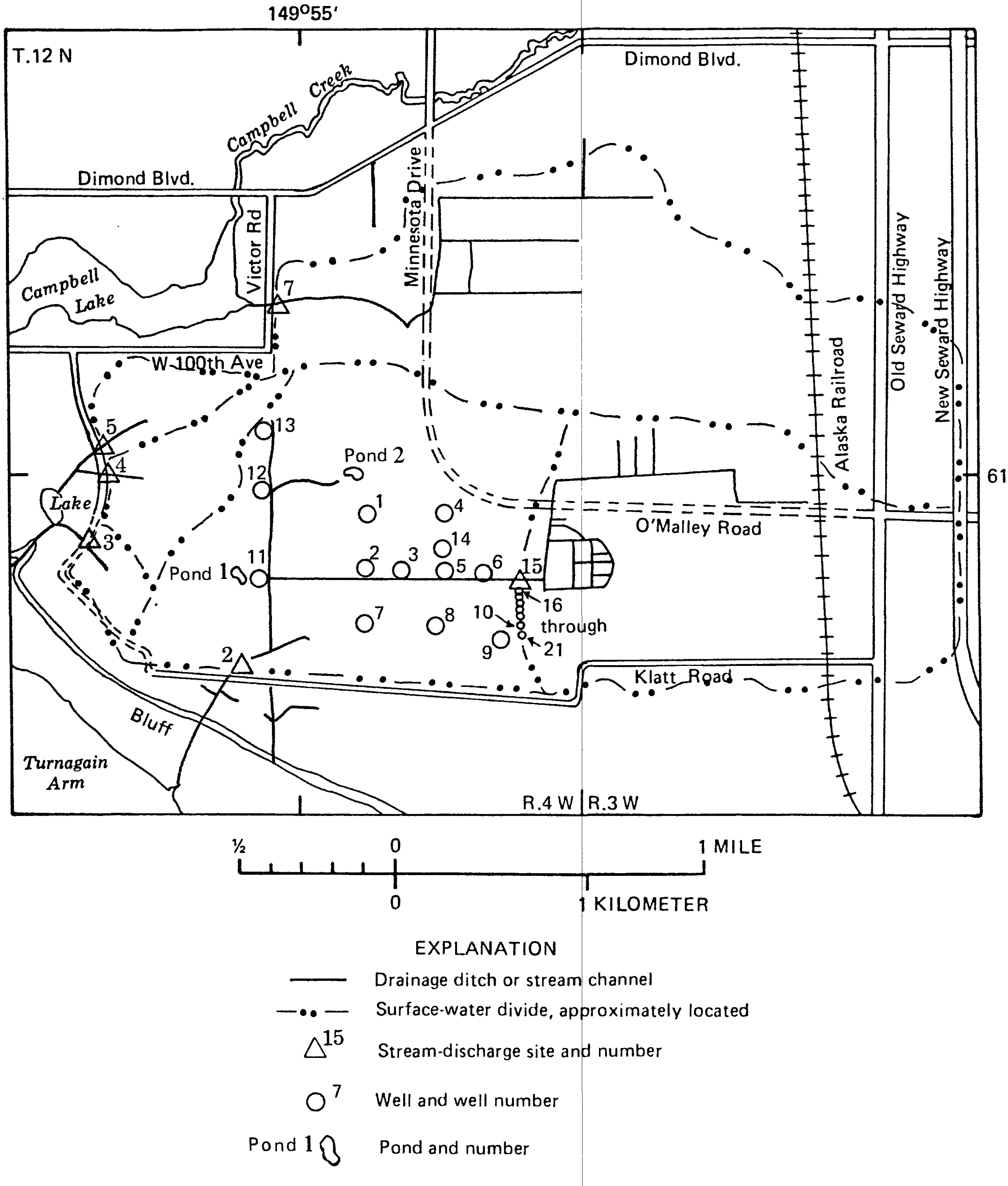


Figure 4.--Data-collection sites.

Table 1. -- Description and lithologic logs of wells

Well number (fig. 4)	Depth drilled (feet)	Depth of perforations (feet below land surface)	Lithology
1	30	2-8	0-15 ft, peat; 15-24 ft, silty sand; 24-30 ft, sandy silt and clay
2	30	2-9	0-15 ft, peat; 15-30 ft, sandy silt and clay
3	21	2-16	0-14 ft, peat; 14-21 ft, clay and silt
4	18	2-8	0-12 ft, peat; 12-14 ft, peat and silt; 14-15 ft, peat and clayey silt; 15-18 ft, clayey silt
5	15	2-9	0-12 ft, peat; 12-13 ft, peat and clayey silt; 13-14 ft, clayey silt; 14-15 ft, clay
6	21	2-9	0-15 ft, peat; 15-17 ft, peat and silt; 17-18 ft, silty clay; 18-21 ft, clay
7	15	2-9	0-11 ft, peat; 11-12 ft, silt; 12-15 ft, clay
8	15	2-9	0-10 ft, peat; 10-11 ft, silt; 11-15 ft, clay
9	15	2-10	0-6 ft, peat; 6-12 ft, silt; 12-15 ft, clay
10	15	2-9	0-13 ft, peat; 13-15 ft, clay
11	19	2-9	0-15 ft, peat; 15-19 ft, sand
12	30	2-9	0-10 ft, peat; 10-22 ft, silt; 22-30 ft, sand
13	30	2-9	0-7 ft, peat; 7-10 ft, clayey silt; 10-24 ft, coarse sand and silt; 24-30 ft, fine sand and silt
14	18	2-18	0-15 ft, peat; 15-18 ft, silt
16	9.2	7.2-9.2	0-9.2 ft, peat
17	7.7	5.7-7.7	0-7.7 ft, peat
18	7.4	5.4-7.4	0-7.4 ft, peat
19	8.7	6.7-8.7	0-8.7 ft, peat
20	6.5	4.5-6.5	0-6.5 ft, peat
21	4.4	2.4-4.4	0-4.4 ft, peat

The volume of water in the wetland's peat deposits is constantly changing. These deposits periodically gain water by infiltration of precipitation, snowmelt, and water from ponds, and by inflow of ground water from upland areas east of the wetland. Water is lost from the system by evapotranspiration, by seepage into stream or drainage channels, and by ground-water outflow. Following the spring 1983 snowmelt period, water levels in most wells were less than 1 ft below land surface, indicating that the volume of water stored in peat was near maximum capacity. Water levels, and therefore the volume of ground water in storage, declined in June and July when precipitation was low and evaporation (as indicated by measurements at Matanuska Agricultural Experiment Station) was high (fig. 5). The average water-level decline measured in 11 wells between June 2 and July 25 was 0.55 ft. Precipitation was high relative to evaporation in August and September, and water levels rose. Water levels in wells distant from drainage ditches (such as well 4) were nearer to land surface and had smaller seasonal fluctuations than those in wells near drainage ditches (such as wells 2 and 10). The greatest depth to water measured in the wetland was 4.08 ft below land surface, in a well 4.1 ft from a drainage ditch (well 16, fig. 4). The water levels in most wells were within 3 ft of land surface during 1983 and were at similar altitudes at snowmelt and freeze-up.

Measurements of water levels in 12 shallow wells and altitudes of land surface where water-level data were sparse were used to determine the water table (the surface of water in an unconfined aquifer) and the direction of ground-water movement (fig. 6). Ground water within the wetland generally flowed from east to west. Near drainage ditches, however, water flowed towards the ditches.

In order to observe the influence of a drainage ditch on ground-water levels, seven shallow wells (wells 10 and 16 through 21, fig. 4) were installed along a line perpendicular to a ditch. The ditch is approximately 6 ft deep and is dug through fibrous peat. The peat is about 12 to 17 ft thick and is underlain by silt and clay. Water flowing in the ditch was about 5 ft below land surface and was always lower than adjacent ground-water levels. In late summer 1983, the ditch influenced water levels over the entire 164-ft line of wells but its effect was greatly reduced at 131 ft and beyond. The level of ground water 4.1 ft from the ditch (well 16) was 0.9 ft above the water level in the drainage ditch, whereas the level of ground water 131 ft from the ditch (well 10) was 4.8 ft above the water level in the drainage ditch (fig. 7). Even though this single drainage ditch did not greatly lower areal ground-water levels, a network of closely spaced (100 ft or less) drainage ditches or drains could lower water levels within the ditched area, especially if the drains are placed in permeable materials that directly underlie peat, such as the sand deposits in the eastern half of the wetland.

Unconfined ground water flows out of the area to the west and southwest through peat, but the volume of this outflow is small compared to evapotranspiration and surface runoff. Assuming high values for hydraulic conductivity (10 ft/d), hydraulic gradient (20 ft/mi), and saturated cross-sectional area (3 mi wide and 10 ft thick), ground-water outflow is estimated to be about 50 acre-ft/yr or 0.2 in/yr over the study area.

The volume of water flowing vertically between the bog's unconfined peat aquifer and deep confined glacial-deposit aquifers is considered small compared to the volume entering and leaving the bog as precipitation and evapotranspiration. Any

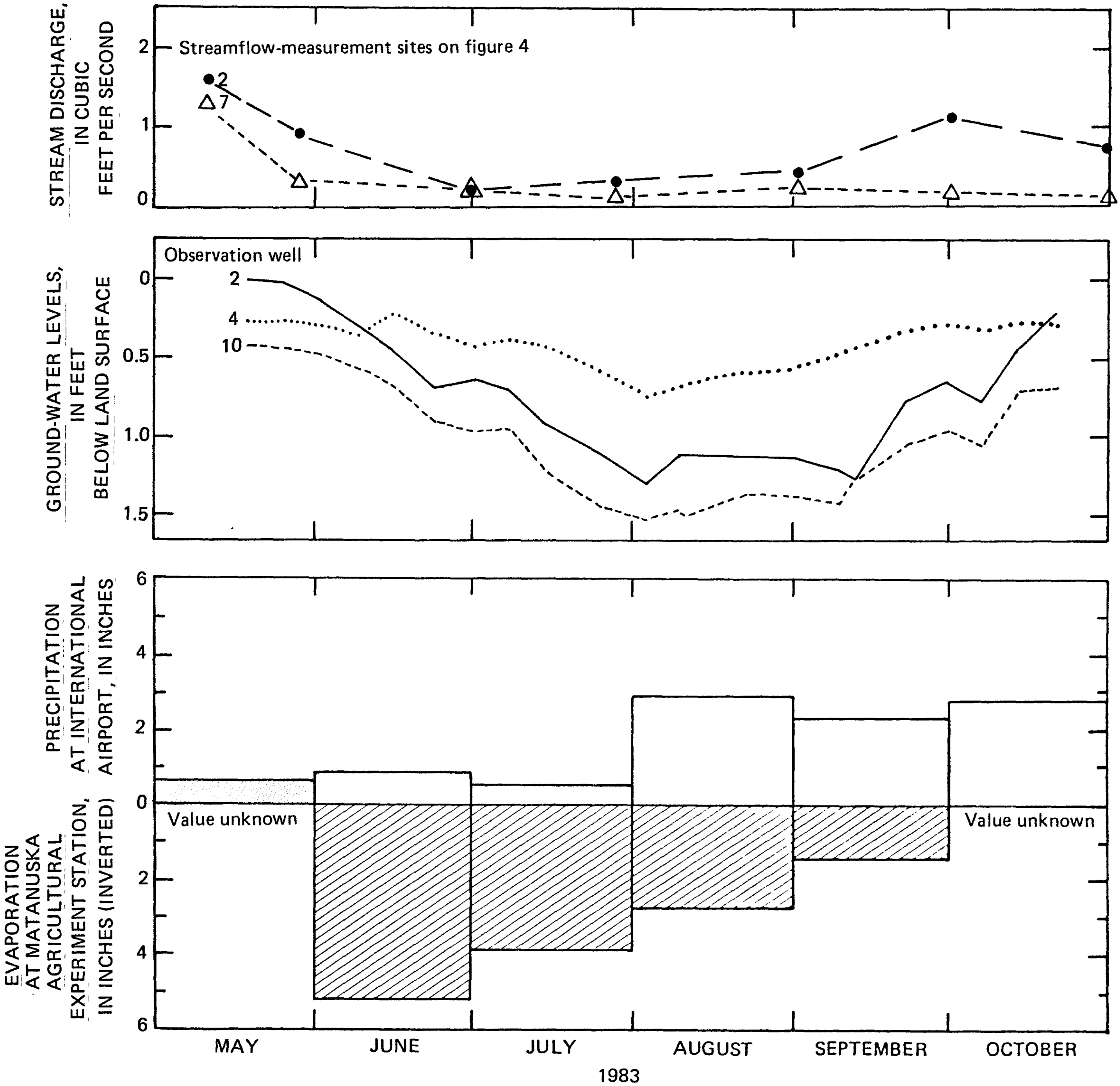
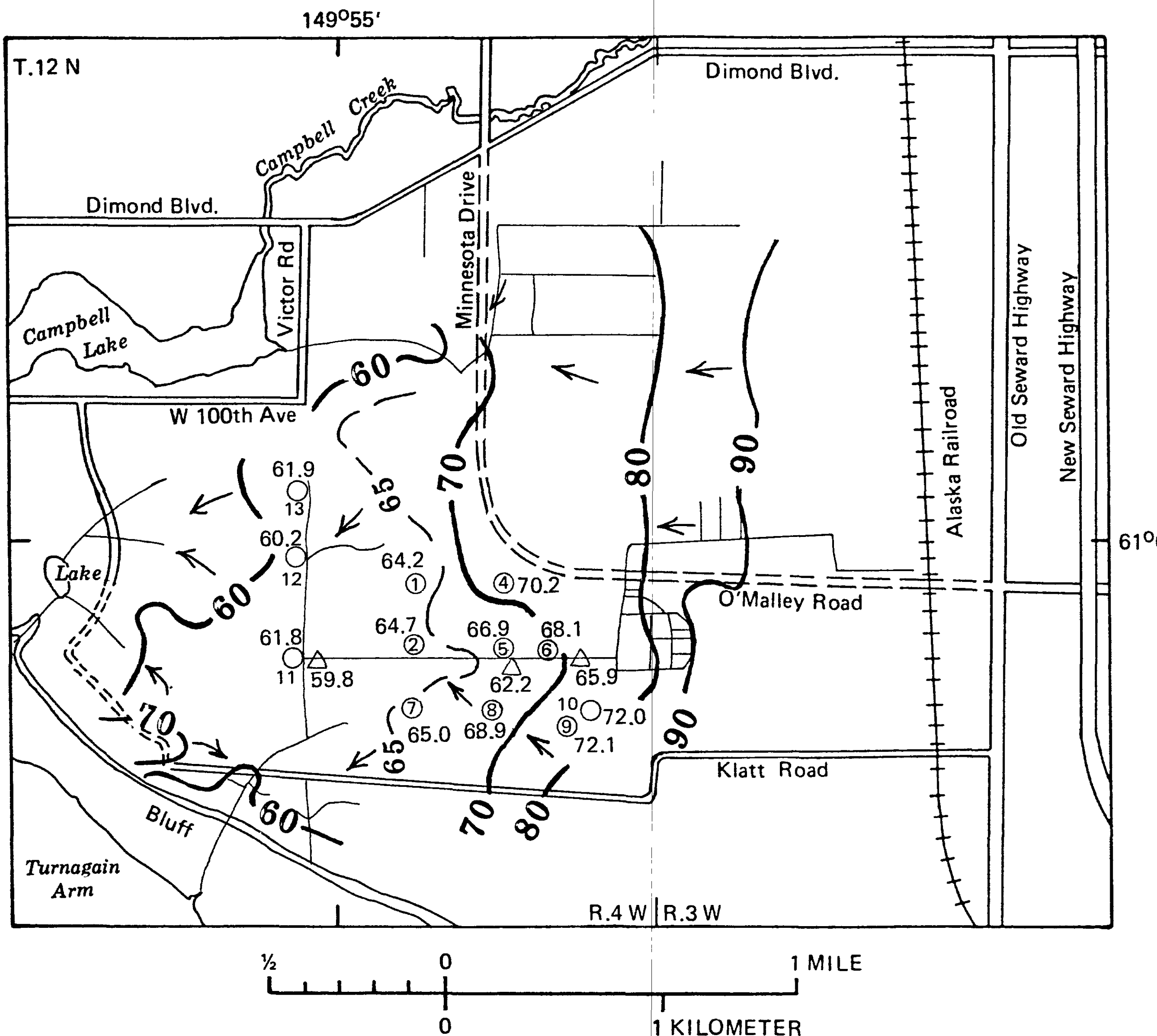


Figure 5.--Relation of stream discharge, ground-water levels, precipitation, and evaporation.



EXPLANATION

———	Drainage ditch or stream channel
←—	Generalized direction of ground-water movement
—60—	Water-table contour, approximately located
61.8 ①	Water level in well (and well number), in feet above sea level
59.8 △	Water level in drainage ditch, in feet above sea level

Figure 6.--Water table and inferred directions of ground-water movement, May 1983.

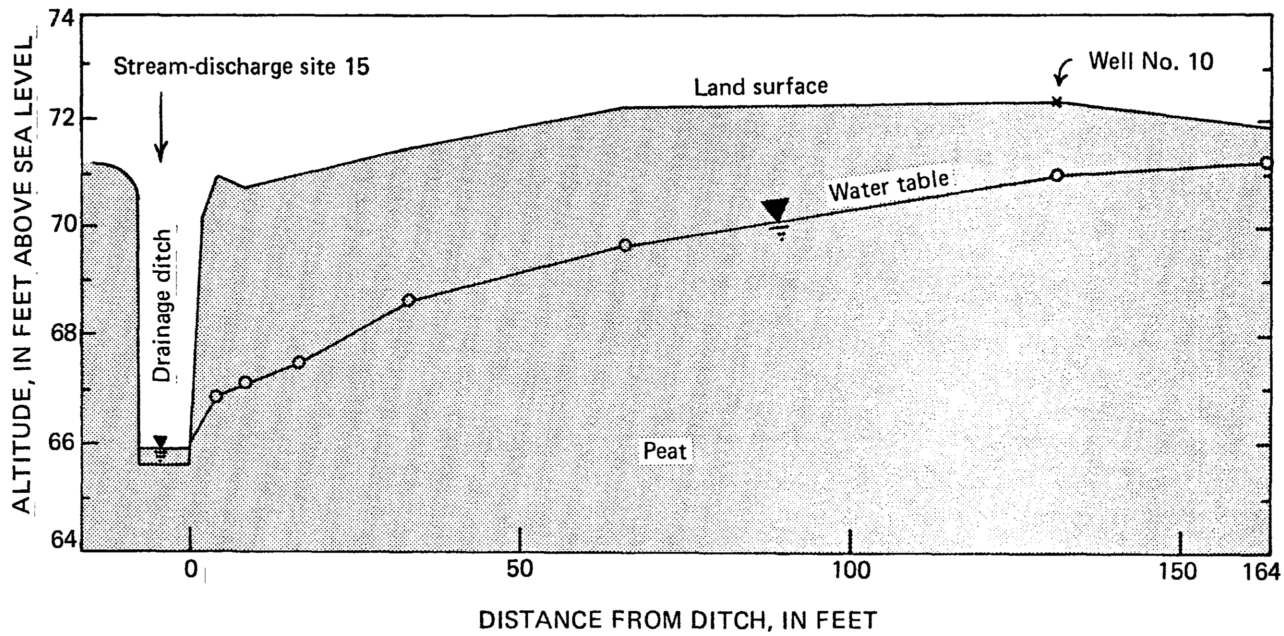


Figure 7.--Ground-water levels near a drainage ditch, September 1, 1983.

significant influx of ground water to the bog from underlying aquifers would result in greater surface outflow from the bog than what was measured. During summer, low streamflows were observed at all outflow sites. Also, no appreciable gains in streamflow were observed between surface-water sites 2 and 15 (table 2 and fig. 4), a reach of about 1.2 mi in the southern part of the wetland.

SURFACE WATER

Fourteen streams or ditches drain Klatt Bog. Drainage within the wetland is poor and drainage boundaries are not known precisely. Stream discharges are small and are sustained throughout most of the year by ground-water seepage. During dry periods in summer, little or no flow is present in streams that have small drainage areas. During cold periods in winter, most streams and drainage channels are frozen. High flows derived from snowmelt occur each spring and high flows derived from rains may occur during summer and autumn.

In 1983, stream discharges were measured intermittently at five outlet sites (sites 2 through 5 and 7, fig. 4) and at one site within the wetland (site 15). Streamflows were highest during the spring snowmelt period and gradually decreased until midsummer (fig. 5 and table 2). Rains in late summer and autumn caused only a slight increase in streamflow at most sites.

The drainage ditch on which site 15 (fig. 4) is located drains an estimated 1.1 mi^2, most of which has been developed for residential, industrial, and agricultural uses. Flow in this ditch during summer is intermittently affected by industrial and agricultural water uses. A sand and gravel company uses water from the ditch and from two shallow (15 and 18 ft deep) wells to replenish the water supply of a closed-circuit gravel-washing operation. The quantity of water used ranges from zero to about 10,000 gal/d. Water is also intermittently pumped or diverted to irrigate about 100 acres of trees, shrubs, and sod.

Table 2.--Stream-discharge measurements

[Discharge in cubic feet per second]

Site number (fig. 4)	Approximate drainage area (square miles)	Approximate wetland area within drainage (square miles)	1983 January 19	May 3	May 27	June 30	July 28	September 1	September 30	October 31
2	2.1	1.10	0.00	1.8	0.89	0.22	0.25	0.44	1.1	0.68
3	.1	.04	.00	.06	.05	.00	.00	< .01	.04	< .01
4	.2	.11	.00	.61	.11	.05	.02	.01	.13	.08
5	.1	.03	.00	.15	.02	.00	.00	.23	.03	.01 estimated
7	1.3	.56	.00	1.3	.34	.18	.09	.15	.12	.08
15	1.1	.18	--	--	.61	.19	.25	.30	.94	.91

During summer, discharges at site 15 were similar to discharges at site 2, 2.1 mi downstream, indicating no appreciable loss or gain of water from a 1-mi^2 wetland area between the sites (table 2). This suggests that the main source of water flowing out of the wetland to the southwest is derived from ground-water seepage near the eastern edge of Klatt Bog and that ground-water seepage from the southern half of the bog is not a significant part of streamflow under low-flow conditions. The greater discharge at site 15 than at the downstream site on October 31 may have been due to ice forming in the stream channel. Water levels in the stream channel between sites 2 and 15 were always lower than nearby ground-water levels during 1983.

The ditch on which site 7 is located drains an area of approximately 1.3 mi^2 in the northern part of the wetland. This area contains residential developments and a wetland that has an extensive network of drainage ditches. Discharges measured at site 7 during summer were as low as 0.09 ft^3/s.

Total instantaneous discharges at the five outlet sites were correlated with mean-daily discharges at nearby gaging stations. Discharge values from Little Rabbit Creek (see fig. 1) correlated best, but the coefficient of determination was only 0.61. Using Little Rabbit Creek as an index station and methods developed by Riggs (1969), mean discharges from Klatt Bog were calculated for periods between measurements. Total runoff from the wetland in 1983 was subsequently calculated to be 2.8 in.

QUALITY OF WATER

Water samples for chemical analysis were collected from four wells, two ponds, and two sites along a stream. All samples had dissolved-solids concentrations of less than 500 mg/L (table 3); however, all were yellowish brown in color and some had concentrations of dissolved iron and manganese higher than those recommended for domestic uses (300 µg/L and 200 µg/L, respectively) by the U.S. Environmental Protection Agency (1977). High concentrations of iron and manganese in ground water are common in Anchorage. Donaldson and others (1975, tables 3a and 4a) show that numerous wells in Anchorage yield water containing greater than 1,000 µg/L of dissolved iron or 200 µg/L of dissolved manganese.

Table 3.--Chemical analyses of water at selected sites

Site number (fig. 4)	Date of sample, 1983	Specific conductance (µS/cm)	pH (standard units)	Temperature (°C)	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, lab (mg/L as $CaCO_3$)
Well										
2	9/12	150	6.2	6.0	64	16	5.8	3.5	2.6	62
4	9/8	600	6.5	7.0	229	72	12	14	.6	281
10	9/8	190	6.2	4.5	81	22	6.3	6.5	.5	87
11	9/9	190	6.0	7.5	75	20	6.1	5.3	.9	80
Stream-discharge site										
2	7/28	320	6.8	21.0	174	50	12	6.2	1.5	152
15	7/28	300	7.0	13.0	165	48	11	6.0	1.5	149
Pond										
1	9/9	140	6.9	14.0	58	14	5.6	7.5	1.1	56
2	9/12	70	6.9	11.5	35	8.8	3.2	4.0	1.0	26

Site number (fig. 4)	Date of sample, 1983	Sulfate dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, NO2+NO3 dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)
Well										
2	9/12	6.9	3.0	<0.1	11	89	<0.10	0.020	2300	1100
4	9/8	10	2.6	<.1	30	313	<.10	.020	3300	320
10	9/8	13	4.4	<.1	22	133	<.10	.020	6100	300
11	9/9	12	9.3	<.1	18	122	<.10	.020	2600	200
Stream-discharge site										
2	7/28	15	11	.1	17	205	.49	.020	320	210
15	7/28	16	11	.1	15	198	.40	.020	260	93
Pond										
1	9/9	5.8	10	<.1	1.1	79	<.10	.020	340	18
2	9/12	5.5	5.1	<.1	.2	44	<.10	.020	190	9

Table 4. -- Field measurements of water-quality properties at stream-discharge sites

Site number (fig. 4)	Date 1983	Specific conductance (µS/cm)	pH (units)	Temperature (°C)
2	5/27	280	7.2	11.0
	6/30	300	6.8	20.0
	7/28	320	6.8	21.0
	9/1	300	--	10.0
	9/30	290	7.2	8.0
	10/31	240	7.2	--
3	5/27	240	6.9	7.5
	9/30	240	6.8	7.0
4	5/27	180	7.3	3.5
	6/30	190	6.8	10.5
	7/28	270	6.8	13.0
	9/1	280	7.4	10.0
	9/30	200	6.8	6.5
5	5/27	150	6.9	8.5
	9/1	130	8.0	13.0
	9/30	190	6.9	8.0
	10/31	180	7.2	--
7	5/27	210	7.6	5.5
	6/30	290	7.6	13.0
	7/28	270	7.8	16.0
	9/1	180	6.9	11.0
	9/30	330	7.3	8.0
	10/31	290	7.9	--
15	5/27	300	7.3	7.5
	6/30	290	6.9	13.0
	7/28	300	7.0	13.0
	9/1	290	--	9.0
	9/30	320	--	6.0
	10/31	330	7.1	--

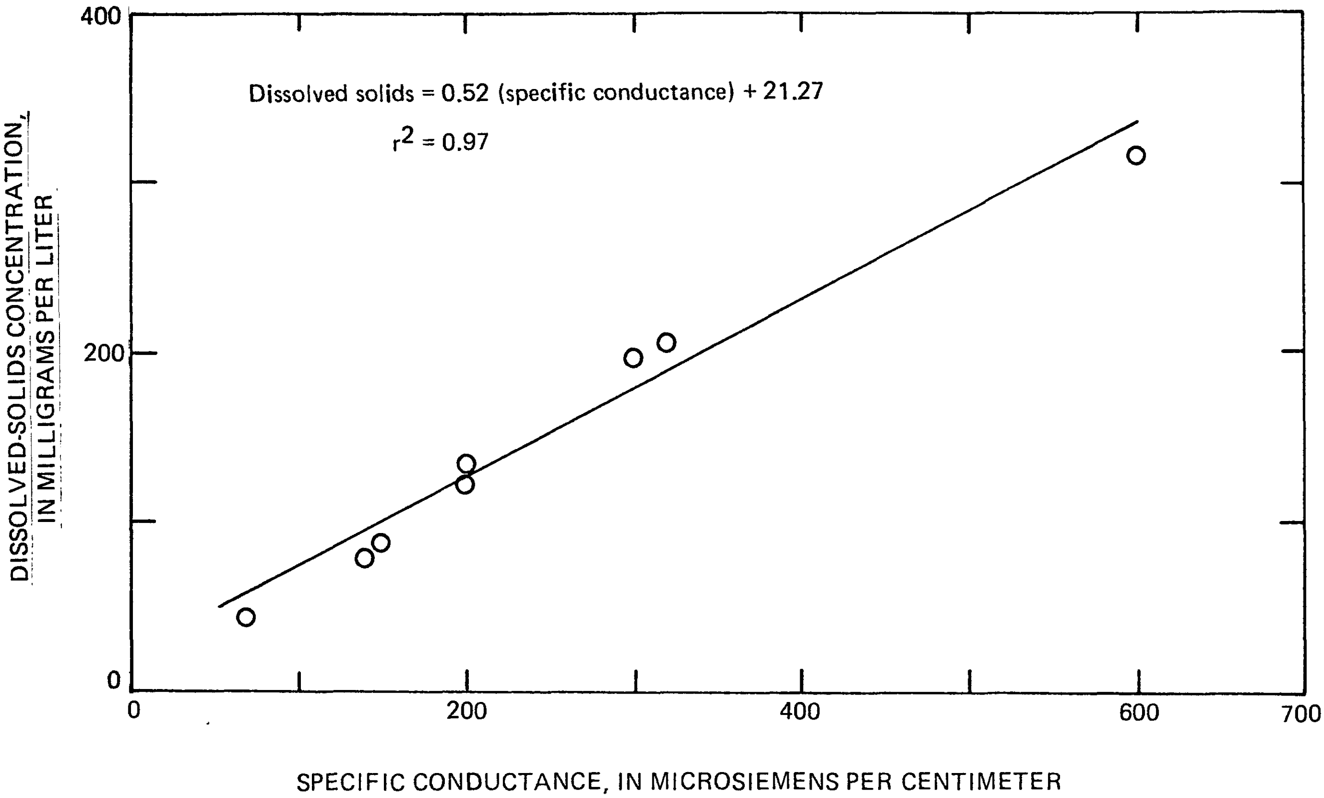


Figure 8.--Relation of specific conductance to concentration of dissolved solids for water in the Klatt Bog area.

Specific conductance is a readily measured property that can be used to indicate the concentration of dissolved solids in water. The specific conductance of water in Klatt Bog is directly proportional to the water's dissolved-solids concentration (fig. 8).

Ponds in Klatt Bog contained water that had very low concentrations of dissolved solids. Specific conductance of water from 16 ponds ranged from 70 to 150 µS/cm, which corresponds to about 58 to 99 mg/L of dissolved solids. The predominant ions in water from two ponds (ponds 1 and 2, fig. 4) were calcium, magnesium, and bicarbonate.

The quality of ground water varied widely. Values of specific conductance for water from 12 shallow wells completed in peat ranged from 60 to 540 µS/cm, which corresponds to about 52 to 300 mg/L dissolved solids. This range of values suggests a wide variation in the composition of geologic materials, and (or) the time which the water has been in contact with these materials. The predominant dissolved ions in water from four shallow wells were calcium and bicarbonate. Concentrations of iron ranged from 2,300 to 6,100 µg/L, and concentrations of manganese ranged from 200 to 1,100 µg/L (table 3). These high concentrations of iron and manganese make the water unsuitable for most uses unless the water is treated.

Specific conductance, pH, and temperature of water at six sites on stream or drainage channels (stream-discharge sites 2 through 5, 7, and 15; fig. 4) were measured intermittently. Values of specific conductance ranged from 130 to 330 µS/cm (table 4), which correspond to about 89 to 205 mg/L of dissolved solids. Sites 3, 4, and 5 drain areas of 0.2 mi^2 or less and all values of stream discharge measured at these sites were low (less than 0.25 ft^3/s). Specific conductance of water at sites 3, 4, and 5 averaged 240, 225 and 163 µS/cm, respectively. Sites 2, 7, and 15 drain areas greater than 1 mi^2 and stream discharges at these sites were generally greater than at sites 3, 4, and 5. Specific conductance at sites 2, 7, and 15 averaged 288, 1262, and 305 µS/cm.

Water from a stream near its outlet (site 2) was chemically similar to water from an upstream site (site 15) during summer when streamflows were low and predominantly from ground-water discharge; calcium and bicarbonate were the predominant dissolved ions.

SUMMARY AND CONCLUSIONS

Klatt Bog is underlain by peat, sand, alluvium, and relatively impermeable silt and clay. Water is supplied by direct precipitation and the inflow of surface runoff and ground water from nearby upland areas. High water levels are maintained because the quantity of water supplied to the wetland exceeds evapotranspiration from the wetland, natural surface drainage is poor, and underlying silt and clay retard the downward movement of water. During 1983, a year of below-average precipitation, ground-water levels were generally less than 3 ft below land surface and seasonally fluctuated less than 2 ft. Ground-water flow was generally from east to west.

Near drainage ditches, however, ground water flowed towards the ditches. The quantity of water flowing out of Klatt Bog as ground water was very small when compared to evaporation or surface runoff.

Streamflows during 1983 were high in spring and low in winter and summer. At a wetland-outflow site that has a drainage area of 2.1 mi^2, measured stream discharges ranged from 0 to 1.8 ft^3/s. Discharges measured at this site in summer were similar to discharges at a site 1.2 mi upstream, indicating that during this low-flow period, ground-water discharge from a 1-mi^2 wetland area between the sites was not a significant part of streamflow and that most of the water flowing out of the wetland was derived from ground-water discharge near the eastern (upgradient) edge of the wetland.

All water samples collected had concentrations of dissolved solids less than 500 mg/L, a maximum concentration recommended for domestic uses. However, all were yellowish brown in color and some contained concentrations of iron and manganese that make the water unsuitable for many uses. Water in ponds had concentrations of dissolved solids ranging from 58 to 99 mg/L, whereas ground water from peat had concentrations of dissolved solids ranging from 52 to 300 mg/L. Water in streams had concentrations of dissolved solids ranging from 89 to 205 mg/L. The main ions dissolved in ground water and water in streams were calcium and bicarbonate; the main ions dissolved in water from two ponds were calcium, magnesium, and bicarbonate.

Because data were collected intermittently over a single year and the area is large and highly variable, interpretations in this report are by necessity general. Site-specific effects of a local drainage or development project would require additional study.

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