GEOHYDROLOGY OF THE LOWLAND LAKES AREA
ANCHORAGE, ALASKA

By Chester Zenone

INTRODUCTION

Man's use of water and land can modify the quantity and quality of both surface water and ground water. Use of these resources is concentrated and intensified as urbanization--an increase in population density--occurs. Urbanization is taking place in much of the Anchorage, Alaska, area (fig. 1), and the expected continued, rapid growth of population will create ever-increasing demands for urban-type development of the remaining natural open spaces. Such areas are present in the western part of the roughly triangular Anchorage glacial plain which in this report will be called the lowland lakes area. Although this area already contains large tracts of high-density development, such as those east and northeast of both Sand and Spenard Lakes, large areas of natural muskeg remain (fig. 2).

The major uses of surface water in the lowlands are for intensive recreation (fishing and boating) at public parks on several of the larger lakes and for private and commercial aircraft operations at the Hood-Spenard Lakes floatplane base. Campbell Creek supports a small sport fishery and is becoming a popular canoeing stream. Campbell Creek also supplies water to manmade Campbell Lake, the only lowland area lake which has a continuous inflow and outflow of surface water. Fish Creek now serves mainly as an urban-area drainage channel. Campbell and Fish Creeks are peripheral to the major area of concern in this report, but ground water does discharge along their channels through the lowland area. Although some private wells are still in use, shallow ground water (from wells less than about 50 ft [feet] or 15 m [metres] deep) is not an important source of domestic water supply. That demand is met largely by deeper (more than 200 ft or 69 m) public-supply wells.

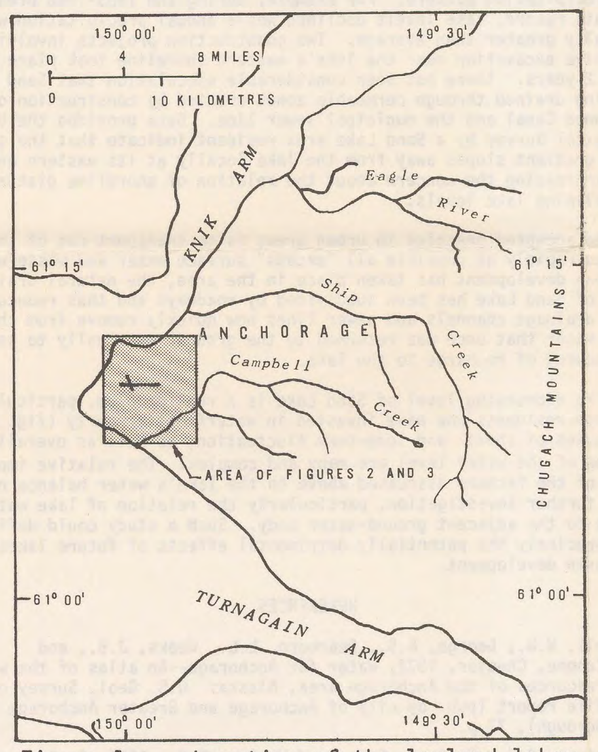

Figure 1. -- Location of the lowland lakes area at Anchorage, Alaska

PURPOSE OF REPORT

The purpose of this report is to explain the interrelationship of geology and hydrology in an urban area. The data upon which the following discussions and interpretations are based have been collected by the U.S. Geological Survey, other public agencies, private organizations, and individuals within the past 20 years. Thus, the data span an interval of rapid urbanization in the Anchorage area.

Leopold (1968) wrote that "Of all land-use changes affecting the hydrology of an area, urbanization is by far the most forceful." Barnwell and others (1972) have discussed changes in natural hydrologic trends, patterns, and values as a consequence of urbanization in Anchorage.

The intensive recreational and economic (commercial floatplane operations) uses of the Anchorage-area lakes emphasize their importance as a water resource. As Anchorage's population continues to grow, there is an increasing demand to develop its remaining open space, much of which consists of the swamp-muskeg land in the lowland area. A comprehensive land-use planning approach must be applied to decisions concerning which natural features will be preserved and how development should proceed.

It is hoped that the presentation of data and discussion of geohydrology in this report will serve as a starting point for evaluations of changes, both beneficial and detrimental, that further urbanization could create in the status of the lakes and other water and water-related resources of the study area.

GEOLOGY

The geologic history of the Anchorage area has been discussed by various authors (Miller and Dobrovolny, 1959; Karlstrom, 1964; Cederstrom, Trainer, and Waller, 1964), and the surficial deposits have been mapped most recently by Schmoll and Dobrovolny (1972). Unconsolidated deposits, chiefly of glacial origin, make up the surficial geologic materials throughout the Anchorage lowland lakes area (Schmoll and Dobrovolny, 1972, and fig. 3). The deposits range in character from predominantly coarse-grained (gravel), through mixed coarse- and fine-grained (gravel-sand-silt-clay) to very fine-grained sediments (clay). Local and extreme lateral and vertical variability of these deposits is illustrated in generalized cross sections (fig. 4). Post-glacial accumulation of a thick organic mat (peat), which partly masks the variability of the glacial deposits, has created the swamp-muskeg terrane of the lowlands.

There is a wide range of topographic expression, stratification, particle size and distribution, and hydrologic properties of the surficial geologic materials in the lowland. The variation is the result of a complexly interrelated and repeated alternation of the action of glacier ice and water. Additionally, the water in which the sediments were deposited occurred both as melt-water streams and as deep proglacial lakes. Present-day lakes of the lowland area occur on a pitted outwash deposit in depressions left by the melting of large, isolated blocks of ice (Miller and Dobrovolny, 1959, p. 54).

GROUND WATER

The presence of ground water results from the infiltration and downward movement of water from the surface. In the lowlands ground water occurs under two conditions: confined (artesian) and unconfined (water table). The confined water, which provides the public water supply for most of the study area, lies beneath silt or clay deposits as much as 300 ft (91 m) thick (Trainer and Waller, 1965). These fine-grained deposits and the upward hydraulic gradient from the confined aquifer (fig. 4) protect the quality of this deep water from any detrimental effects of urbanization in the lowlands.

Ground water also occurs under water-table conditions at or near the surface and thus saturates the surficial materials in much of the lowland area. Locally, this saturated, near-surface zone is very thin. Excavation for the municipal sewer main through peat-covered areas north and east of the International Airport revealed many sites where 5 to 10 ft (1.5 to 3 m) of saturated peat interlayered with gravel and sand lenses overlie thick layers of clay-silt deposits (Shannon and Wilson, 1969). It is the shallow ground water in storage that is responsible for and maintains the swamp-muskeg nature of much of the as yet undrained and undeveloped terrane in the lowland area. Ground-water storage is estimated to be 90 million gallons (about 341,000 cubic metres) based on an average porosity of 30 percent and a saturated thickness of 50 ft (15 m). The low permeability of the surficial geologic materials and low hydraulic gradients cause the very low rates of flow for this shallow ground water.

A contour map of the water table--the top surface of the unconfined ground-water body--in the lowlands (fig. 3) shows a relatively low hydraulic gradient compared to the rest of the Anchorage area. The contours indicate movement of shallow ground water away from a low divide that extends east-northeast from Sand Lake. In the area west of the heavy blue line the deep aquifer's confining layers grade into more permeable sediments. The water-table contours are terminated at this transition zone because neither the separate existence nor distinction between the shallow and deep aquifer systems west of the zone can be well defined.

WETLAND DRAINAGE AND LAKE LEVELS

The ease with which a wetland or high water-table area can be drained is dependent upon permeability of the earth materials and the hydraulic gradient of the ground water. The permeability of a rock or soil is a measure of its ability to transmit fluid, in this case water, under a hydropotential gradient (Lohman, 1972, p. 4). Experiments have shown that permeability depends to some degree on the average grain size of the rock or soil. Coarse-grained material will transmit water faster (has a higher permeability) than will a fine-grained material. The geologic units mapped in the lowland area (Schmoll and Dobrovolny, 1972) are here grouped and ranked from highest to lowest relative permeability (fig. 3). Ranking of the units was done on the basis of predominant grain size and size distribution of particles within each mapped unit. Users of figure 3 are cautioned that at any specific site the type of materials mapped and their relative permeabilities may vary from what the generalized map indicates and that these characteristics may apply only to a thin (10 ft [3 m] or less) surface layer.

Unless fill material is placed over saturated surface deposits, wetland areas normally require some drainage or lowering of the water table prior to the placement of building foundations. Assuming that drainage ditches or subdrains are constructed to the most efficient depth, gradient, outfall elevation, and horizontal spacing, the ease of land drainage will be dependent on horizontal permeability of the surface materials.

The ease with which an area can be drained may be either beneficial or detrimental to a particular development plan. For example, a tract of land underlain by sand and gravel may have a high water table, a very low hydraulic gradient, and contain a desirable recreational lake. Coarse-grained materials usually will drain easily if a steep gradient is present or is artificially created. In an area which has very low topographic relief and thus very low hydraulic gradient, an increased gradient would probably have to be established away from the lake. Such action could result in declining water levels of lakes that are sustained by the surrounding ground-water body.

Fine-grained materials of low permeability, which are prevalent in the Anchorage lowland area, are difficult to drain by conventional drainage practices. Such practices may be totally ineffective in organic muskeg material (MacFarlane, 1969). Land "reclamation" might then involve actual removal of saturated materials, filling to required construction level with other, more suitable foundation material, and perhaps installation of subdrains within the fill. The effect of such action on lake levels can vary from practically no change to a significant or drastic change, depending on the role of ground water in maintaining lake levels. If the local ground-water body recharges a lake, then removal of adjacent naturally rather impermeable material and its replacement by more permeable or artificially drained fill would create a ground-water gradient away from the lake and eventually cause lake drainage. If ground water is not an important source of lake recharge and materials of low permeability act as a barrier to subsurface outflow, then peripheral land drainage activities would have negligible effect on lake water levels.

Apparently the latter of the two conditions described above exists along the north shore of Lake Spenard where excavations have been made to provide additional floatplane taxiing and parking space. After nearly 2 years, the water level in a 6-ft (1.8-m) deep open excavation was approximately 5 ft (1.5 m) lower than the water level in Lake Spenard, yet the excavation through surficial peat and into a clay-silt material was separated from the lake by a strip of undisturbed land only 75 ft (22.8 m) wide.

Records of water levels in shallow auger holes at two sites near Sand Lake (A. B. Scouler, written commun., 1970, and unpub. data, U.S. Geological Survey) show that ground-water gradients can differ locally along the shoreline of a single lake. Such variation makes it difficult to make a general statement concerning ground-water level as related to lake water levels. Prediction of the effect of near-shore terrain disturbances on lake levels requires onsite investigation of subsurface hydrologic conditions.

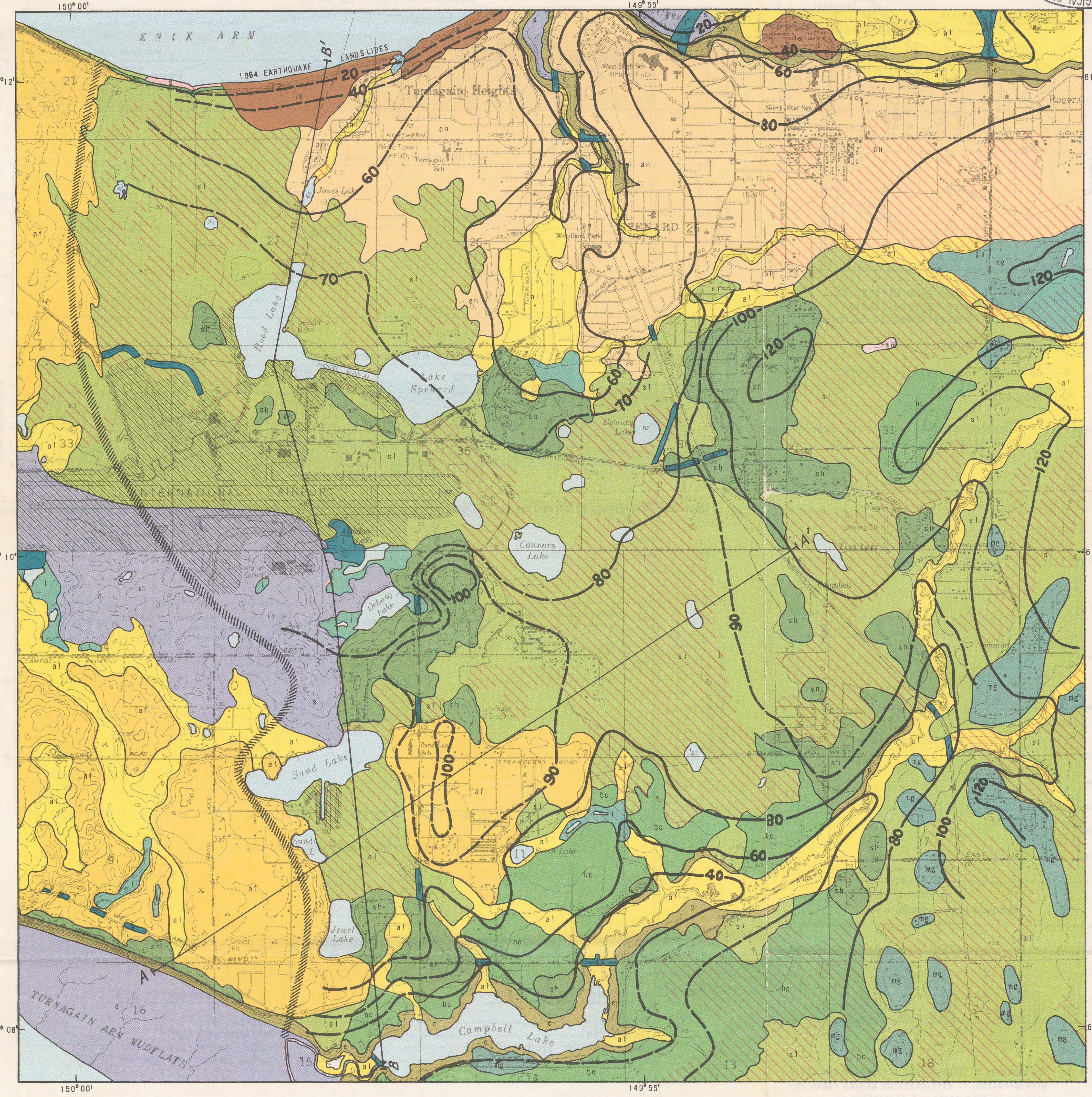

Figure 3.-- Geologic map of the Anchorage lowland lakes area.

EXPLANATION FOR FIGURE 3

DESCRIPTION OF MAP UNITS

RELATIVE PERMEABILITY (INCREASING ↑ / DECREASING ↓)

- **an, al** — ALLUVIUM -- gravel and sand, either of the Anchorage glacial plain (an) or in abandoned stream channels and terraces along present streams (al).
- **af** — ALLUVIAL FANS, CONES, EMERGED DELTAS -- Dominantly gravel in area east of Sand Lake and adjacent to Sand, Sundi and Jewel Lakes. Mostly sand with coal fragments in areas along western edge of map.
- **sl, sh** — SAND DEPOSITS -- Almost exclusively sand in low hills and dunes (sh). Chiefly sand, with some gravel, in flat low-lying areas (sl) where it is generally underlain by Bootlegger Cove Clay (described below) and overlain by varying thickness of peat.
- **s, c, mg** — SILT - silt with some fine sand and clay interbedded locally. COLLUVIUM (c) -- poorly sorted to well sorted mixture of sand, silt and clay. MARINE GLACIAL OR LACUSTRINE DEPOSITS (mg) -- variety of interbedded, dominantly fine-grained material.
- PEAT -- indicated by lined overprint where more than 2 feet thick; commonly 5 to 10 feet thick. Overlies the (sl) unit in most of the lowland area.
- **bc, l** — CLAY (bc) -- chiefly clay and silt of the Bootlegger Cove Clay ; locally contains pebbles, cobbles or boulders. LAKE AND POND SEDIMENTS (l) -- chiefly clay and silt, with some marl.
- **ls** — Deposits of landslides of 1964 earthquake
- **f** — Manmade fill
- Area containing numerous man-made cuts and fills
- A—A' Line of cross-section
- 80 Water-table contours, in feet above mean sea level. Dashed where inferred. Contour intervals 10 feet and 20 feet.
- Approximate western extent of two-aquifer system (confined and unconfined). Confining layers grade into more permeable sediments west of this zone.

0 ½ 1 MILE
0 .5 1 KILOMETRE

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Map unit descriptions modified from Schmoll and Dobrovolny (1972). Water-table contours modified from Dearborn and Freethey (1974).

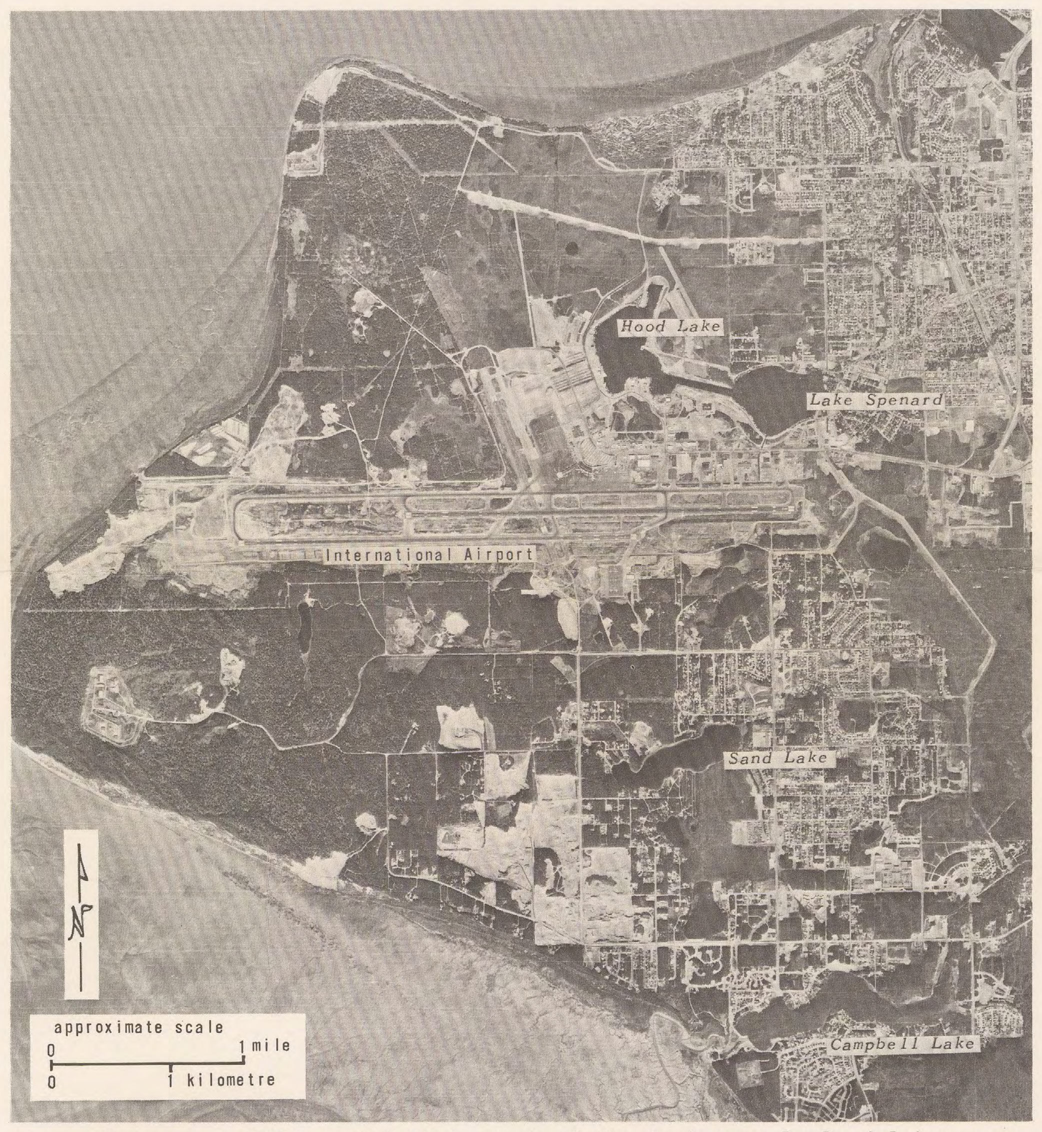

Figure 2. -- June 1974 aerial photograph of the Anchorage lowland lakes area showing areas of intensive development and remaining undeveloped, mostly muskeg terrain. PHOTO BY NORTH PACIFIC AERIAL SURVEYS

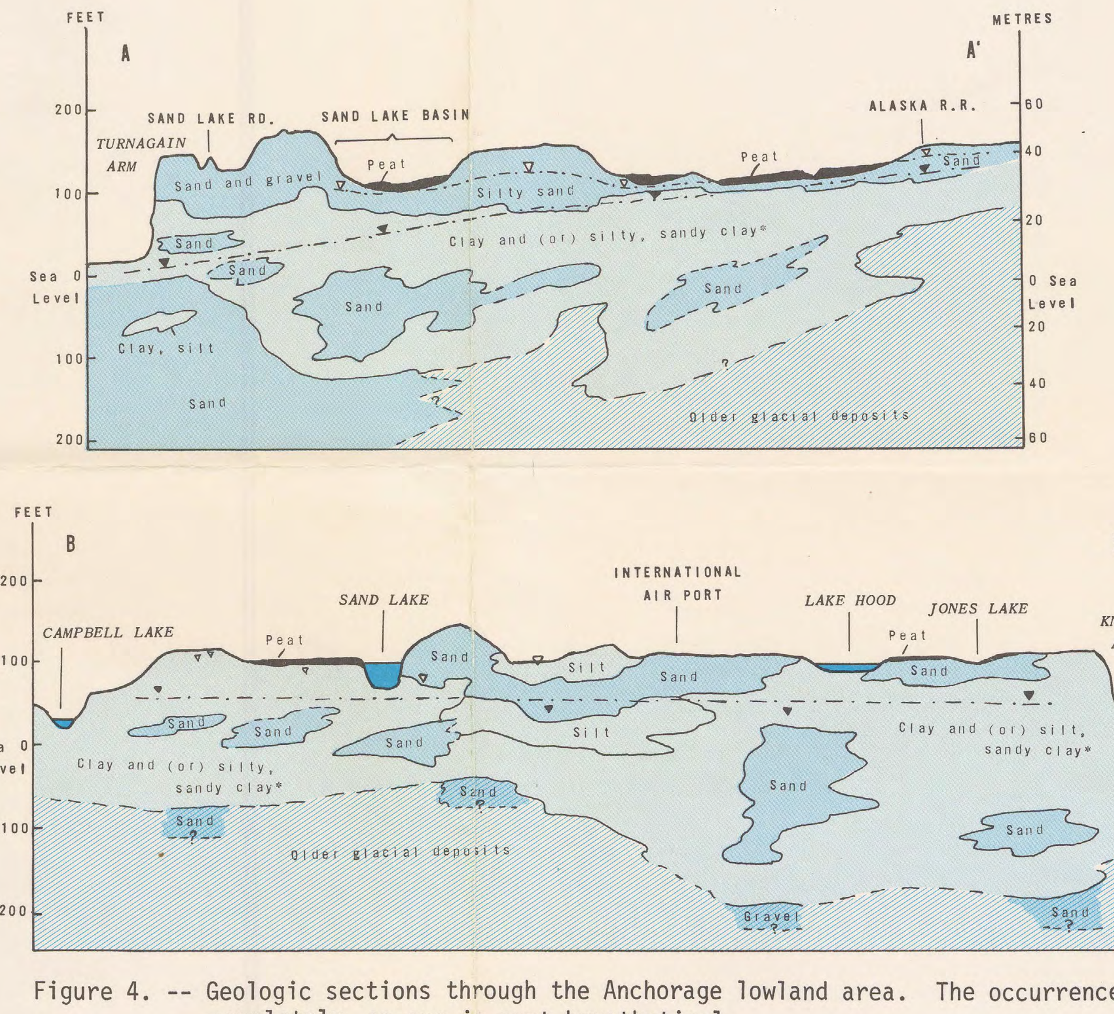

Figure 4. -- Geologic sections through the Anchorage lowland area. The occurrence and configuration of subsurface materials are not known completely, so are in part hypothetical.

EXPLANATION FOR FIGURE 4

▽ Water level in unconfined aquifer

▼ Potentiometric water level of confined aquifer

—·—·— Water-table surface (section A-A' only) and potentiometric surface (water level in wells completed in confined aquifer).

*Bootlegger Cove Clay

0 1000 2000 FEET
0 ½ 1 KILOMETRE
HORIZONTAL SCALE
VERTICAL EXAGGERATION X20

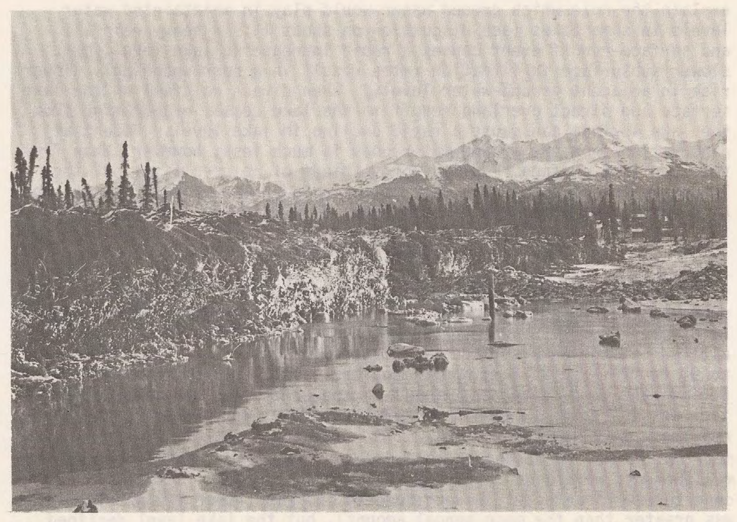

Figure 5. -- Saturated peat layer, 4 feet (1 metre) thick, exposed at excavation for road bed at East 76th Avenue and New Seward Highway (November 1973 photograph).

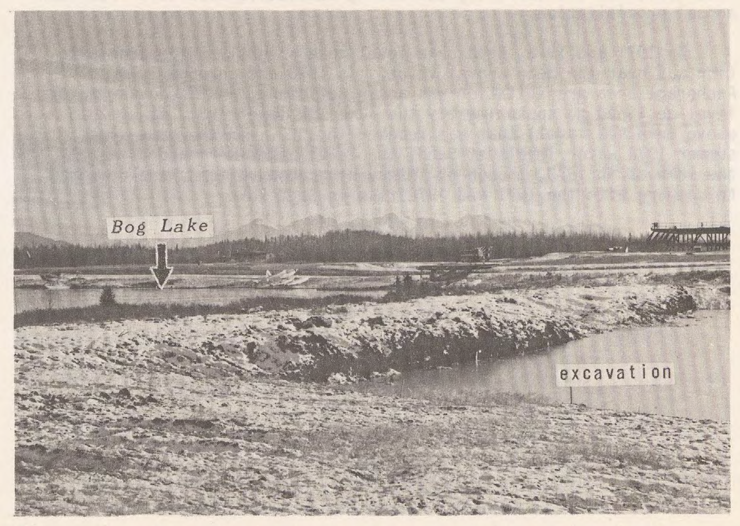

Figure 6. -- Lake Spenard--Bog Lake area at east end of Hood Canal, October 1973. Water level (arrow) in excavation at right is approximately 6 feet (2 metres) lower than level in Bog Lake at left, even though excavation was more than a year old at time photograph was taken and separating strip of land is only 75 feet (23 metres) wide. No seepage was evident at the face of the excavation cut; the water present apparently is chiefly from precipitation.

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