Prepared in cooperation with
ALASKA WATER STUDY COMMITTEE
and the STATE OF ALASKA, DEPARTMENT OF
NATURAL RESOURCES, DIVISION OF GEOLOGICAL
AND GEOPHYSICAL SURVEYS

GEOLOGY

INTRODUCTION

The Cook Inlet hydrologic subarea, hereafter referred to as the Cook Inlet basin, encompasses approximately 38,000 square miles. (See location map.) Population of the basin is estimated at over 245,000 (1978), more than half of Alaska's population. The largest community, Anchorage, has a population of 205,000 (July 1979 estimate) and is the primary center for labor, trade, distribution, and transportation for the State. Growth of communities in the Matanuska-Susitna and Kenai Peninsula Boroughs has kept pace with that of Anchorage.

The eastern side of the basin is traversed by major highways and a railway. Cook Inlet is a major water trade route. The western side of the basin is sparsely populated and accessible only by air or boat.

Major development of the Cook Inlet basin started with the fishing industry in the 1880's and quickly expanded as a result of mineral exploration and the need to provide transportation to and from the Fairbanks gold region. The first major population influx occurred with the construction of the Alaska Railroad in the 1917-20 period. Since World War II, the population of the basin has had a steady increase as people came to work at the military bases near Anchorage, to develop the oil and gas reserves in Cook Inlet, and to provide the logistics and the financial and administrative support for post-earthquake (1964) construction and the boom generated by the North Slope oil discovery (1969).

The Cook Inlet basin is near the coast of the Gulf of Alaska, but it exhibits the climatic characteristics of the transition zone between maritime and continental climates. High mountain ranges bordering the basin protect its southern half from the wet maritime climate and its northern half from the more extreme climate of continental interior Alaska. Precipitation in the lowlands is slight because they lie in the rainshadow of the Chugach Mountains. Some areas in the lowlands may receive less than 10 in. (inches) per year while the high mountains receive 60 in. or more per year. Average annual recorded precipitation ranges from 10 to 15 in. at Sheep Mountain, Anchorage, Palmer, and Kenai, and from 40 to 60 in. at Girdwood, Portage, and Kasitsna Bay.

This report is a summary of the availability of water in the Cook Inlet basin. Sheet 1 explains and illustrates how geologic and topographic features control the movement and regional availability of ground water. Although most ground-water data come from the populated areas of the basin, yield capabilities in other areas have been estimated by extrapolating known subsurface conditions and by interpreting subsurface conditions from surficial features. Surface-water resources are summarized on sheets 3 and 4 by describing how basin characteristics affect the discharge in streams. Regression analyses were made to obtain relationships for estimating floodflows and low flows and annual and monthly discharges of ungaged streams. Mean annual discharges, mean monthly discharges and basin characteristics were tabulated for all gaging stations used in the regression analyses, and representative low-flow and floodflow frequency curves are shown.

Water quality is not described in this report. Although little is known about the ground-water quality in the sparsely populated parts of the basin, much information is available on the quality of ground water beneath Anchorage and the other developed areas. Ground-water quality for the study area was summarized briefly by Balding (1976, p. 192 and 194). Surface-water quality is better defined than ground-water quality throughout the basin, and the data are presented in the annual series of water-resources publications by the U.S. Geological Survey; they also were summarized by Balding (1976, p. 187-189).

Both surface water and ground water are important resources in the Cook Inlet basin. Prior to the early 1950's, the military bases and the city of Anchorage depended primarily on surface water for their public supply. During the 1950's, ground water began to be recognized as a source for public supplies because it is 3° to 4°F (Fahrenheit) warmer than surface water during the winter when distribution lines are subject to freezing. Ground water also exhibits less seasonal variation in quality than surface water. Although surface water continues to be a significant part of the Anchorage area water supply, ground water is now the principal source. Other communities in the Cook Inlet basin utilize surface water or ground water, depending on local availability and economics of the water distribution system.

Acknowledgments

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EXPLANATION OF GEOLOGIC UNITS

MAP UNIT	Qow Outwash and valley train deposits	Qal Holocene flood plains, terraces, and alluvial fans.	Qlf Proglacial lake and associated fluvial deposits	Qmd Moraines and other unsorted glacial drift	Qes Sand dunes and other eolian deposits	Brim Igneous and metamorphic bedrock	Brs Sedimentary bedrock
LITHOLOGY	Stratified sediments, chiefly sand and gravel with some silt and clay intermixed. Generally grades to finer grained materials with increasing distance from its glacial source.	Well stratified silt, sand, and gravel. Coarser grained materials near mountains grading to sand and silt away from mountains.	Heterogeneous mixtures of silt, sand, and gravel, interlayered with more homogeneous deposits of silt and clay (lake deposition) and sand and gravel (fluvial deposition).	Heterogeneous blend of gravel, sand, silt, and clay, and with discontinuous lenses consisting largely of well-sorted material.	Well-sorted windblown sand and silt deposits containing some clay-size particles.	Igneous and highly metamorphosed rocks, usually well consolidated and dense; jointing and faulting common. Lower grade metamorphic rocks are less consolidated and less dense.	Well-consolidated to poorly consolidated sedimentary rocks, including arkose, graywacke, gravel conglomerate, sandstone, siltstone, shale, coal, and limestone.
LANDFORMS AND OCCURRENCE	Forms as long, narrow deposits confined by the valley walls downstream from terminal moraines or as fans or other broad alluvial sheets of glacial outwash sediments immediately downstream from glaciers.	Forms alluvial flood plains, alluvial fans, and terraces along most streams. Long, narrow deposits too small to be shown at the map scale used.	Forms channeled and terraced, marsh- and muskeg-covered flat areas, typically in the lowest parts of the basin. Surrounds numerous bedrock exposures in the uplands near the northwestern boundary of the basin.	Forms hummocky terrain with muskeg- and marsh-filled depressions, in places extensively dissected by postglacial erosional processes. Typically occurs near the upland areas of basins where bedrock may be at shallow depths.	Forms dunes near Points Campbell and Woronzof and a broad, flat, finer grained deposit near the mouth of the Susitna River. Numerous small loess deposits occur throughout the basin, generally as a thin mantle overlying thicker glacial deposits.	Underlies entire basin. Exposed in ridges and rounded hills near the foot of mountain ranges and on steep hills and peaks in the Chugach, Kenai, and Alaska Ranges. Found at shallow depths in some places under Quaternary sediments near the mountain fronts.	Forms ridges, rounded hills, and bluffs in the Talkeetna and Chugach Mountains, steeper slopes and hills on the west side of Cook Inlet in the Alaska Range; found at shallow depths beneath Quaternary sediments on the southern half of the Kenai Peninsula and in places near mountain fronts.
SURFACE DRAINAGE, INFILTRATION, AND PERMEABILITY	Surface drainage poor to moderate, since relief is generally low. Infiltration moderate to good, due to coarseness of material and thin soil cover. Permeability moderate to good where coarse-grained materials predominate; poor to moderate in finer grained sediments.	Surface drainage, infiltration, and permeability moderate to good.	Surface drainage poor, due to low relief; numerous lakes, marshes, and swamps are typical. Infiltration poor to good, depending on soil texture and type of surficial deposits present. Permeability good in coarse-grained strata, poor in fine-grained strata.	Surface drainage moderate to good on slopes, poor in depressions. Infiltration poor to good, depending on soil texture and grain size. Permeability poor to good, depending on amount of fine-grained materials.	Surface drainage poor to good, depending on relief. Infiltration moderate to good, except where deposits consist of silt. Permeability poor to good.	Surface drainage very good. Infiltration poor to moderate. Primary permeability poor; secondary permeability in fault zones and jointed areas poor to moderate.	Surface drainage good. Infiltration poor to moderate. Primary permeability poor to good, depending on coarseness of material, type of cementation, and degree of consolidation. Secondary permeability in fault zones and joint systems, poor to moderate.
POTENTIAL FOR GROUND-WATER USE	Ground-water potential depends on the extent and thickness of the deposit. Thickness usually limited in upper valleys. Recharge source is readily available. Occurs in unpopulated areas where few wells have been drilled. Ground-water availability probably poor to moderate.	Ground-water potential usually good because of abundant sources for recharge and, normally, large saturated thickness. Wells drilled into this material usually obtain adequate domestic supplies at less than 100 feet. A few yields greater than 1,000 gallons per minute have been reported.	Ground-water potential moderate to good where surficial materials are coarse grained and thick. Many domestic wells are less than 100 feet deep. Confined aquifers at greater depths have a potential for yields large enough for public supplies. Near the northwestern basin boundary the potential probably is poor, due to limited thickness; few wells have been drilled in this area.	Ground-water potential ranges from poor to moderate, depending on grain size of underlying material, saturated thickness, and availability of recharge. Typical domestic wells are finished in a relatively shallow lens of coarse-grained material which yields enough water for a household supply. Few large-yield wells have been drilled in areas underlain by this material.	Ground-water potential poor because deposits typically are thin and fine grained and are above the water table. Wells drilled in these areas usually penetrate deeper water-bearing sediments.	Ground-water potential poor because of low permeability and limited saturated thickness. Many wells drilled into this type of material are dry. Nearly all ground-water yields are less than 5 gallons per minute.	Ground-water potential poor where rocks are well consolidated or consist mostly of fine-grained rock types such as siltstone, shale, or graywacke. Ground-water potential poor to good in poorly consolidated formations of coarse-grained sandstone and gravel conglomerate.

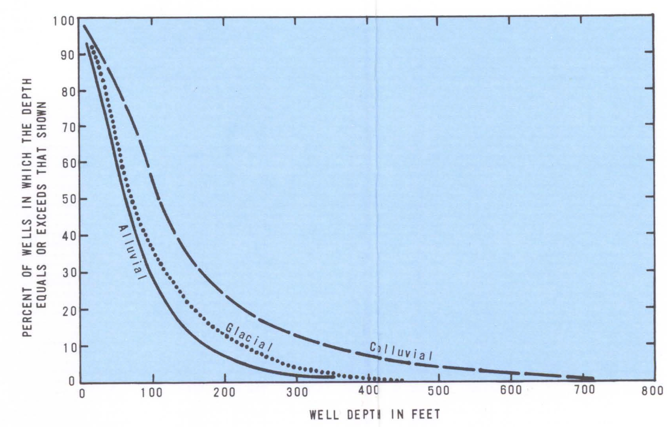


FIGURE 1.—Frequency distribution of depth in wells drilled in areas represented by three contrasting depositional environments.

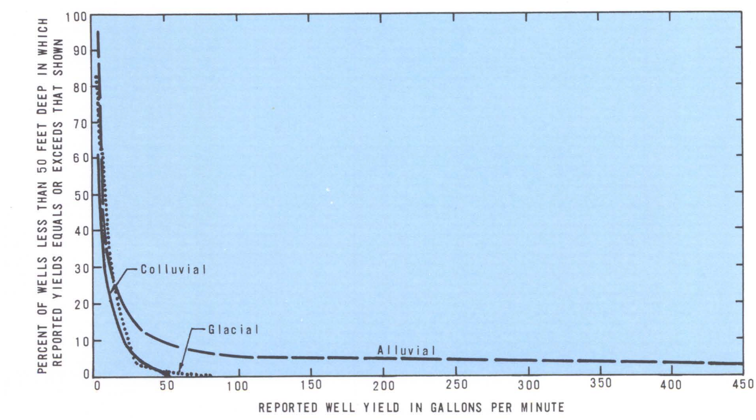


FIGURE 2.—Frequency distribution of yield in wells less than 50 feet deep drilled in areas represented by three contrasting depositional environments.

Ground-water potential of geologic materials

For this report the geologic materials are discussed in two categories, consolidated rocks and unconsolidated sediments.

Consolidated rocks, loosely termed bedrock, crop out in the mountain ranges surrounding the basin and consist of sedimentary and metasedimentary rocks, as well as intrusive and volcanic rocks. Slate, graywacke, argillite, greenstone, and other metasediments are exposed in the Kenai and Chugach Mountains; granite and metamorphosed basalts and andesites in the Talkeetna Mountains; and granites, granodiorites, undifferentiated volcanic rocks, argillite, shale, sandstone, and siltstone in and bordering the Alaska Range. For the purpose of identifying ground-water potential, consolidated rocks have been mapped as sedimentary rocks and as igneous-metamorphic rocks. (See generalized geology map.) Ground-water potential of the igneous-metamorphic rocks depends on the abundance of water-saturated fracture zones at depths reasonable for recovery of the water through the use of wells. Ground-water potential of sedimentary rocks depends on both primary (intergranular) permeability and secondary (fracture) permeability. Primary permeability is greater in coarse-grained sedimentary rocks, such as sandstone and conglomerate, than in fine-grained siltstone or claystone. The last two columns in the table of explanation of the geologic units are summaries of the hydrologic properties and the water-supply potential of these two bedrock categories.

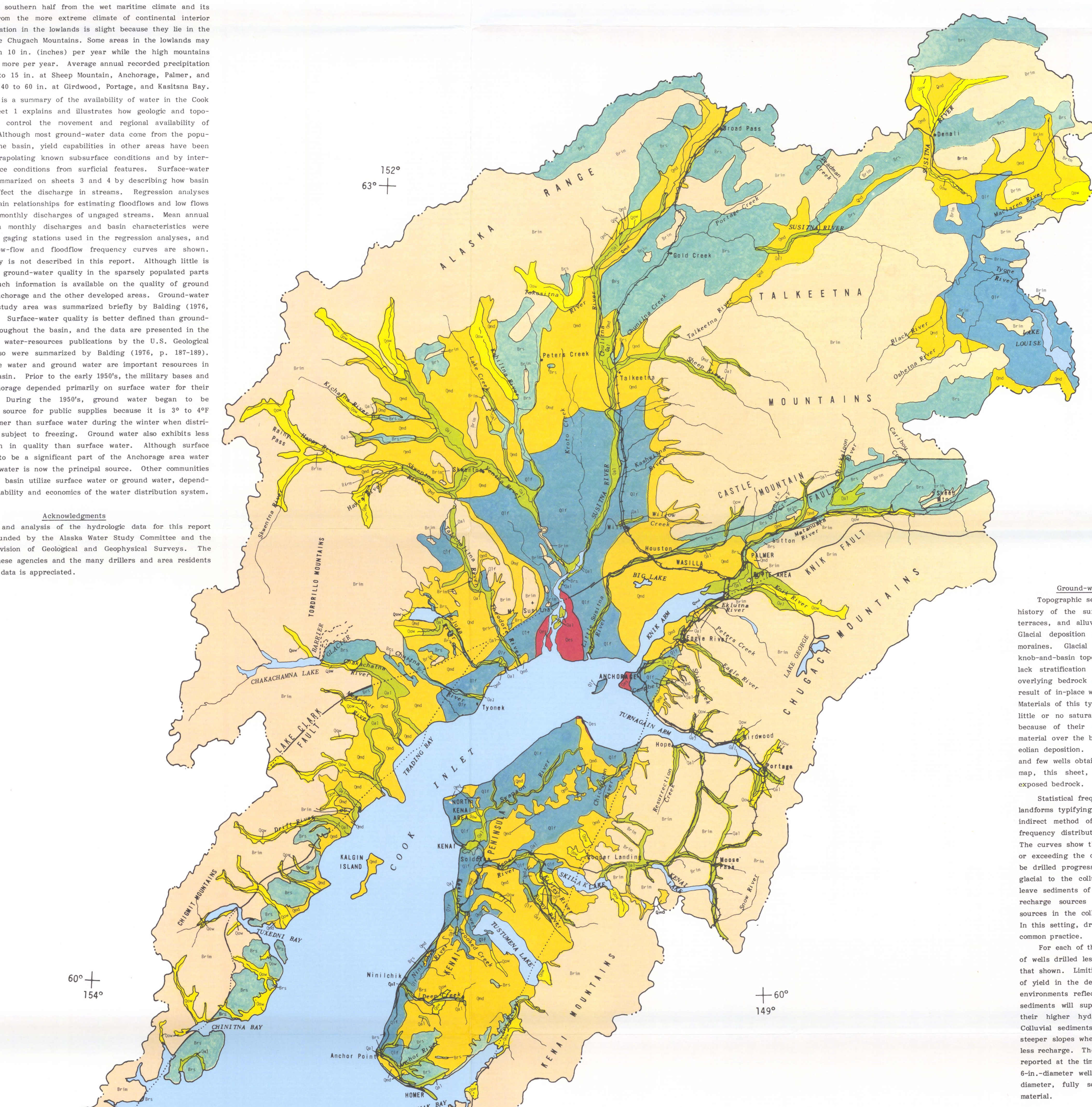
The unconsolidated sediments generally occupy the low-lying central part of the study area and consist of clay, silt, sand, gravel, and boulders deposited by glacial, eolian, alluvial, colluvial, lacustrine, and marine processes. Because these unconsolidated materials yield most of the ground water used by the current population, they were divided into five categories based on their hydraulic properties and their known potential for yielding ground water. Ground-water potential for these sediments depends on their permeability, their thickness and areal extent, and their recharge. Hydrologic properties and water-supply potential for the five categories of unconsolidated sediments are summarized in the table describing the geologic units.

Ground-water potential and depositional environment

Topographic settings within the study area reflect the depositional history of the surficial material. Landforms such as valley floors, terraces, and alluvial fans are the result of deposition by streams. Glacial deposition is indicated by landforms such as drumlins and moraines. Glacial deposits also commonly display the characteristic knob-and-basin topography. Glacial drift and morainal deposits usually lack stratification and are poorly sorted. The mantle of sediments overlying bedrock on hillslopes, in steep draws, and on hilltops is a result of in-place weathering and of mass wasting (colluvial deposition). Materials of this type are usually thin and discontinuous and thus have little or no saturated thickness. Colluvial deposits were not mapped because of their discontinuity, but they generally occur as mantle material over the bedrock units. Dunes and flat loess blankets typify eolian deposition. This type of deposit is uncommon in the study area, and few wells obtain ground water from these sediments. The geologic map, this sheet, shows the distribution of surficial deposits and exposed bedrock.

Statistical frequencies of depth and yield data on wells drilled into landforms typifying alluvial, glacial, and colluvial deposition provide an indirect method of estimating ground-water potential. In the first frequency distribution (fig. 1), data from all wells on file were used. The curves show the percentage of wells in each environment equaling or exceeding the depths shown. The graph indicates that wells must be drilled progressively deeper as one moves from the alluvial to the glacial to the colluvial depositional environments. Alluvial processes leave sediments of high hydraulic conductivity near the surface where recharge sources are usually present. In contrast, ground-water sources in the colluvial environment are most often found in bedrock. In this setting, drilling deeper to create a reservoir to draw upon is a common practice.

For each of the three environments, figure 2 shows the percentage of wells drilled less than 50 ft (feet) deep in which the yield exceeds that shown. Limiting the well depth to 50 ft emphasizes the character of yield in the depositional environment of surficial landforms because environments reflected in deeper sediments are not included. Alluvial sediments will support wells with greater yields primarily because of their higher hydraulic conductivity and availability of recharge. Colluvial sediments have low yields primarily because they occur on steeper slopes where runoff is high and infiltration low; thus there is less recharge. The yields used to draw the frequency curves are those reported at the time of well construction and for the most part are from 6-in.-diameter wells. Higher yields would probably result from larger diameter, fully screened, and better developed wells in the same material.



EXPLANATION

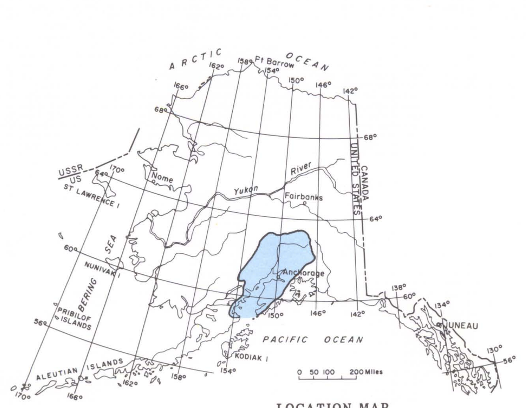
Fault (location generalized) – dotted where concealed

Contact

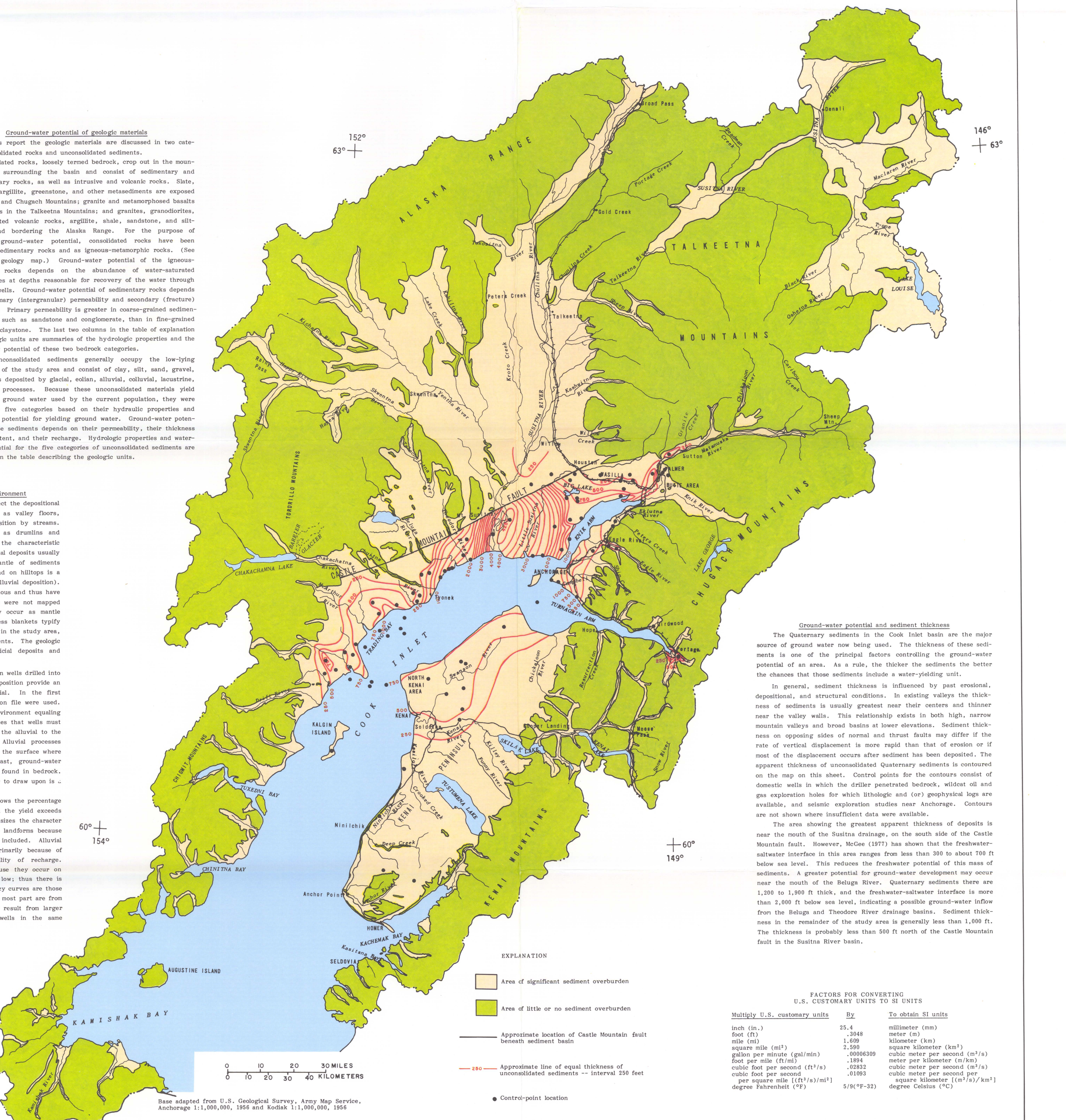
0 10 20 30 MILES
0 10 20 30 40 KILOMETERS

Base adapted from U.S. Geological Survey, Army Map Service, Anchorage 1:1,000,000, 1956 and Kodiak 1:1,000,000, 1956

GENERALIZED GEOLOGY



LOCATION MAP



0 10 20 30 MILES
0 10 20 30 40 KILOMETERS

Base adapted from U.S. Geological Survey, Army Map Service, Anchorage 1:1,000,000, 1956 and Kodiak 1:1,000,000, 1956

QUATERNARY SEDIMENT THICKNESS

EXPLANATION

Area of significant sediment overburden

Area of little or no sediment overburden

Approximate location of Castle Mountain fault beneath sediment basin

250 Approximate line of equal thickness of unconsolidated sediments -- interval 250 feet

● Control-point location

Ground-water potential and sediment thickness

The Quaternary sediments in the Cook Inlet basin are the major source of ground water now being used. The thickness of these sediments is one of the principal factors controlling the ground-water potential of an area. As a rule, the thicker the sediments the better the chances that those sediments include a water-yielding unit.

In general, sediment thickness is influenced by past erosional, depositional, and structural conditions. In existing valleys the thickness of sediments is usually greatest near their centers and thinner near the valley walls. This relationship exists in both high, narrow mountain valleys and broad basins at lower elevations. Sediment thickness on opposing sides of normal and thrust faults may differ if the rate of vertical displacement is more rapid than that of erosion or if most of the displacement occurs after sediment has been deposited. The apparent thickness of unconsolidated Quaternary sediments is contoured on the map on this sheet. Control points for the contours consist of domestic wells in which the driller penetrated bedrock, wildcat oil and gas exploration holes for which lithologic and (or) geophysical logs are available, and seismic exploration studies near Anchorage. Contours are not shown where insufficient data were available.

The area showing the greatest apparent thickness of deposits is near the mouth of the Susitna drainage, on the south side of the Castle Mountain fault. However, McGee (1977) has shown that the freshwater-saltwater interface in this area ranges from less than 300 to about 700 ft below sea level. This reduces the freshwater potential of this mass of sediments. A greater potential for ground-water development may occur near the mouth of the Beluga River. Quaternary sediments there are 1,200 to 1,900 ft thick, and the freshwater-saltwater interface is more than 2,000 ft below sea level, indicating a possible ground-water inflow from the Beluga and Theodore River drainage basins. Sediment thickness in the remainder of the study area is generally less than 1,000 ft. The thickness is probably less than 500 ft north of the Castle Mountain fault in the Susitna River basin.

FACTORS FOR CONVERTING
U.S. CUSTOMARY UNITS TO SI UNITS

Multiply U.S. customary units	By	To obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon per minute (gal/min)	.00006309	cubic meter per second (m^3/s)
foot per mile (ft/mi)	.1894	meter per kilometer (m/km)
cubic foot per second (ft^3/s)	.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
degree Fahrenheit (°F)	5/9(°F-32)	degree Celsius (°C)

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WATER RESOURCES OF THE COOK INLET BASIN, ALASKA

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