

Overview of Environmental and Hydrogeologic Conditions at Bethel, Alaska

By Joseph M. Dorava and Eppie V. Hogan

U.S. GEOLOGICAL SURVEY

Open-File Report 95-173

Prepared in cooperation with the

FEDERAL AVIATION ADMINISTRATION



Anchorage, Alaska
1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
4230 University Drive, Suite 201
Anchorage, AK 99508-4664

Copies of this report may be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Federal Center
Denver, CO 80225-0425

CONTENTS

Abstract	1
Introduction	1
Background	1
Location.....	1
History and socioeconomics	3
Physical setting	3
Climate	3
Vegetation	5
Bedrock geology	5
Surficial geology and soils	5
Hydrology	8
Surface water	8
Floods	9
Flood-protection measures	10
Erosion.....	11
Ground water.....	11
Ground-water and surface-water interaction.....	12
Drinking water.....	12
Present drinking-water supplies	12
Quality of the water supply	14
Alternative drinking-water sources	14
Quality of the alternative sources	15
Summary	15
References cited.....	16
Appendix 1: Well logs from the Pan American Petroleum Company and the U.S. Department of Energy.....	A-1
Appendix 2: Summary of Ground Water Site Inventory data from wells within 40 km of Bethel	A-2
Appendix 3: Selected ground-water quality data for the FAA well at the Bethel Airport ...	A-3

FIGURES

1. Map showing location of Bethel, Alaska, and Federal Aviation Administration facilities.....	2
2. Generalized lithologic logs for well 1 and well 2 near Bethel	6
3. Map showing location of well 2 near Bethel and cross section showing approximate thickness of permafrost	7
4. Hydrograph of discharge for the Kuskokwim River at Crooked Creek,	13
1992 water year.....	13
5. Diagram showing ground-water/surface-water interaction	13

TABLES

1. Mean monthly temperature, precipitation and snowfall for the period 1923-87, Bethel.	4
2. Mean monthly flows for water years 1985-93, Kuskokwim River at Crooked Creek	8
3. Mean monthly flows for water years 1988-93, Browns Creek near Bethel.	9
4. Flood records for the Kuskokwim River at Bethel.	10

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

	Multiply	By	To obtain
millimeter (mm)		0.03937	inch
centimeter (cm)		0.3937	inch
meter (m)		3.2808	foot
kilometer (km)		0.6214	mile
square kilometer (km ²)		0.3861	square mile
meter per kilometer (m/km)		5.2801	foot per mile
liter (L)		0.2642	gallon
liter per second (L/s)		15.85	gallon per minute
liter per day (L/d)		0.2642	gallon per day
cubic meter per second (m ³ /s)		35.31	cubic foot per second
degree Celsius (°C)		$^{\circ}\text{F} = 1.8 \times ^{\circ}\text{C} + 32$	degree Fahrenheit (°F)

Sea level:

In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in this report:

mg/L, milligram per liter
mL, milliliter

Overview of Environmental and Hydrogeologic Conditions at Bethel, Alaska

By Joseph M. Dorava and Eppie V. Hogan

Abstract

The city of Bethel is on the alluvial plain of the Kuskokwim River in southwestern Alaska. It has long cold winters and short summers. Bethel obtains its drinking water from a deep aquifer underlying permafrost. Surface spills and disposal of hazardous materials combined with possible annual flooding of the Kuskokwim River could affect the quality of drinking water. Alternative drinking-water sources are available from local lakes, streams, the Kuskokwim River, and possible undiscovered aquifers. The Federal Aviation Administration owns or operates airway support facilities in Bethel. They wish to consider the severity of contamination and the current environmental setting when evaluating options for compliance with environmental regulations at their facilities. This report describes the ground- and surface-water hydrology, geology, climate, vegetation, soils, and flood potential of the area surrounding Bethel.

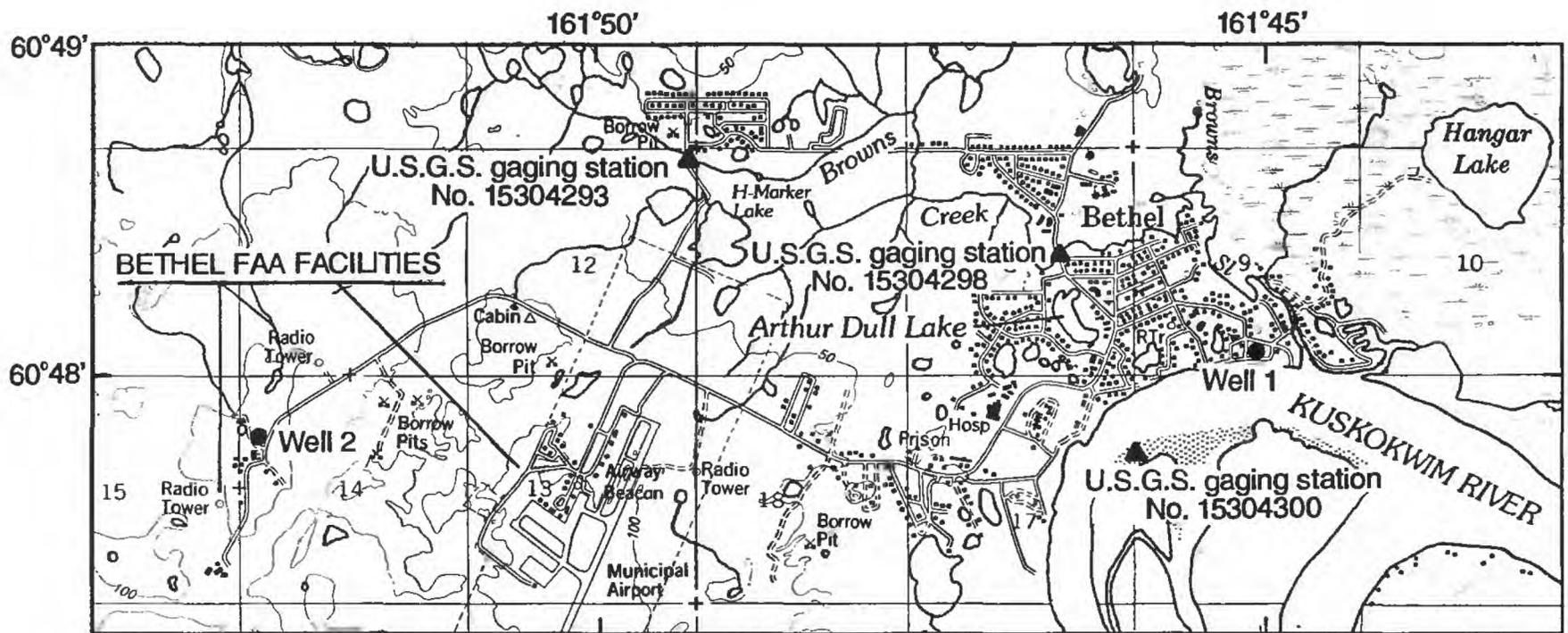
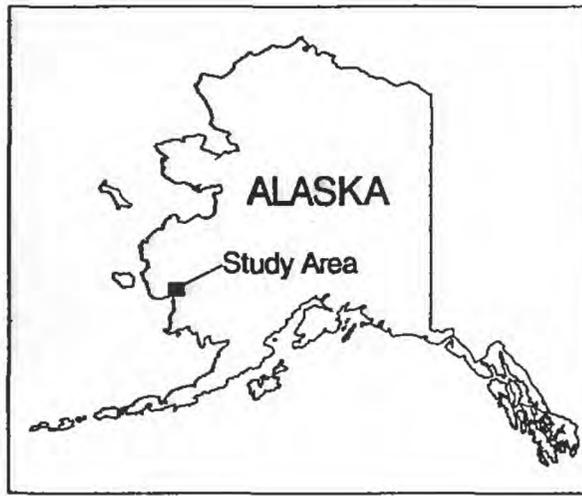
INTRODUCTION

The Federal Aviation Administration (FAA) owns and (or) operates airway support and navigational facilities throughout Alaska. At many of these sites, fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls, and pesticides may have been used and (or) disposed of. To determine if environmentally hazardous materials have been spilled or disposed of at the sites, the FAA is conducting environmental studies mandated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund Act") and the Resource Conservation and Recovery Act (RCRA). To complete these more comprehensive environmental studies, the FAA requires information on the hydrology and geology of areas surrounding the sites. This report, the product of compilation, review, and summary of existing hydrologic and geologic data by the U.S. Geological Survey, in cooperation with the FAA, provides such information for the FAA facility and nearby areas at Bethel, Alaska. Also presented in this report is a description of the history, socioeconomics, and physical setting of the Bethel area.

BACKGROUND

Location

Bethel is in southwestern Alaska (fig. 1) at lat 60°48" N. and long 161°45" W., on the banks of the Kuskokwim River approximately 645 km west of Anchorage. The city is in the southeastern part of the Yukon-Kuskokwim Coastal Lowland, a large delta formed by the Yukon and Kuskokwim Rivers. The FAA facilities in Bethel are concentrated at the municipal airport about 3.5 km west of the city. A detailed list of these facilities can be found in a report by Ecology and Environment, Inc. (1992).



Base from U.S. Geological Survey, Bethel (D-8), Alaska, 1:63,360, 1985.

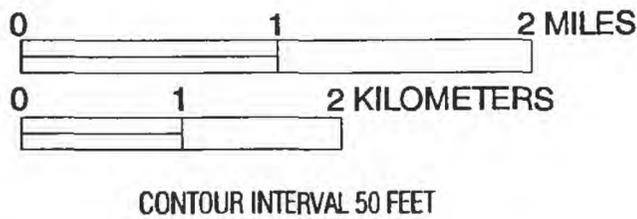


Figure 1. Location of Bethel, Alaska, and Federal Aviation Administration facilities.

History and Scioeconomics

At the time of first western contact, the Bethel area was occupied by the Yupik Eskimos who utilized the Kuskokwim River and its tributaries for subsistence fishing. A Moravian mission was established in 1885 and Bethel has since evolved into a transportation and commercial center for the lower Yukon and Kuskokwim Rivers area, as well as for most of southwestern Alaska. Bethel residents maintain some traditional Yupik life-styles: 70 percent of the population engages in subsistence food gathering and 40 percent speaks or understands Yupik (Darbyshire and Associates, 1979). Principal subsistence foods gathered in the area are fish, berries, and game birds.

The population of Bethel has increased by more than 4,000 people during the last 40 years. In 1950, the population was 650; in 1979 the population was about 3,900; and in 1990 it was 4,674 (Darbyshire and Associates, 1979; U.S. Bureau of Census, 1991). According to the 1990 census, 2,986 people are American Indian, Eskimo, or Aleut; 1,551 people are Caucasian, and the rest are of Asian, Pacific Islander, Black, or Hispanic origin. According to Harry Parsi (Bethel Public Works, written commun., 1994) the population of Bethel in June 1994 was 5,023 people.

Bethel is located approximately 100 km upstream from the Bering Sea and has become a transportation center for the region. Barges, mostly from Seattle and the Anchorage area, deliver food, fuel, construction supplies, and miscellaneous goods to the city port where they are distributed throughout the region by boat and plane.

In an area with few roads, the Kuskokwim River acts as a river highway system connecting Bethel with 48 other villages (U.S. Army Corps of Engineers, 1982). During the summer months, the river is used by boats and during the winter months, it becomes a frozen highway for dog-sleds, snowmobiles, and automobiles. The Bethel airport ranks third in Alaska for total flights and plays a key role in public transportation for the entire southwest region of Alaska (Darbyshire and Associates, 1979).

During and immediately following World War II, the Civil Aeronautics Administration (predecessor to the FAA) operated the Bethel Airport. At that time, the airport was on the east side of the Kuskokwim River. Frequent flooding caused the airport to be relocated in the early 1960's to the west side of the Kuskokwim River, about 3.5 km west of the city (fig. 1). The airport is currently operated and maintained by the Alaska Department of Transportation and Public Facilities. A detailed account of FAA owned, leased, or transferred properties in or near Bethel and a listing of suspected sources of contamination near these facilities can be found in an environmental compliance investigation report by Ecology and Environment, Inc. (1992).

PHYSICAL SETTING

Climate

Bethel lies in the transitional climate zone, where maritime conditions prevail during the summer and continental conditions dominate during the winter (Hartman and Johnson, 1984). Little precipitation and low humidity are typical in the long cold winter, while cloudy humid conditions characterize the short summer. The mean annual temperature is -1.6°C , but temperatures range from a July mean maximum of 19.2°C to a February mean minimum of about -18.4°C (Leslie, 1989). Mean annual precipitation is about 430 mm, with most rainfall occurring in August and September. Approximately 1,300 mm of snow falls annually. Mean monthly temperature, precipitation, and snowfall are summarized in table 1.

Table 1. Mean monthly temperature, precipitation, and snowfall for the period 1923 to 1987, Bethel
 [Modified from Leslie (1989); °C, degree Celsius; mm, millimeter]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	-10.6	-4.9	-1.0	4.1	12.6	17.7	19.2	17.8	13.6	5.3	-0.5	-5.9	5.6
	(Record maximum, 30.0 °C, July 1951)												
Mean minimum	-18.0	-18.4	-15.4	-9.4	-0.1	5.8	8.6	8.0	3.4	-4.4	-11.2	-17.6	-5.7
	(Record minimum, -43.3 °C, January 1973)												
Mean	-14.1	-13.7	-10.9	-4.1	4.6	10.8	12.6	11.5	7.3	-0.8	-8.1	-13.9	-1.6
Precipitation (mm of moisture)	20.6	18.0	20.3	16.5	21.1	32.8	55.4	92.7	65.5	37.6	24.9	24.1	429.3
Snowfall (mm)	185.4	167.6	213.4	142.2	45.7	2.5	0	0	2.5	101.6	195.6	228.6	1,285.2

Vegetation

Vegetation on the wet tundra near Bethel consists of sedges, sphagnum moss, Labrador tea, dwarf birch, and other low-growing tundra shrubs (Hinton and Girdner, 1966; Viereck and Little, 1972). Shrub thickets consisting of dense growths of alder, willows, and resin birch are found in some areas near Bethel, primarily along the Kuskokwim River. South of Bethel, where the land slopes toward the Kuskokwim River, the vegetation is moist tundra which consists of sedges, scattered willows, and dwarf birches (Viereck and Little, 1972).

Bedrock Geology

The geology of the Bethel area has been described by Spurr (1900), Maddren (1915), Mertie (1938, 1940), Rutledge (1948), Payne (1955), Cady and others (1955), Coonrad (1957), and Hoare and Coonrad (1959). Bedrock exposures in the Bethel area lie south and east of the city in the Kuskokwim and Kilbuck Mountains. The mountains run in a north-northeasterly direction approximately 65 km southeast of the city. The bedrock exposures consist mainly of volcanic and sedimentary rocks (Hoare and Coonrad, 1959). Little data are available on the depth to bedrock in the Bethel area. A Pan American Petroleum Company well, drilled approximately 26 km west of Bethel, reported permafrost to 107 m, a fresh-water zone from 107 to 143 m, and bedrock starting at 143 m below the land surface; however, two Department of Energy test wells drilled in 1980 in Bethel penetrated only unconsolidated deposits to depths of approximately 230 m below the land surface (appendix 1).

Surficial Geology and Soils

Bethel is on the alluvial plain of the Kuskokwim River. Major surficial deposits surrounding Bethel are Quaternary-age alluvium consisting of mud, silt, sand, gravel, and boulders, intermixed with wood, peat, and other organic material (Hoare and Coonrad, 1959). The alluvial plain is bounded on the west by a terrace escarpment of older silt and sandy silt Yukon-Kuskokwim delta deposits.

Waller (1957) describes the lithology from well 1 (fig. 1), a 119-m-deep well drilled in the flood plain near Bethel. A generalized lithologic log of this well (fig. 2) shows that the soil was frozen to a depth of about 115 m. A thawed coarse-gravel aquifer yielded water between 116 m and the bottom of the well at 119 m. A generalized lithologic log from well 2 (fig. 2), a 202-m-deep well drilled in the delta deposits near Bethel (fig. 1), indicates permafrost to a depth of about 184 m below land surface. A silty sand and pebble aquifer underlies the permafrost (Feulner and Schupp, 1964).

The soils of the Bethel area are similar to those found along Alaska's western coastal plain and deltas (Rieger and others, 1979). The upland area east of Bethel is mantled with wind-blown silt; however, exposures of stratified sand and alluvial silt sediments deposited by the Yukon and Kuskokwim Rivers are present. The silty soils are susceptible to frost and are generally saturated over shallow permafrost at depths ranging from 12 to 75 cm below land surface (Rieger and others, 1979; Hinton and Girdner, 1966).

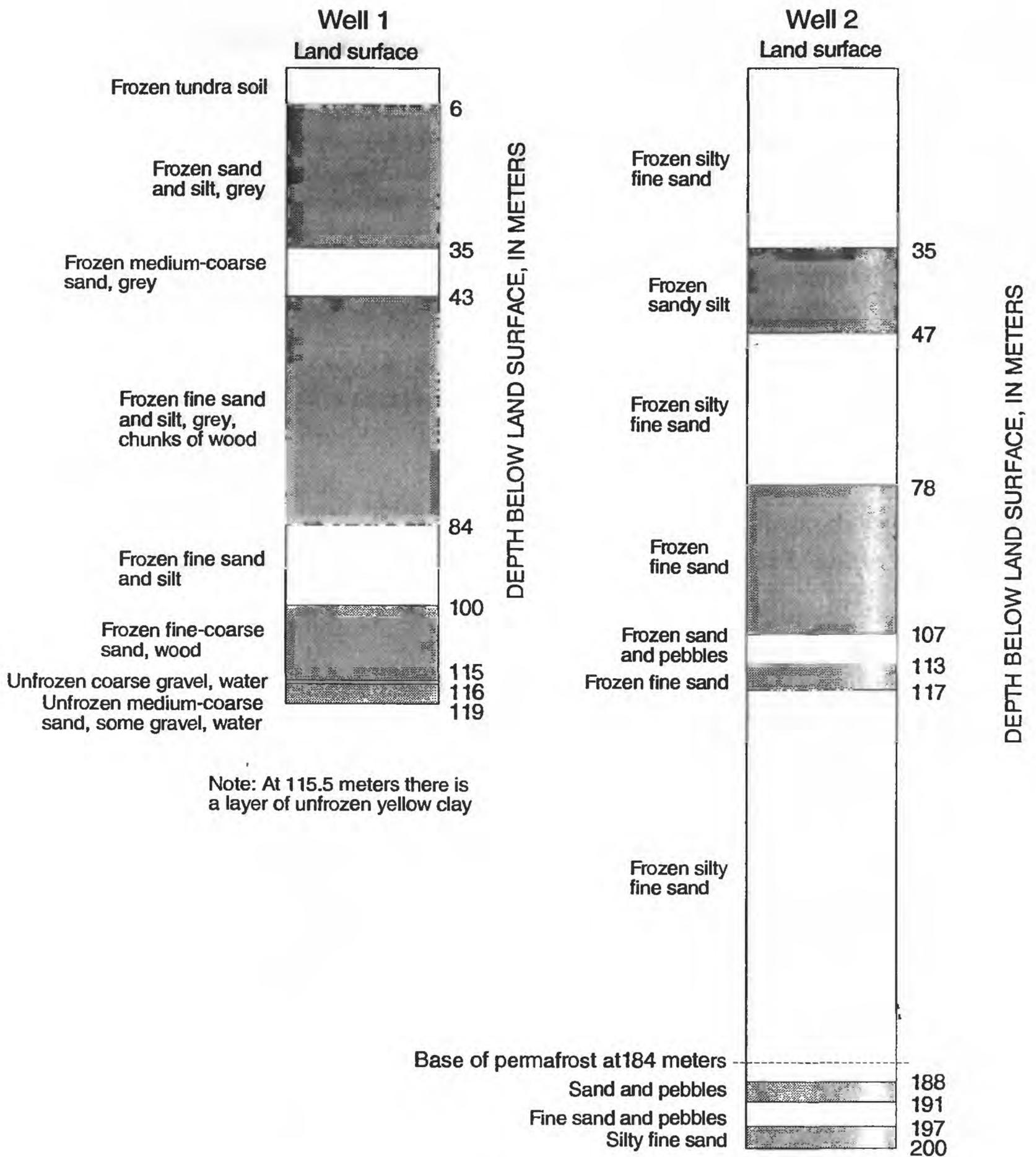


Figure 2. Generalized lithologic logs for well 1 and well 2 near Bethel. (See figure 1 for well locations.) [Well 1 modified from Waller (1957); well 2 modified from Feulner and Schupp (1964)].

Six principal soil series have been identified and mapped in the Bethel area (Hinton and Girdner, 1966). Soil identified as the Kuskokwim-Kwethluk complex makes up about 37 percent of the mapped area. This soil is found in small areas on low knolls, on convex slopes bordering drainages, and adjacent to drained thaw lakes. Kuskokwim silt loam accounts for 36 percent of the mapped area. This soil consists of poorly drained silty soils having shallow permafrost tables and is primarily found on the wet tundra. Susitna fine loam accounts for about 12 percent of the mapped area. This well-drained soil is found on alluvial plains bordering the Kuskokwim River. The three other soil groups—Napaishak, Tuluksak, and Tupuknuk—occupy only 14 percent of the mapped area and primarily occur along the shores of small lakes and streams (Hinton and Girdner, 1966).

The Bethel area is near the southern border of the continuous permafrost zone (Ferrians, 1965). The city and most of the area west of the Kuskokwim River appear to be underlain with permafrost; however, the area east of the river and isolated areas to the west appear to be free of permafrost to a depth of 60 m (Waller, 1957). In isolated areas west of the river, thawed zones exist where there is or was an overlying body of surface water. These thawed zones may have been created by a tributary of the Kuskokwim River within comparatively recent times (Feulner and Schupp, 1964) (fig. 3).

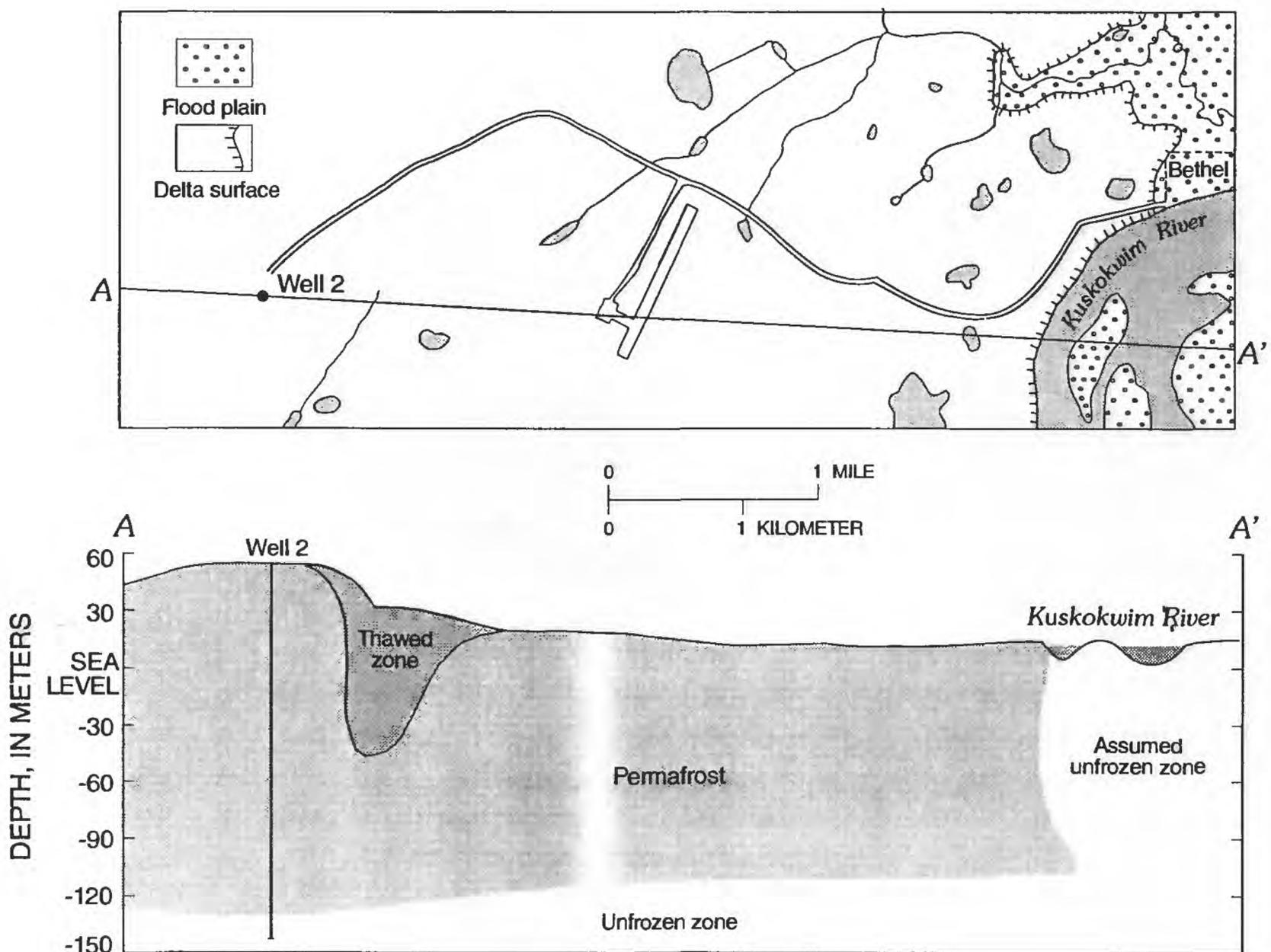


Figure 3. Location of well 2 near Bethel showing approximate thickness of permafrost (modified from Feulner and Schupp, 1964).

HYDROLOGY

Surface Water

The Kuskokwim River is the principal fresh-water body near Bethel and flows from northeast to southwest along the southern edge of the city. The river stage is influenced by diurnal tidal back-water effects. Corresponding with the normal flood and ebb flow, velocities in the river range from 0.25 to 0.67 m/s (Lanning, 1987). Despite tidal influences, saltwater does not infiltrate into areas near Bethel. Surrounding the city in all directions are numerous small lakes, ponds, and marshes that are characteristic of the Yukon-Kuskokwim Coastal Lowlands.

Daily flow of the Kuskokwim River near Bethel has not been measured; however, from 1951 to 1993, data were collected at an upstream location: Kuskokwim River at Crooked Creek (USGS gaging-station No. 15530400). This gaging-station is approximately 225 km northeast of Bethel and has a drainage area of about 50,000 km² (U.S. Geological Survey, 1994). Mean monthly flow data for the Kuskokwim River at Crooked Creek are given in table 2. The mean monthly flow of the river changes significantly from summer to winter. Peak flows during spring breakup in May and June average about 2,300 m³/s. Fall rains in August and September also cause an increase in discharge from the summer low in July. Flow in the river drops rapidly after freeze-up to a winter low of about 300 m³/s in March (U.S. Geological Survey, 1994).

Table 2. Mean monthly flows for the water years 1985-93, Kuskokwim River at Crooked Creek (USGS gaging-station No. 15530400)

[Values in cubic meters per second]

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
370	330	300	390	2,200	2,400	1,940	2,150	2,000	1,220	590	430

The mean monthly flow of the Kuskokwim River near Bethel has been estimated from the record at Crooked Creek. During the open-water months from May to September, the estimated mean flow of the Kuskokwim River near Bethel is about 1,700 m³/s and during winter months, from November to March, mean flow is about 425 m³/s (U.S. Army Corps of Engineers, 1982). The Kuskokwim River drains an area of about 111,000 km² upstream from the city of Bethel (U.S. Army Corps of Engineers, 1968). The Kuskokwim River typically freezes in late October or early November and breaks up in May. Although the river is important to residents of Bethel, it has also caused damage to the community by flooding and erosion of the riverbanks.

Browns Creek, a small tributary stream draining the area north and west of Bethel, flows from northeast to southwest between the city and the airport (fig. 1). This stream drains an area of about 27 km² upstream from USGS gaging-station No. 15204298, Browns Creek at Bethel, where peak flow discharges have been collected from 1985 to 1993. The peak discharge for this period was 9.9 m³/s on May 7, 1985. In the 1993 water year, rainfall runoff on September 10 caused a maximum discharge of 6.4 m³/s, and snowmelt runoff on April 22 caused a discharge of about 3.6 m³/s (U.S. Geological Survey, 1994).

Another gaging-station, Browns Creek near Bethel (USGS gaging-station No. 15304293, fig. 1), is approximately 3 km northwest of Bethel and has a drainage area of 12.4 km². For the period 1985-93, mean monthly flows from April to October are all less than 0.4 m³/s and are summarized in table 3 (U.S. Geological Survey, 1994). The greatest mean flows on Brown's Creek are observed during spring breakup when water is abundant from snowmelt. Little rainfall occurs during June and July when summer low flows are often less than 0.08 m³/s. Rainstorms in late August and early September are the source of increased flow during the fall, and the creek is believed to freeze completely during winter months. Discharge measurements were not obtained from November to March.

Table 3. Mean monthly flows for the water years 1985-93, Browns Creek near Bethel (USGS gaging-station No.15304293)

[Values in cubic meters per second]

April	May	June	July	August	September	October
0.248	0.362	0.077	0.020	0.100	0.183	0.074

Numerous sloughs and small lakes in meander scars near Bethel (fig. 1) indicate that the Kuskokwim River has changed its course over time. Hangar Lake, approximately 1 km² in size, is about 3 km east of Bethel and is used for a seaplane anchorage. H-Marker Lake, approximately 0.5 km² in size, is about 2 km west of Bethel immediately north of the airport.

A gradual topographical gradient of approximately 10 m/km is present between the Bethel Airport and the city of Bethel (fig. 3). The northeasterly slope generally causes runoff to flow towards tributaries that drain to the Kuskokwim River. Little data are available to determine the degree to which runoff is infiltrating the aquifer, but the quantity of surface water in the immediate area and the presence of extensive permafrost indicate that infiltration is minimal.

Floods

Bethel is flooded to some extent annually and is considered to have a high flood hazard (U.S. Army Corps of Engineers, 1982 and 1993a). Although flooding during spring breakup is caused primarily by ice jams, late summer and early fall rains can also be a source of flooding (U.S. Army Corps of Engineers, 1987). Autumn rain falling on saturated soils and areas where permafrost exists, runs off rapidly causing a subsequent rapid rise in the river (U.S. Army Corps of Engineers, 1987).

Ice-jam flooding is the predominant type of flooding in the Bethel area. This type of flooding occurs during spring breakup, when ice begins to move in the river. As the ice breaks up, it flows downstream until its movement is blocked. The blockage restricts water flow which produces a rise in water level or "backwater" effect upstream from the ice jam. When the ice jam releases, a flood wave propagates downstream and large ice volumes are mobilized (Beltaos, 1990).

On the Kuskokwim River downstream from Bethel, tight meander bends and islands create narrow channels that work together to produce frequent ice-jam formations and subsequent backwater floods in the city. In addition, the Kuskokwim River near Bethel flows through low-gradient topography with little velocity to clear ice jams (Larry Rundquist, National Weather Service River Forecast Center, oral commun., 1994)

Backwater effects from ice-jam floods are responsible for most of the reported damage to personal property and buildings in Bethel (Federal Emergency Management Agency, 1984). Ice-jam floods may cause several times more damage than open-water floods because of the large ice volumes transported (Beltaos, 1990). The flood records and subsequent flood heights (table 4) are from the U.S. Army Corps of Engineers (1982) with reference to mean lower low water datum of the Kuskokwim River.

Table 4. Flood records for the Kuskokwim River at Bethel

Date	Height (meters above mean lower low water datum)
Ice-jam floods	
Spring 1941	4.3
5-14-76	4.3
5-14-89	4.1
Runoff floods	
9-1-63	3.8
6-9-64	4.4

Floods on small drainages in the Bethel area are similar to those occurring on the Kuskokwim River. Peak flooding on smaller streams usually occurs during spring breakup in April or May; however, a peak caused by rainstorms in the fall can be comparable. On Browns Creek near Bethel, eight out of nine annual peaks occurred during spring breakup (U.S. Geological Survey, 1994).

Low-relief terrain, frozen ground, and poor drainage exacerbate small flooding problems in the Bethel area. Snow and ice clog stream channels in the spring, causing water to flow in over-bank areas. In addition, frozen culverts at road crossings force meltwater to collect up slope, thereby making roads susceptible to flooding and erosion.

The FAA facilities near the airport are not affected by flooding on the Kuskokwim River because they are at an elevation higher than the 100-year flood (U.S. Army Corps of Engineers, 1970). However, the facilities may be affected by potential flooding in small unnamed streams that drain the airport area during heavy rainfall or snowmelt runoff periods. Not enough detail on the local topography is available to quantify this flood potential at specific FAA facilities.

Flood Protection Measures

No specific flood protection measures have been constructed in the Bethel area; however, emergency sandbagging and evacuations have been undertaken during times of flooding (U.S. Army Corps of Engineers, 1968). The National Weather Service (NWS) and the Alaska Division of Emergency Services (ADES) have set up a warning system to keep residents along the Kuskokwim River informed of potential flooding (U.S. Army Corps of Engineers, 1987). Officials from the NWS, U.S. Army Corps of Engineers, and the ADES are in the field each spring monitoring breakup and reporting ice conditions that might endanger the population. The ADES coordinates emergency flood protection and evacuation measures carried out by various Federal, State, and local agencies (U.S. Army Corps of Engineers, 1987).

Erosion

Erosion in Bethel has been a problem since the community was settled. Initially the waterfront in Bethel was separated from the main channel of the Kuskokwim River by a series of small islands. By 1939, the river had eroded the protective islands and had begun migrating towards the city (U.S. Army Corps of Engineers, 1993b). Two types of erosion occur along the river: during spring breakup localized high velocity water influences the shape of the riverbed and the location of the main channel, and during summer months warm-water eddies thaw the permanently frozen riverbanks, making them susceptible to sloughing (Lanning, 1987).

Factors that may exacerbate erosion problems along the Kuskokwim River at Bethel include a steep riverbank that is composed of easily erodible material, a riverbank that has a southeast aspect which results in direct sun causing the melting of permafrost, and heavy foot traffic that destroys protective vegetation. These factors, combined with wave action from prevailing winds and wakes from boat traffic, create an unstable riverbank. The result is 5 m or more of bank erosion during the last 50 years (U.S. Army Corps of Engineers, 1982; Lanning, 1987).

Since 1966, the city of Bethel and the U.S. Army Corps of Engineers have been working together to find solutions to the erosion problem. Potential solutions, such as erecting a timber bulkhead and driving steel pilings 10-15 m below the ground, have been tried. The first official erosion control structure was a 914-m-long timber bulkhead that was built in 1965-66. By 1971, this structure had been undermined by scour and became ineffective. Following the failure of this bulkhead, the local community began to place junked cars and other large objects along the waterfront. Although this was moderately successful in controlling erosion, the Alaska Department of Environmental Conservation prohibited any further placement of additional cars because of contamination concerns. In 1982 and 1984, the city used State funding to erect sheet pile walls in hopes of alleviating the situation. These actions have helped, but have not solved the erosion problem. Further studies and planning continue (U.S. Army Corps of Engineers, 1993b; Lanning, 1987).

Ground Water

Ground water is abundant in the Bethel area and is present as a confined aquifer in the deep subpermafrost silt, sand, and pebble deposits west of the Kuskokwim River, and in permafrost-free areas along the east side of the river. Little relief is present near Bethel, and adequate data are not available to define flow directions or depths of ground water. On a regional scale, however, the subpermafrost ground water is probably flowing towards the southwest, matching the flow direction of the Kuskokwim River (Waller, 1957). The shallow ground water above permafrost probably flows in the direction of topographic gradients to local surface-water drainages such as Browns Creek.

Waller (1957) reports that well 1 (fig. 1) was drilled to a depth of about 119 m and reached water that rose in the well to a depth of 2.74 m below the land surface. The uncased well was pumped at a rate of 1.3 L/s which resulted in a 7.62 m drawdown. The water level recovered completely within 41 minutes. The well was then cased and a static water level was maintained between 2.74 and 3.0 m below land surface. After 6 hours of pumping at a rate of 0.3 L/s, drawdown in this well was 5.8 m. After this pumping, the water again returned to a level maintained between 2.74 and 3.0 m below land surface.

Two test wells drilled east of the city indicated the existence of an isolated thawed area within the permafrost, called a “talik,” which contains ground water (Waller, 1957). However, because of the presence of extremely fine-grained sediment, development of this supra-permafrost aquifer would not be practical (Waller, 1957). Shallow zones of unfrozen ground were also found east of the city near Hangar Lake (fig. 1). These unfrozen zones appear to be ubiquitous throughout the region and are probably the result of local thawing under the numerous lakes and ponds in the area. Taliks may also represent thawing under a former position of the Kuskokwim River (Waller, 1957; Williams, 1970). In the event of a surface release of contaminating materials, permafrost, acting as an impermeable layer, would inhibit flow of these materials to the underlying aquifer.

Ground Water and Surface Water Interaction

Typically, discharges of local rivers fluctuate from a snowmelt maximum in late May or early June to a pre-breakup minimum in late March or April. In addition, several rainfall-induced peaks may be observed in late summer. This seasonal fluctuation of discharge from local streams is illustrated by the hydrograph for the Kuskokwim River at Crooked Creek (fig. 4). When permafrost does not confine flow to a narrow zone or strip adjacent to the river, shallow ground water flows into and out of the riverbanks as the elevation of the river rises and falls. These “bank storage effects” fluctuate with river stages, and decrease with distance from the river (Linsley and others, 1982) (fig. 5). The extent of ground-water/surface-water interaction at Bethel has not been documented, but frozen banks were likely to significantly reduce bank storage.

DRINKING WATER

Present Drinking Water Supplies

The main source of drinking water in the Bethel area is ground water, located predominately under the permafrost at depths greater than 114 m (Waller, 1957; Williams, 1970). Public drinking water in Bethel comes from two wells: one has a capacity of approximately 28 L/s and the other approximately 4 L/s. Bethel has a public utility that provides approximately 4,750 residents with drinking water (Harry Parsi, Bethel Public Works, written commun., 1994). The public utility water is filtered for sediment, treated with chlorine, and stored in two storage tanks with a combined capacity of approximately 379,000 L. The water is distributed by truck to about 2,290 people and by piping through an above-ground system to another 2,460 people. The remaining people in the Bethel area do not receive water services from the public utility. Long-range plans are being formulated to serve the entire city with the above-ground drinking-water distribution utility (Harry Parsi, Bethel Public Works, oral commun., 1994).

Four wells have been reportedly owned by the FAA in Bethel (appendix 2). Well SB00807213ACBB1 002 is the only well that currently supplies water to the FAA facilities. The others have been abandoned or use by the FAA has been discontinued (Ecology and Environment, 1992).

The estimated average residential water consumption rate for Bethel’s piped system users is 10 times greater than that for hauled system users. The approximately 736 residences and businesses using truck-hauled water consume an estimated 50,400 L/d of water, while the approxi-

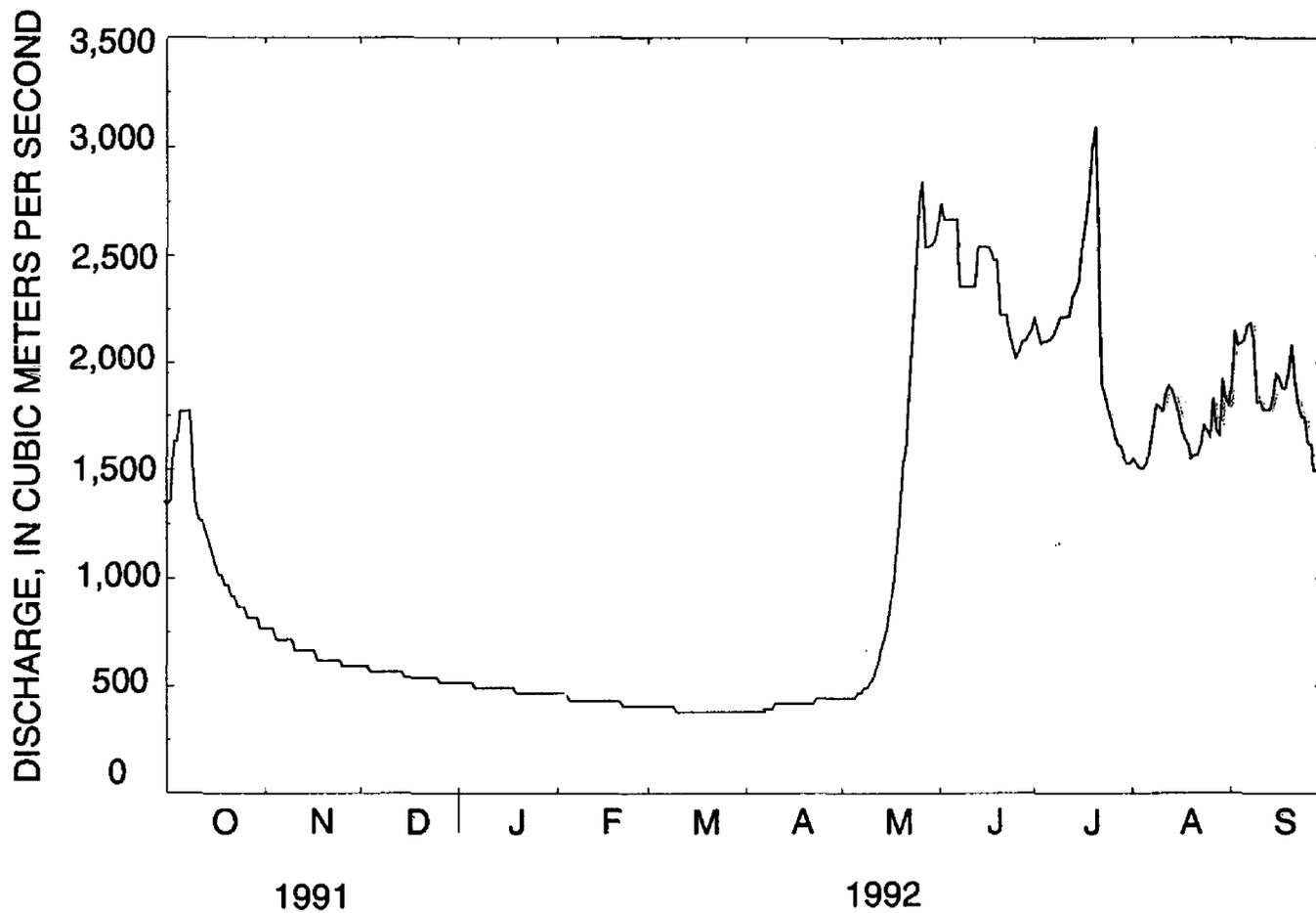


Figure 4. Discharge for the Kuskokwim River at Crooked Creek, 1992 water year.

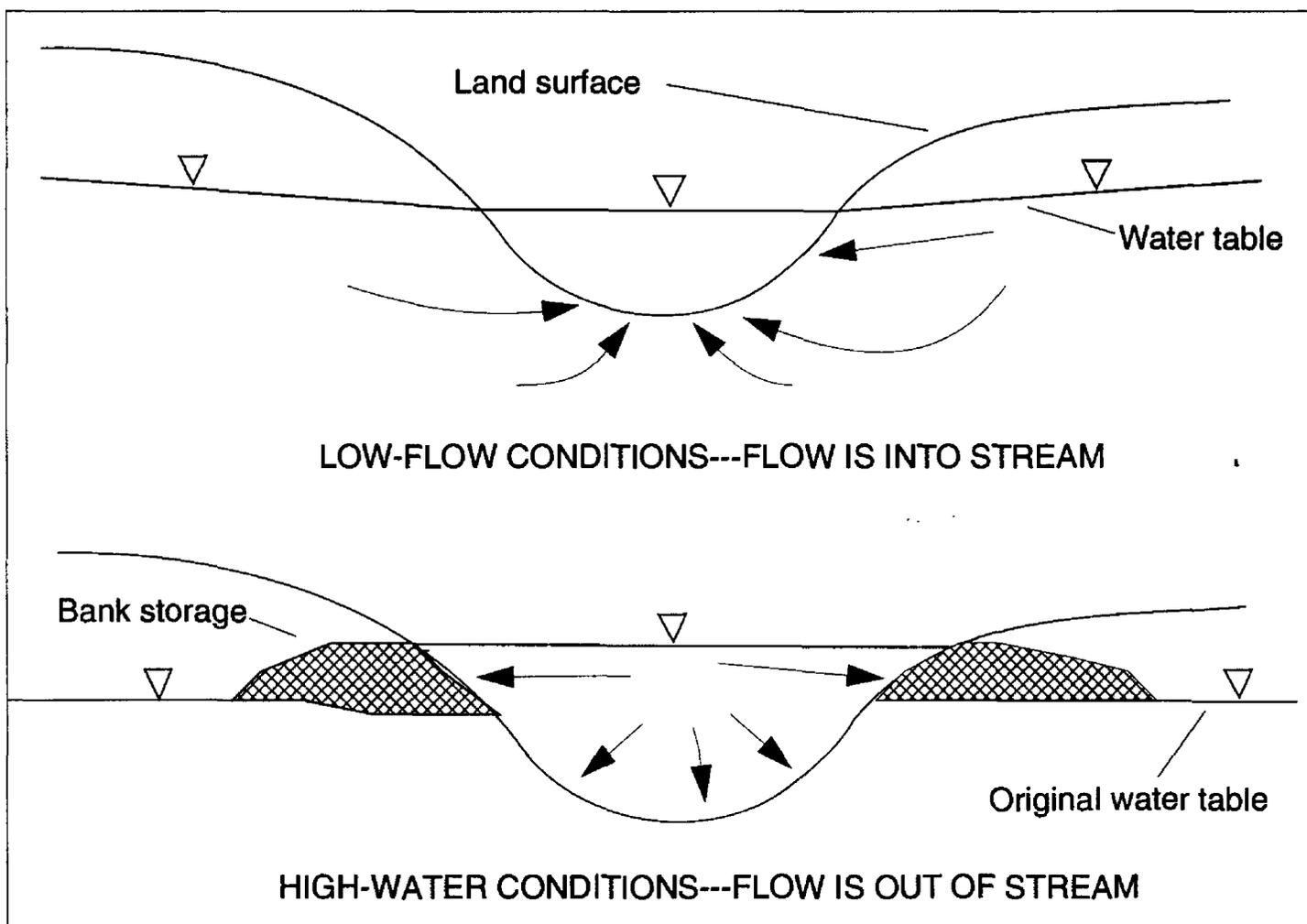


Figure 5. Ground-water/surface-water interaction.

mately 794 piped system residences consume an estimated 528,900 L/d, or 22 L/d per person, of water, for a combined total of 579,300 L/d of water drawn from the Bethel public system overall. The water use in the city of Bethel is less than 20 percent of the average water use of 1,950 L/d per person for the State of Alaska (Solley and Pierce, 1993).

Quality of the Water Supply

The aquifer on the west side of the Kuskokwim River lies below permafrost. Waller (1957) found that this water typically has iron concentrations higher than the U.S. Environmental Protection Agency (USEPA, 1992) secondary maximum contaminant level of 0.30 mg/L. Water-quality analyses of samples from one well at the airport and two wells about 2 km west of the airport (Feulner and Schupp, 1964) also indicated iron concentrations above the USEPA secondary maximum contaminant level. These samples contained dissolved iron contents of less than 0.87 mg/L, a silica content ranging from 9.8 to 34 mg/L, and a hardness as CaCO₃ ranging from 98 to 118 mg/L. Silica and hardness may create scale in plumbing or boilers but is generally of little concern to most users.

Water samples were collected by the USGS in 1959 from two wells at the airport owned by the FAA. Analyses of the water samples indicated that major inorganic constituents were at concentrations acceptable for drinking water. A 132-m-deep well produced water having an iron content of 0.130 mg/L, and a silica content of 34 mg/L. A 128-m-deep well produced water that had an iron content of 3.2 mg/L. Although the iron content is higher than the 0.30 mg/L secondary maximum contaminant level guidelines set by the USEPA (1992) for drinking water, it does not prohibit this water from being utilized for drinking. The USGS Ground-Water Site Inventory contains information on approximately 35 wells located within 40 km of Bethel (appendix 2).

Water-quality analyses of samples obtained each month from a well at the FAA facilities indicate that the water is of acceptable quality for a drinking-water supply (Harry Gilmore, Federal Aviation Administration, written commun., 1994). Analyses made from May 1990 through July 1992 for volatile and semi-volatile organic carbons, radio-chemicals, and some metals are shown in appendix 3.

Alternative Drinking-Water Sources

Alternative drinking-water sources for Bethel may include local lakes, streams, the Kuskokwim River, and undiscovered aquifers. Many of the local lakes may be too small to supply the city with adequate drinking water. Shallow lakes may freeze completely in the winter or to such depths that dissolved salts are concentrated in the unfrozen water. Hangar Lake, H-Marker Lake, and Arthur Dull Lake (fig. 1) may supplement the water supply, but the quantity and quality are unknown.

The flow from Browns Creek near Bethel, measured at USGS gaging-station No. 15304293, (fig. 1) is controlled directly by the amount of runoff present. During winter and dry periods in the summer, flow may be inadequate (table 3) to supply the estimated water use for Bethel. However, when runoff is abundant from snowmelt or rainfall, this source may be used to augment the drinking water supply. Browns Creek is vulnerable to contamination by human activities in the Bethel area.

The Kuskokwim River represents an abundant source of drinking water for Bethel. During months of low discharge in the winter, mean flow of the Kuskokwim River at Bethel is approximately 425 m³/s and is more than 60,000 times the quantity of estimated water use at Bethel.

Exploratory drilling for aquifers deeper than the presently used aquifer has not been conducted. Permafrost is found at depths between 107 and 184 m below land surface (appendix 1). Almost all of the Bethel's residents utilize the confined subpermafrost aquifer for drinking water. Contamination of the present drinking-water supply would likely require the development of a surface-water collection and treatment system.

Quality of the Alternative Sources

The quality of the Kuskokwim River water was monitored at a stream-gaging station in Bethel (No. 15304300) (fig. 1) during 1954-55 and 1970-71. The limited record of water quality indicates that with appropriate treatment facilities, the Kuskokwim River could be used as a drinking-water source. The most recent water sample from the Kuskokwim River at Bethel, taken in 1970, indicated dissolved iron concentrations of 0.02 mg/L, a hardness as CaCO₃ of 26 mg/L, and silica concentrations of 12 mg/L.

The quality of the Kuskokwim River has been monitored at Crooked Creek (USGS gaging-station No. 15530400) for more than 35 years as part of the USGS National Stream-Quality Accounting and Radiochemical Network. The record of water quality indicates that the number of fecal coliform in the water, especially during the fall season following salmon spawning, has exceeded drinking-water regulations. On October 5, 1989, the fecal coliform count was 43 colonies/100 mL of water (U.S. Geological Survey, 1991). The suspended-sediment concentration in the water was measured at 316 mg/L on July 16, 1991 (U.S. Geological Survey, 1992).

In 1955, water-quality samples were collected by the U.S. Geological Survey from Hangar Lake near Bethel. Sample analysis indicates a silica content of 4.0 mg/L, a hardness as CaCO₃ of 7.0 mg/L, and dissolved iron concentrations as high as 0.29 mg/L (Waller, 1957). Data to determine the quality of water in Browns Creek have not been obtained.

SUMMARY

Bethel's remote location makes it dependent on the airport and the river for transportation. The subsistence lifestyle of the Native residents makes them dependent on a sustainable environment. Flooding caused by ice jams and runoff are a hazard for Bethel residents. Most residents currently obtain drinking water from a single subpermafrost aquifer. If this aquifer becomes contaminated, the potential for developing new wells in undiscovered aquifers is unknown. The Kuskokwim River, Browns Creek, and local lakes may represent alternative drinking-water sources; however, the quality and quantity of these water resources have not been adequately documented.

REFERENCES CITED

- Beltaos, Spyridon, 1990, Breakup jams, *in* Ryan, R.L., and Crissman, R.D., eds., Cold regions hydrology and hydraulics: American Society of Civil Engineers Monograph, p. 485-510.
- Cady, W.M., Wallace, R.E., Hoare, J.M., and Webber, E.J., 1955, The central Kuskokwim region, Alaska: U.S. Geological Survey Professional Paper 268, 132 p.
- Coonrad, W.L., 1957, Geological reconnaissance in the Yukon-Kuskokwim delta region, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-223, scale 1:500,000.
- Darbyshire and Associates, 1979, City of Bethel comprehensive development plan—Volume 1, Community survey analysis—A statement of Bethel community attitudes: U.S. Department of Housing and Urban Development, and Alaska Department of Community and Regional Affairs, variously paged.
- Ecology and Environment, Inc., 1992, Environmental compliance investigation report, Bethel FAA station, Bethel Alaska: Anchorage [Draft report available from Federal Aviation Administration, Alaskan Region], variously paged.
- Federal Emergency Management Agency, 1984, Flood insurance study—City of Bethel, Alaska: Federal Emergency Management Agency, 10 p.
- Ferrians, O.J., Jr., 1965, Permafrost map of Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-445, 1 sheet, scale 1:250,000.
- Feulner, A.J., and Schupp, R.G., 1964, Temperature and chemical quality of water from a well drilled through permafrost near Bethel, Alaska, *in* Geological survey research, 1964: U.S. Geological Survey Professional Paper 501-D, p. D145-D148.
- Hartman, C.W., and Johnson, P.R., 1984, Environmental atlas of Alaska: University of Alaska Fairbanks, Institute of Water Resources/Engineering Experiment Station, 95 p.
- Hinton R.B., and Girdner C.L., 1966, Soils of Bethel area, Alaska: U.S. Soil Conservation Service report, 29 p.
- Hoare, J.M., and Coonrad, W.L., 1959, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Map I-285, scale 1:250,000.
- Lanning, D.C., 1987, Kuskokwim River bank erosion—Bethel Alaska: *The Northern Engineer*, v. 18, nos. 2 & 3, 6 p.
- Leslie, L.D., 1989, Alaska climate summaries (2d ed.): University of Alaska Anchorage, Arctic Environmental Information and Data Center, Alaska Climate Center Technical Note 5, variously paged.
- Linsley, R.K., Kohler, M.A., and Paulhus, J.L., 1982, Hydrology for engineers (3d ed.): McGraw Hill Book Company, 508 p.
- Maddren, A.G., 1915, Gold placers of the lower Kuskokwim, *with a note on* Copper in the Russian Mountains: U.S. Geological Survey Bulletin 622-H p. 292-360.
- Mertie, J.B., Jr., 1938, The Nushagak district, Alaska: U.S. Geological Survey Bulletin 903, 96 p.
- _____ 1940, The Goodnews platinum deposits, Alaska: U.S. Geological Survey Bulletin 918, 97 p.
- Payne, T.G., 1955, Mesozoic and Cenozoic tectonic elements of Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-84, scale 1:5,000,000.
- Rieger, Samuel, Schoephorster, D.B., and Furbush, C.E., 1979, Exploratory soil survey of Alaska: Soil Conservation Service report, 213 p.
- Rutledge, F.A., 1948, Investigation of the Rainy Creek mercury prospect, Bethel District, Kuskokwim Region, southwestern Alaska: U.S. Bureau of Mines Report of Investigations 4361, 7 p.
- Solley, W.B., and Pierce, R.R., 1993, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.
- Spurr, J. E., 1900, A reconnaissance in southwestern Alaska in 1898: Twentieth Annual Report of the U.S. Geological Survey, 1898-99, part VIIb, p. 31-264.

- U.S. Army Corps of Engineers, 1968, Flood plain information, Kuskokwim River, Bethel, Alaska: U.S. Army Corps of Engineers, variously paged.
- ____ 1970, Flood insurance study—Kuskokwim River, Bethel, Alaska: U.S. Army Corps of Engineers, Alaska District [prepared for Federal Insurance Administration], 11 p.
- ____ 1982, Bank stabilization, Bethel, Alaska, final environmental impact statement and feasibility report: U.S. Army Corps of Engineers, variously paged.
- ____ 1987, Interim water resource study, Yukon and Kuskokwim Rivers, Alaska: U.S. Army Corps of Engineers, variously paged.
- ____ 1993a, Alaskan communities—Flood hazard data: U.S. Army Corps of Engineers, Alaska District, 335 p.
- ____ 1993b, Environmental assessment, bank stabilization plan, Bethel, Alaska: U.S. Army Corps of Engineers, variously paged.
- U.S. Bureau of Census, 1991, *Percent distribution Alaska population by sex, race and Hispanic origin—1990 census*: Compiled by Alaska Department of Labor, Research and Analysis, 3 p.
- U.S. Geological Survey, 1991 Water resources data for Alaska, water year 1990: U.S. Geological Survey Water-Data Report AK-90-1, 252 p.
- ____ 1992, Water resources data for Alaska, water year 1991: U.S. Geological Survey Water-Data Report AK-91-1, 415 p.
- ____ 1994, Water resources data for Alaska, water year 1993: U.S. Geological Survey Water-Data Report AK-93-1, 373 p.
- Viereck, L.A, and Little, E.L., 1972, Alaska trees and shrubs: U.S. Department of Agriculture, Agriculture Handbook No. 410, 265 p.
- Waller, R.M., 1957, Groundwater and permafrost at Bethel, Alaska: U.S. Geological Survey Hydrological Data Report 2, 11 p.
- Williams, J.R., 1970, Ground water in the permafrost regions of Alaska: U.S. Geological Survey Professional Paper 696, 60 p.

APPENDIX 1

Well logs from the Pan American Petroleum Company
and U.S. Department of Energy

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

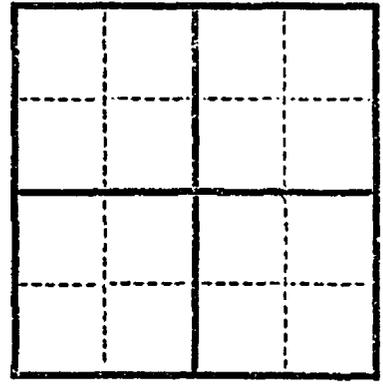
WELL SCHEDULE

Date MARCH 27, 1963 Field No. _____
Record by W Office No. _____
Source of data COPY LTR. W. VAN ALLEN to T.L. PEWIE 3-14-63

1. Location: State ALASKA County _____
Map 1900' S/NL; 800' E/W L (BITHEL AREA)
1/4 sec. 20 T 8 S R 74 (W)

2. Owner: PAN-AM OIL - PAN AM OIL Address MAPAŁUK CREEK
Tenant CORIE HOLE #1 Address _____
Driller _____ Address _____

3. Topography _____
4. Elevation 35± ft. above _____
below _____
5. Type: Dug, drilled, driven, bored, jetted 1961
6. Depth: Rept. 470 ft. Meas. _____ ft.
7. Casing: Diam. _____ in., to _____ in., Type _____
Depth _____ ft., Finish _____



8. Chief Aquifer _____ From _____ ft. to _____ ft.
Others _____
9. Water level _____ ft. rept. _____ 19 _____ above
meas. _____ below _____
_____ which is _____ ft. above
below surface

10. Pump: Type _____ Capacity _____ G. M.
Power: Kind _____ Horsepower _____
11. Yield: Flow _____ G. M., Pump _____ G. M., Meas., Rept. Est. _____
Drawdown _____ ft. after _____ hours pumping _____ G. M.
12. Use: Dom., Stock, PS., RR., Ind., Irr., Obs. _____
Adequacy, permanence _____

13. Quality _____ Temp _____ °F.
Taste, odor, color _____ Sample Yes _____
No _____
Unfit for _____

14. Remarks: (Log Analyses, etc.) pts to 350'
fresh water zone 350 to 470'
bedrock @ 470'

SURFACE FROZEN QUATERNARY
350' BASE OF PERMA FROST
470' TOP OF CONSOLIDATED SEDIMENTS
(BED ROCK)

WELL DATA FOR BETHEL, ALASKA - DEPARTMENT OF ENERGY WELLS

1DATE: 02/06/

95

PAGE 1

C001	Site ID (station number)	604734161450401
C009	Latitude	604734
C010	Longitude	1614504
C014	Name of location map	BETHEL D-8
C016	Altitude of land surface	45.
C020	Hydrologic unit code	19030502
C021	Date well constructed	19800920
C028	Depth of well	800.
C900	Station name	SB00807109CDCD2 010
C161	Owner	BETHEL AQUIFER
THERMAL STOR PROJ		
C161	Owner	DOE BETHEL THERMAL
RESISTIVITY & SPONTANEOUS		
C091	Depth to top of interval	0.
C092	Depth to bottom of interval	6.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	BROWN, FINE GRAINED,
MOIST - DRY & NOT FROZEN		
C091	Depth to top of interval	6.
C092	Depth to bottom of interval	10.
C093	Aquifer code	110QRNR
C096	Lithology code	PEAT
C097	Description of material	BROWN & SOFT, STIFF,
MOIST - WET W/SOME FINE SAND & SILT. NOT FROZEN.		
C091	Depth to top of interval	10.
C092	Depth to bottom of interval	14.
C093	Aquifer code	110QRNR
C096	Lithology code	PEAT
C097	Description of material	FROZEN, NO VISIBLE
ICE. PEAT IS MORE MATTED & DECAYED, DENSER.		
C091	Depth to top of interval	14.
C092	Depth to bottom of interval	45.5
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SILTY VERY FINE
SAND, NOT FROZEN 7 SATURATED WHEN T HAWED. SMALL AMOU		
(cont)		
DRILLED DEEPER. SAMPLE FROM 30F		
C091	Depth to top of interval	45.5
C092	Depth to bottom of interval	74.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY W/TRACE OF
GRAVEL & FEW TRACE LAYERS OF CLAY		
C091	Depth to top of interval	74.
C092	Depth to bottom of interval	100.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	WASH RETURNS INDICATE
CLAYEY SILT		
C091	Depth to top of interval	100.

C092	Depth to bottom of interval	134.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	FROM WASH SAMPLE.
GREY, CLAYEY, SANDY SILT. OCCASIONAL CLAY LAYERS W/VER (cont)		Y FINE SAND &
OCCASIONAL GRAVEL < 1/4 INCH		
C091	Depth to top of interval	134.
C092	Depth to bottom of interval	136.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY, FINE GRAINED
SAND & FROZEN		
C091	Depth to top of interval	136.
C092	Depth to bottom of interval	140.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	FINE - MEDIUM SAND
C091	Depth to top of interval	140.
C092	Depth to bottom of interval	178.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	GREY CLAYEY, SANDY,
SILT. VERY FINE SAND W/ AN OCCASIONAL 1 INCH GRAVEL LA		
C091	Depth to top of interval	178.
C092	Depth to bottom of interval	183.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C091	Depth to top of interval	183.
C092	Depth to bottom of interval	191.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SILTY SAND W/
WOOD CHIPS.		
C091	Depth to top of interval	191.
C092	Depth to bottom of interval	199.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	WASH INDICATES GREY,
FINE - MEDIUM GRAINED SAND W/SOME SILT AND NUMEROUS PI		
C091	Depth to top of interval	199.
C092	Depth to bottom of interval	215.
C093	Aquifer code	110QRNR
C096	Lithology code	COBB
C091	Depth to top of interval	215.
C092	Depth to bottom of interval	229.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C091	Depth to top of interval	229.
C092	Depth to bottom of interval	284.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	MEDIUM - FINE GRAINED
C091	Depth to top of interval	284.
C092	Depth to bottom of interval	291.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR

C097	Description of material	ABUNDANT WOOD
FRAGMENTS		
C091	Depth to top of interval	291.
C092	Depth to bottom of interval	374.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	FROM WASH RETURNS,
GREY SILT & SAND W/WOOD FRAGEMNTS @ 306FT.		
C091	Depth to top of interval	374.
C092	Depth to bottom of interval	399.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	PERMAFROST BOUNDRY
C091	Depth to top of interval	399.
C092	Depth to bottom of interval	457.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SILTY SAND, NOT
FROZEN & SATURATED		
C091	Depth to top of interval	457.
C092	Depth to bottom of interval	494.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	UNABLE TO READ LOG
C091	Depth to top of interval	494.
C092	Depth to bottom of interval	502.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	FROM WASH, GREY SAND.
C091	Depth to top of interval	502.
C092	Depth to bottom of interval	518.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	FROM WASH, GREY SAND.
C091	Depth to top of interval	518.
C092	Depth to bottom of interval	532.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	532.
C092	Depth to bottom of interval	594.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	UNABLE TO READ LOG
C091	Depth to top of interval	594.
C092	Depth to bottom of interval	610.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	GREY
C091	Depth to top of interval	610.
C092	Depth to bottom of interval	695.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	INCREASING SAND
LENSES W/DEPTH		
C091	Depth to top of interval	695.
C092	Depth to bottom of interval	703.

C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	W/ SILTY SAND LAYER
BETWEEN 698. - 700.		
C091	Depth to top of interval	703.
C092	Depth to bottom of interval	707.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY SAND
C091	Depth to top of interval	707.
C092	Depth to bottom of interval	709.
C093	Aquifer code	110QRNR
C096	Lithology code	GRVL
C091	Depth to top of interval	709.
C092	Depth to bottom of interval	711.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	711.
C092	Depth to bottom of interval	714.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	714.
C092	Depth to bottom of interval	716.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	716.
C092	Depth to bottom of interval	719.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	719.
C092	Depth to bottom of interval	722.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	722.
C092	Depth to bottom of interval	724.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	RIG HESITATION,
DRILLER ASSUMES GRAVEL LAYER		
C091	Depth to top of interval	724.
C092	Depth to bottom of interval	727.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	727.
C092	Depth to bottom of interval	739.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	739.
C092	Depth to bottom of interval	741.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY

C091	Depth to top of interval	741.
C092	Depth to bottom of interval	745.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	745.
C092	Depth to bottom of interval	747.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	747.
C092	Depth to bottom of interval	760.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	SANDY
C091	Depth to top of interval	760.
C092	Depth to bottom of interval	764.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	764.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT

THE OTHER WELL DATA STARTS HERE

C001	Site ID (station number)	604734161450301
C009	Latitude	604734
C010	Longitude	1614503
C014	Name of location map	BETHEL D-8
C016	Altitude of land surface	46.
C020	Hydrologic unit code	19030502
C021	Date well constructed	19800930
C027	Hole depth	789.
C028	Depth of well	789.
C755	Last update for CONS subrecord of CONS file	19880325
C073	Depth to top of this interval	0.
C074	Depth to bottom of this interval	789.
C075	Diameter of this interval	6.
C724	Record number for hole subrecord	1
C161	Owner	BETHEL AQUIFER
THERMAL STOR PROJ		
C161	Owner	DOE BETHÉL THERMAL
STORAGE PROJ		
C200	Depth to top of logged interval	0.
C201	Depth to bottom of logged interval	789.
C200	Depth to top of logged interval	0.
C201	Depth to bottom of logged interval	422.
C200	Depth to top of logged interval	15.
C201	Depth to bottom of logged interval	413.
C200	Depth to top of logged interval	15.
C201	Depth to bottom of logged interval	421.
RESISTIVITY LOG AVAILABLE		
C091	Depth to top of interval	0.
C092	Depth to bottom of interval	4.
C093	Aquifer code	110QRNR
C096	Lithology code	SDGL

C097	Description of material	BROWN
C091	Depth to top of interval	4.
C092	Depth to bottom of interval	5.
C093	Aquifer code	110QRNR
C096	Lithology code	PEAT
C097	Description of material	BROWN
C091	Depth to top of interval	5.
C092	Depth to bottom of interval	25.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY, GREEN, SILTY,
FINE SAND, DENSE		
C091	Depth to top of interval	25.
C092	Depth to bottom of interval	65.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SILTY SAND W/
RYING AMOUNTS OF SILT LAYERS		
C091	Depth to top of interval	65.
C092	Depth to bottom of interval	74.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	GREY SILTY CLAY
C091	Depth to top of interval	74.
C092	Depth to bottom of interval	92.
C093	Aquifer code	110QRNR
C096	Lithology code	GRVL
C097	Description of material	WET GRAVEL W/SOME
FINE SAND & WOOD FRAGMENTS		
C091	Depth to top of interval	92.
C092	Depth to bottom of interval	139.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	GREY SANDY SILT.
FINE GRAINED SAND		
C091	Depth to top of interval	139.
C092	Depth to bottom of interval	148.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	INCREASING SAND
CONTENT		
C091	Depth to top of interval	148.
C092	Depth to bottom of interval	151.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C091	Depth to top of interval	151.
C092	Depth to bottom of interval	158.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	INCREASING SAND
C091	Depth to top of interval	158.
C092	Depth to bottom of interval	185.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY SAND W/
WOOD CHIPS IN WASH		
C091	Depth to top of interval	185.

C092	Depth to bottom of interval	225.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY W/HIGH
ORGANIC CONTENT(WOOD CHIPS) & ICE LAYERS AROUND 215.		
C091	Depth to top of interval	225.
C092	Depth to bottom of interval	265.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY, MEDIUM -
FINE GRAINED SAND		
C091	Depth to top of interval	265.
C092	Depth to bottom of interval	336.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY WELL
SORTED SAND, W/GRVL LAYERS @ 321. & 347FT & WOOD CHIPS		
C091	Depth to top of interval	336.
C092	Depth to bottom of interval	338.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY SAND W/ICE
C091	Depth to top of interval	338.
C092	Depth to bottom of interval	355.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	SILTY
C091	Depth to top of interval	355.
C092	Depth to bottom of interval	368.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY W/ICE
CRYSTALS		
C091	Depth to top of interval	368.
C092	Depth to bottom of interval	406.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY
C091	Depth to top of interval	406.
C092	Depth to bottom of interval	409.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	SILTSTONE ROCK CHIPS
& SAND IN WASH. DRILLER BELIEVES GRAVEL/COBBLE LENS.		
C091	Depth to top of interval	409.
C092	Depth to bottom of interval	425.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	OCCASSIONAL ROCKY
DRILLING, POSSIBLE GRAVEL LENSES		
C091	Depth to top of interval	425.
C092	Depth to bottom of interval	465.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY & FINE,
NOT FROZEN		
C091	Depth to top of interval	465.

.C092	Depth to bottom of interval	474.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY SILTY SAND,
STIFF W/SOME LARGE WOOD FRAGMENTS		
C091	Depth to top of interval	474.
C092	Depth to bottom of interval	611.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY & SILTY W/SMALL
AMOUNTS OF GRAVEL		
C091	Depth to top of interval	611.
C092	Depth to bottom of interval	617.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	W/WOOD CHIPS
C091	Depth to top of interval	617.
C092	Depth to bottom of interval	625.
C093	Aquifer code	110QRNR
C096	Lithology code	SILT
C097	Description of material	GREY & SANDY
C091	Depth to top of interval	625.
C092	Depth to bottom of interval	645.
C093	Aquifer code	110QRNR
C096	Lithology code	STCL
C097	Description of material	GREY CLAYEY SILT W/
SMALL FRACTION OF VERY FINE SAND, STIFF & MOIST		
C091	Depth to top of interval	645.
C092	Depth to bottom of interval	725.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	VERY SANDY SILT,
STIFF W/WOOD CHIPS.		
C091	Depth to top of interval	725.
C092	Depth to bottom of interval	737.
C093	Aquifer code	110QRNR
C096	Lithology code	SDGL
C097	Description of material	GREEN SILTY FINE -
MEDIUM SAND W/GRAVEL, ALTERNATING LAYER OF GREY-BLACK PA (cont)		
SILTSTONE.		
C091	Depth to top of interval	737.
C092	Depth to bottom of interval	739.
C093	Aquifer code	110QRNR
C096	Lithology code	OTHR
C097	Description of material	HARD STREAK
C091	Depth to top of interval	739.
C092	Depth to bottom of interval	745.
C093	Aquifer code	110QRNR
C096	Lithology code	SDST
C097	Description of material	SILTY W/FEW SAND
GRAINS, VEGITATION INCLUDED. WOOD CHIPS.		
C091	Depth to top of interval	745.
C092	Depth to bottom of interval	761.
C093	Aquifer code	110QRNR
C096	Lithology code	SAND
C097	Description of material	GREY GREEN VERY SITLY

FINE GRAINED SAND

C091 Depth to top of interval
C093 Aquifer code
C096 Lithology code
C097 Description of material

761.
110QRNR
SAND
DARK GREY TO GREEN

APPENDIX 2

Summary of Ground Water Site Inventory data from
wells within 40 km of Bethel

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
SB00707105DADD1 001	T	79.0	15.75	03-05-63	USBIA OSCARVILLE	--	--	D
SB00707108DDDB1 001	P	71.8	--	01-01-61	NAPASKIAK VILLAGE	--	--	D
SB00707109CBDC1 001	P	116	8.00	01-01-64	USBIA NAPASKIAK	--	--	D
SB00707217DBBC1 001	T	200	--	01-01-59	VSBIA NAPAKIAK	NAPAKIAK	BIA SCHOOL	-
SB00707217DBBC2 001	P	116	8.00	11-21-64	VBSIA NAPAKIAK	NAPAKIAK	VILLAGE	D
SB00707218DDBA1 001	T	122	8.60	03-26-69	USBIA NAPAKIAK	--	--	D
SB00806905CAAB1 001	T	145	11.00	--	USBIA KWETHLUK	--	--	D
SB00807108DABB1 001	-	--	--	04-27-72	BETHEL HEIGHTS	--	--	-
SB00807109CACCC1 009	P	399	--	01-01-60	NICHOLSON A.L.	USGS	BET-18	-
SB00807109CBBD1 006	T	--	--	--	BETHEL SCHOOL	USGS	BET-17	-
SB00807109CDAD1 003	U	112	--	01-01-55	LEIB MAX	WALLER 1957 OFR	BET-01	-
SB00807109CDDB1 004	U	85.0	--	01-01-55	SCHMIDT ALBERT	WALLER 1957 OFR	BET-12	D
SB00807109CDCD1 010	U	39.0	--	01-01-55	USPHS BETHEL	WALLER 1957 OFR	BET-10	-
SB00807109CDCD2 010	U	800.	--	09-20-80	BETHEL AQUIFER THERM	USPHS USS 4117	TEST HOLE1 L06	-
SB00807109CDCD3 010	U	789.	--	09-30-80	DOE BETHEL THERMAL S	ATES - TRW TRW JOE NUMBER BETHEL THERM PJ ATES - TRW USS 4117	BORING 0-1 1008700107 BORING 0 1 BORING 0-2 L06	- - - D -
SB00807109CDCC1 007	H	421	25.00	09-01-69	NORTHERN COMMERCL	TRW JOE NUMBER BETHEL THERM PJ NC	1008700101 BORING 0 2 WELL-1	- - -
SB00807109CDD1 008	H	--	--	08-04-72	MENDOLA JOE	--	--	-
SB00807109DCCB1 005	U	390	9.00	05-01-56	AK HEALTH BETHEL	WALLER 1957 OFR	BET-14	D
SB00807110BACD1 001	U	20.0	.00	06-01-55	AK HEALTH BETHEL	WALLER 1957 OFR	BET-08	D
SB00807110BACD2 001	U	15.5	--	06-11-55	AK HEALTH BETHEL	ADH BETHEL USGS	TEST HOLE1 BET-08A	- -
SB00807110BACD3 001	U	--	.00	06-11-55	AK HEALTH BETHEL	ADH BETHEL USGS	TEST HOLE2 BET-08B	- -
SB00807115DDCC1 001	U	197	22.00	04-05-49	FAA BETHEL	ADH BETHEL	TEST HOLE3	-
SB00807115DDCC2 001	U	18.0	--	12-01-48	FAA BETHEL	WALLER 1957 OFR	BET-03	D
SB00807117ABCD1001 80003	-	--	--	--	--	USGS	BET-03A	-
SB00807117ABCD2 001	-	454	--	01-01-52	USPHS BETHEL	--	--	D
SB00807117ACAB1 002	U	165	--	01-01-48	USPHS BETHEL	WALLER 1957 OFR	BET-01	-
SB00807122ABAC1 002	T	51.0	9.00	01-01-54	USAF BETHEL	WALLER 1957 OFR	BET-06	-
SB00807122DDAC1 001	U	75.0	18.00	01-01-51	US ARMY BETHEL	WALLER 1957 OFR	BET-04	D
SB00807213ACBB1 002	T	421	90.00	01-01-58	FAA BETHEL	WALLER 1957 OFR	BET-15	D
SB00807213BDAD1 001	T	434	90.00	12-01-58	FAA BETHEL	USGS	BET-16	D
SB00807214CABB1 001	P	651.	--	11-12-62	USBIA BETHEL	USBIA	BIA-2	D
SB00807214CACCC1 002	T	202	57.49	02-27-56	USAF BETHEL	USAF PROF PASS 501-D WALLER 1957 OFR	USAF-2 WELL-2 BET-13	- - D
SB00807214CACCC2 002	U	185	60.00	01-01-49	USAF BETHEL	PROF PASS 501-D WALLER 1957 OFR	WELL-2 BET-02	- -
SB00807214CCBC1 003	-	290	--	12-27-61	USAF BETHEL	--	--	-
SB01006732CBBC2 001	T	33.0	--	04-06-70	USBIA AKIAK	--	--	-
SB01006936DCAA1 001	P	200	10.40	07-23-66	USBIA AKIACHAK	--	--	D

APPENDIX 3

Selected ground water-quality data
for the FAA well at the Bethel Airport

BET VOC

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

PAGE 1 of 2

Volatile Organics Analysis Data Sheet
Lab Name: Douglas Lab Facility
Method Code: EPA 524.2
Matrix: Water
Date Sampled: 8/27/91
Date Received: 8/27/91
Date Analyzed: 9/05/91
Laboratory No.: 91DEC101400

PWS No.: 271122
Chain of Custody: NA
Sampler No: SH271122
Lab File ID: >1I04M::
Dilution Factor: 1.0000
Location: FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Reported values less than the Method Detection Limit are estimated.

Table with 3 columns: Compound Name, UNITS: ug/l, MDL. Lists various organic compounds like Benzene, Bromobenzene, etc., with values mostly 0.0 and MDL <1.0. One value for Chloroform is .7.

Analyst

Don LaFusa

Date

10-27-91

Reviewed

Alan J. Love

Date

10/30/91

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet
Lab Name: Douglas Lab Facility
Method Code: EPA 524.2
Matrix: Water
Date Sampled: 8/27/91
Date Received: 8/27/91
Date Analyzed: 9/05/91
Laboratory No.: 91DEC101400

PWS No.: 271122
Chain of custody: NA
Sampler No: SH271122
Lab File ID: >1104M:
Dilution Factor: 1.00000
Location: FAA BETHEL TRANSIT
Project: VOC MONITORING

Note: Reported values less than the Method Detection Limit are estimated.

.....
.....
.....
.....
.....

Table with 3 columns: Compound Name, UNITS: ug/l, MDL. Lists various organic compounds like 1,2-Dichloropropane, Ethylbenzene, Toluene, etc., with values 0.0 and MDL <1.0.

Analyst [Signature] Date 10-27-91
Reviewed [Signature] Date 10/30/91

BET VOC

WALTER J. HICKFL. GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

PAGE 1 of 2

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 1/06/92

Date Received: 1/08/92

Date Analyzed: 1/13/92

Laboratory No.: 92DEC100073

Note: Results reported below the MDL are estimated.

PWS No.: 271122

Chain of Custody: NA

Sampler No: 271122

Lab File ID: >1A13P::

Dilution Factor: 1.0000

Location: FAA BETHEL TRANSIT

Project: VOC MONITORING

.....
.....
.....
.....
.....

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
Chloroethane	0.0	0.3
Chloroform	.5	0.2
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.3
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyt Don L. Lavoie Date 1-27-92
 Reviewed Alan L. Lavoie Date 1-31-92

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 1/06/92

Date Received: 1/08/92

Date Analyzed: 1/13/92

Laboratory No.: 92DEC100073

PWS No.: 271122

Chain of custody: NA

Sampler No: 371122

Lab File ID: >1A13P::

Dilution Factor: 1.00000

Location: FAA BETHEL TRANSIT

Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

.....

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.2
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.3
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.4
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
THM	.5	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.3
1,2,4-Trichlorobenzene	0.0	0.2
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.2
m-Xylene	0.0	0.2
o-Xylene	0.0	0.2

Analyst Don L. Fair

Date 1-27-92

Reviewed Alan L. Love

Date 1-31-92

DET VOC

STATE OF ALASKA

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

PAGE 1 of 2

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 4/27/92

Date Received: 4/28/92

Date Analyzed: 4/30/92

Laboratory No.: 92DEC100843

Note: Results reported below the MDL are estimated.

PWS-COMPUTER
ENTERED

MAY 11 1992

PWS No.: 271122

Chain of Custody: NA

Sampler No: 271122

Lab File ID: >1D29T::

Dilution Factor: 1.0000

Location: FAA BETHEL TRANSIT

Project: VOC MONITORING

.....
.....
.....
.....
.....

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
chloroethane	0.0	0.3
Chloroform	.8	0.5
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.5
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyst David A. Chover

Date 5/1/92

Reviewed Alan L. Love

Date 5/4/92

STATE OF ALASKA

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

Page 2 of 2

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 4/27/92

Date Received: 4/28/92

Date Analyzed: 4/30/92

Laboratory No.: 92DEC100843

Note: Results reported below the MDL are estimated.

PWS No.: 271122

Chain of custody: NA

Sampler No: 271122

Lab File ID: >1D29T::

Dilution Factor: 1.00000

Location: FAA BETHEL TRANSIT

Project: VOC MONITORING

UNITS: ug/l MDL

1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.5
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.5
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.5
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
TTHM	.8	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.5
1,2,4-Trichlorobenzene	0.0	0.5
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.4
m-Xylene	0.0	0.4
o-Xylene	0.0	0.4

Analyst

David B. Glover

Date

5/1/92

Reviewed

Alan Love

Date

5/4/92

BET VOC

WALTER J. HICKEL, GOVERNOR

DEPT. OF ENVIRONMENTAL CONSERVATION

PAGE 1 of 2

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 7/1/92

Date Received: 7/2/92

Date Analyzed: 7/08/92

Laboratory No.: 92DEC101413

Note: Results reported below the MDL are estimated.

PWS No.: 271122

Chain of Custody: NA

Sampler No: 271122

Lab File ID: >1G08H::

Dilution Factor: 1.0000

Location: FAA BETHEL TRANSIT QTR

Project: VOC MONITORING

PWS-COMPUTER
SEP 02 1992

.....
.....
.....
.....
.....

	UNITS: ug/l	MDL
Benzene	0.0	0.2
Bromobenzene	0.0	0.3
Bromochloromethane	0.0	0.2
Bromodichloromethane	0.0	0.4
Bromoform	0.0	0.6
Bromomethane	0.0	0.3
n-Butylbenzene	0.0	0.4
sec-Butylbenzene	0.0	0.4
tert-Butylbenzene	0.0	0.2
Carbon Tetrachloride	0.0	0.4
Chlorobenzene	0.0	0.2
Chlorodibromomethane	0.0	0.4
Chloroethane	0.0	0.3
Chloroform	1.5	0.5
Chloromethane	0.0	0.6
o-Chlorotoluene	0.0	0.4
p-Chlorotoluene	0.0	0.5
1,2-Dibromo-3-chloropropane	0.0	0.4
Dibromomethane	0.0	0.2
1,4-Dichlorobenzene	0.0	0.5
m-Dichlorobenzene	0.0	0.3
o-Dichlorobenzene	0.0	0.3
Dichlorodifluoromethane	0.0	0.4
1,1-Dichloroethane	0.0	0.3
1,2-Dichloroethane	0.0	0.2
1,1-Dichloroethylene	0.0	0.2
cis-1,2-Dichloroethylene	0.0	0.3
trans-1,2-Dichloroethylene	0.0	0.3
Dichloromethane	0.0	0.3

Analyst Don LaFare Date 7-22-92
Reviewed Don LaFare Date 7/27/92

DEPT. OF ENVIRONMENTAL CONSERVATION

Volatile Organics Analysis Data Sheet

Lab Name: A.D.E.C. Juneau Laboratory

Method Code: US EPA 524.2

Matrix: Water

Date Sampled: 7/1/92

Date Received: 7/2/92

Date Analyzed: 7/08/92

Laboratory No.: 92DEC101413

PWS No.: 271122

Chain of custody: NA

Sampler No: 271122

Lab File ID: >1G08H::

Dilution Factor: 1.00000

Location: FAA BETHEL TRANSIT QTR

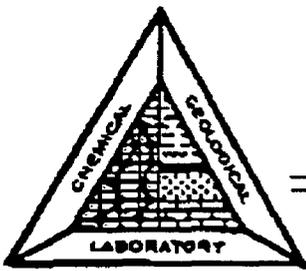
Project: VOC MONITORING

Note: Results reported below the MDL are estimated.

.....

	UNITS: ug/l	MDL
1,2-Dichloropropane	0.0	0.3
1,3-Dichloropropane	0.0	0.2
2,2-Dichloropropane	0.0	0.5
1,1-Dichloropropene	0.0	0.4
1,3-Dichloropropene	0.0	0.2
Ethylbenzene	0.0	0.5
Ethylene Dibromide	0.0	0.2
Fluorotrichloromethane	0.0	0.4
Hexachlorobutadiene	0.0	0.5
Isopropylbenzene	0.0	0.2
p-Isopropyltoluene	0.0	0.4
Naphthalene	0.0	0.5
n-Propylbenzene	0.0	0.4
Styrene	0.0	0.2
1,1,1,2-Tetrachloroethane	0.0	0.3
1,1,2,2-Tetrachloroethane	0.0	0.3
Tetrachloroethylene	0.0	0.4
THM	1.6	
Toluene	0.0	0.2
1,2,3-Trichlorobenzene	0.0	0.5
1,2,4-Trichlorobenzene	0.0	0.5
1,1,1-Trichloroethane	0.0	0.3
1,1,2,-Trichloroethane	0.0	0.3
Trichloroethylene	0.0	0.2
1,2,3-Trichloropropane	0.0	0.5
1,2,4-Trimethylbenzene	0.0	0.4
1,3,5-Trimethylbenzene	0.0	0.4
Vinyl Chloride	0.0	0.5
p-Xylene	0.0	0.4
m-Xylene	0.0	0.4
o-Xylene	0.0	0.4

Analyst Don LaFara Date 7-22-92
 Reviewed Alan Love Date 7/27/92



CHEMICAL & GEOLOGICAL LABORATORY

A DIVISION OF COMMERCIAL TESTING & ENGINEERING CO.

5633 B STREET ANCHORAGE, ALASKA 99518 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 53700
Chemlab Ref. # 92.2066 Sample # 1 Matrix: WATER

Client Sample ID : DRINKING WATER FAA BETHEL WSM SINK
PWSID : 271122
Collected : 05/12/92 @ 08:30 hrs.
Received : 05/12/92 @ 15:05 hrs.
Preserved with : AS REQUIRED

Client Name : FEDERAL AVIATION ADMINISTRATION
Client Acct : FEDAVIA
BPO# : DTFA04-92-P-20046 PO# :
Req# :
Ordered By :

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. IDE
Released By : *(Signature)*

Send Reports to:
1) FEDERAL AVIATION ADMINISTRATION
2) DOT FAA BET SFO

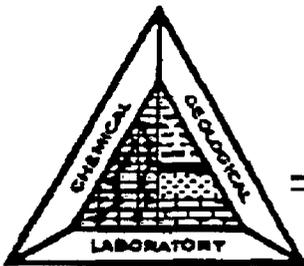
Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LT 2	pCi/L	EPA 900.0	15

Sample ROUTINE SAMPLE COLLECTED BY: R. ATKINS, WITNESSED BY C.S.
Remarks: RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed * See Special Instructions Above UA-Unavailable
 ND- None Detected ** See Sample Remarks Above
 NA- Not Analyzed LI-Less Than, GT-Greater Than



Member of the SGS Group (Société Générale de Surveillance)



CHEMICAL & GEOLOGICAL LABORATORY

A DIVISION OF COMMERCIAL TESTING & ENGINEERING CO.

5633 B STREET ANCHORAGE, ALASKA 99518 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 55455

Chemlab Ref. # 92.3192 Sample # 1 Matrix: WATER

Client Sample ID : DRINKING WATER BETHEL FAA TRANSIENT QTRS
PWSID : 271122
Collected : 07/01/92 @ 11:23 hrs.
Received : 07/01/92 @ 14:12 hrs.
Preserved with : AS REQUIRED

Client Name : FEDERAL AVIATION ADMINISTRATION
Client Acct : FEDAVIA
BPO# : DTFAC4-92-P-20046 PO# :
Req# :
Ordered By : CHARLES SMITH

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. EDE
Released By :

Send Reports to:
1) FEDERAL AVIATION ADMINISTRATION
2) DOT FAA BET SFO

Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LI 2	pCi/L	EPA 900.0	15

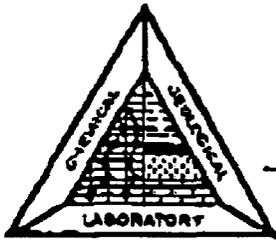
Sample ROUTINE SAMPLE COLLECTED BY: WILLIAM BULL, WITNESSED BY C.A.
Remarks: RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed
ND- None Detected
NA- Not Analyzed

* See Special Instructions Above UA-Unavailable
** See Sample Remarks Above
LI-Less Than, GI-Greater Than



Member of the SGS Group (Société Générale de Surveillance)



CHEMICAL & GEOLOGICAL LABORATORY

A DIVISION OF COMMERCIAL TESTING & ENGINEERING CO.

5633 B STREET ANCHORAGE, ALASKA 99516 TELEPHONE (907) 562-2343 FAX: (907) 561-5301

ANALYSIS RESULTS for INVOICE # 56793

Chemlab Ref. # 92.3988 Sample # 1 Matrix: WATER

Client Sample ID : MSM SINK
PWSID : 271122
Collected : 08/05/92 @ 08:00 hrs.
Received : 08/06/92 @ 08:30 hrs.
Preserved with : AS REQUIRED

Client Name : FEDERAL AVIATION ADMINISTRATION
Client Acct : FEDAVIA
BPO# : DIPA04-92-P-20046 PO# : NONE RECEIVED
Log# :
Ordered by :

Analysis Completed : 11/13/92
Laboratory Supervisor : STEPHEN C. EDE
Released By : *[Signature]*

Send Reports to:
1) FEDERAL AVIATION ADMINISTRATION
2) DOT, FAA, BET, SPO

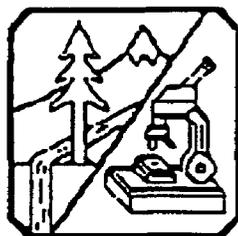
Parameter	Results	Units	Method	Allowable Limits
GROSS ALPHA	LT 2	pCi/l	RPA 900.0	15

Sample ROUTINE SAMPLE COLLECTED BY: R.A.
Remarks: RESULT ANALYZED BY CONTROLS FOR ENVIRONMENTAL POLLUTION, INC., SANTA FE, NEW MEXICO.

1 Tests Performed	" See Special Instructions Above	UA-Unavailable
ND- None Detected	** See Sample Remarks Above	
NA- Not Analyzed	LT-Less Than, GT-Greater Than	

Member of the SGS Group (Société Générale de Surveillance)

BET INORG. CHEM



NORTHERN TESTING LABORATORIES, INC.

2505 FAIRBANKS STREET
3330 INDUSTRIAL WAY

ANCHORAGE, ALASKA 99503
FAIRBANKS, ALASKA 99701

907-277-8378 - FAX 274-9845
907-456-3178 - FAX 456-3125

Federal Aviation Administration
222 West 7th Avenue, #14
AAL-463
Anchorage AK 99513-7587

Report Date: 06/22/90

Date Arrived: 05/14/90
Date Sampled: 05/14/90
Time Sampled: 0930
Collected By: RA

Attn: Harry Gilmore

Flag Definitions

U = Below Detection Limit
DL Stated in Result
B = Below Regulatory Min.
H = Above Regulatory Max.
E = Below Detection Limit
Estimated Value

Our Lab #: A100514
Location/Project: FAA Bethel
Your Sample ID: Tapwater-Club
Sample Matrix: Water
Comments:

Method	Parameter	Units	Result Flag
EPA 206.2	Arsenic	mg/l	0.001 U
EPA 208.2	Barium	mg/l	0.08
EPA 213.2	Cadmium	mg/l	0.0011
EPA 218.2	Chromium	mg/l	0.002
EPA 239.2	Lead	mg/l	0.0029
EPA 245.1	Mercury	mg/l	0.0003
EPA 270.2	Selenium	mg/l	0.007
EPA 272.2	Silver	mg/l	0.003 U
EPA 300.0	Nitrate-N	mg/l	0.6
SM 413C	Fluoride	mg/l	0.1

Reported By: Francois Rodigari
Anchorage Operations Manager

Harding Lawson Associates

APPENDIX C

FAA Drinking Water Sampling
Summary of Sample Locations and Analytical Data
(continued)

LEAD & COPPER

Site	Location	Laboratory	Wells Used	Lead ^a (mg/L)	Copper ^b (mg/L)
Yakutat	State Parks House	93.4442-1	2 wells, alternated	0.0050 U	0.82
	National Weather Service No. 3	93.4442-2	2 wells, alternated	0.0050 U	0.51
	National Weather Service No. 5	93.4442-3	2 wells, alternated	0.0050 U	0.51
	FAA Quarters 102-4	93.4442-4	2 wells, alternated	0.0050 U	0.30
	FAA Quarters 101-4	93.4442-5	2 wells, alternated	0.0050 U	0.30
Bethel	MarkAir Air Terminal (Bushflight: Coffee Shop)	93.4582-1	Untreated well	0.0050 U	0.05 U
	FAA Transition, #101-2	93.4582-2	Treated well	0.01	0.64
	National Weather Transient #8-2	93.4582-3	Treated well	0.005	1.20
	FAA Fourplex, #107-1	93.4582-4	Treated well	0.025	0.56
	FAA Fourplex, #105-2	93.4582-5	Treated well	0.41	7.00
	Tower Manager Quarters (FAA House 110 8-6)	93.4598-1	Treated well	0.011	0.050 U

^a The Environmental Protection Agency (EPA) action level for lead is 0.015 mg/L.

^b The EPA action level for copper is 1.3 mg/L.

mg/L = Milligrams per liter.

U = Undetected, reported value is the practical quantification limit.

1093H

Approved by: *MIS*

C-2