Environmental Overview and Hydrogeologic Conditions At Federal Aviation Administration Facilities Near Fairbanks, Alaska

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

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
hectare (ha)	2.471	acre
liter per second (L/s)	15.85	gallon per minute
cubic meter per second (m^3/s)	35.31	cubic foot per second
degree Celsius (°C)	°F = 1.8 x °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 unit used in this report:

µg/L, microgram per liter

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Abstract

The Federal Aviation Administration (FAA) operates facilities at several sites in and near Fairbanks, Alaska. This report was prepared to assist the FAA in its investigations of the hydrogeology of these sites. Most sites are located on the alluvial plain of the Tanana and Chena Rivers. The alluvial aquifer supplies high yields of hard, calcium bicarbonate water which can contain excessive quantities of iron. Several outlying FAA facilities are located on hillsides or in stream valleys of the uplands near Fairbanks. These sites are situated on loess deposits overlying bedrock of muscovite-quartz schist. Ground water at these sites is usually at depths greater than 60 meters, except for the Fox FAA facility, which has a shallower water table. Water yields in these upland sites are about 0.6 to 1.0 liters per second of hard, calcium bicarbonate water which can contain iron and arsenic in excess of drinking-water regulations.

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 supplementary information for the FAA facilities and nearby areas at Fairbanks, Alaska.

The Federal Aviation Administration facilities (fig. 1) are located within an area included on the Fairbanks D-2 NE quadrangle in central Alaska about 160 km south of the Arctic Circle. Most of the facilities are located at or near the Fairbanks International Airport at about lat 64°49' N., long 147°51' W. The facilities have been described in detail by Ecology and Environment Inc. (1993), and will not be discussed here. This report will concentrate upon the environmental setting of the facilities.

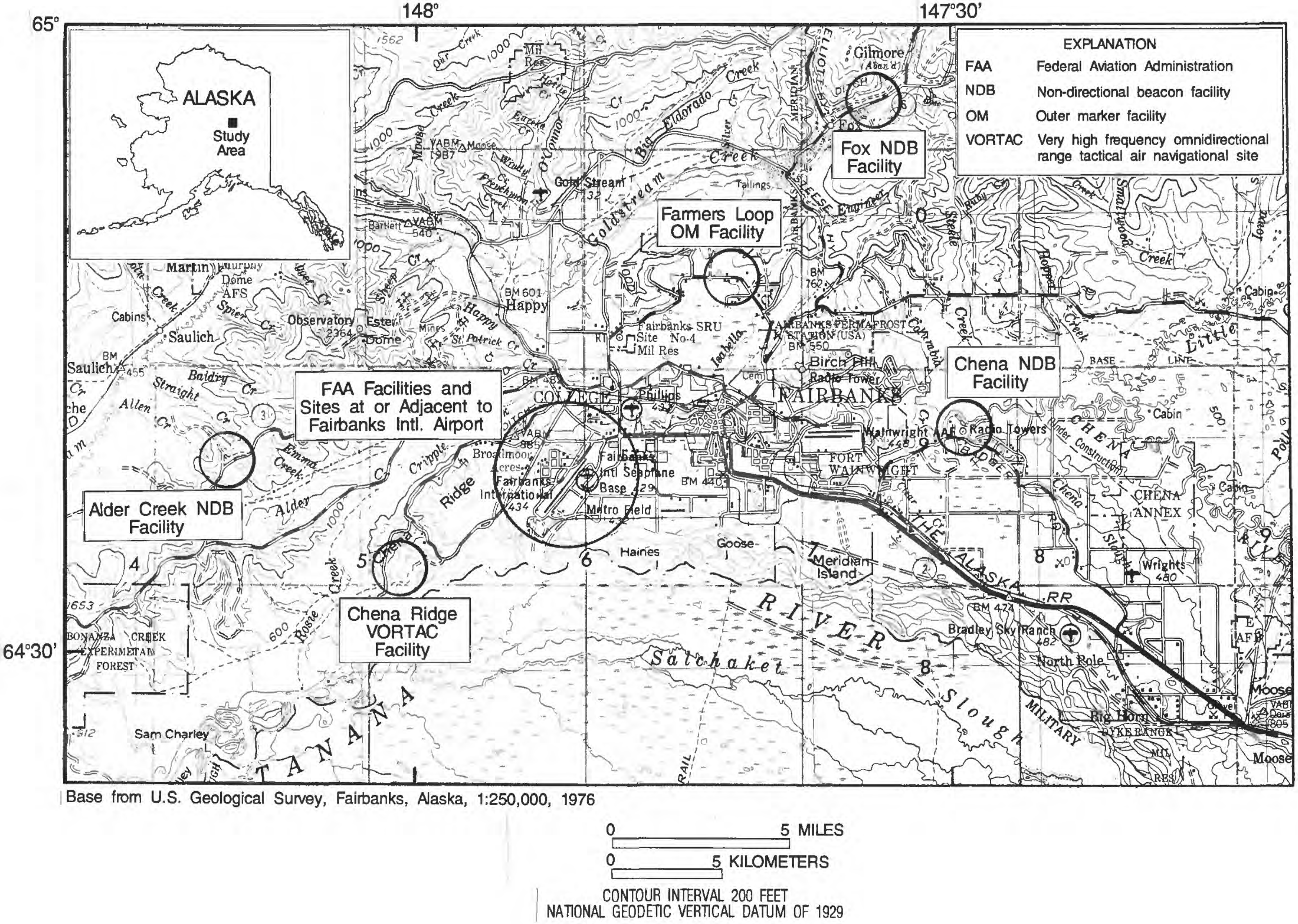

Figure 1. Location of Fairbanks, Alaska, and location of Federal Aviation Administration facilities (modified from Ecology and Environment, Inc., 1993).

PHYSICAL SETTING

Fairbanks is located at an elevation of about 130 m on the north side of the broad Tanana River valley near the base of hills of the Yukon-Tanana Upland, a broad northwest-trending highland between the Tanana and Yukon Rivers (Péwé and others, 1976). In the Fairbanks region, the highest hills are about 660 m elevation and are more than 15 km to the west and north of the airport.

Climate

The Fairbanks area is characterized by a continental climate of warm summers and cold winters (Hartman and Johnson, 1984). For the period 1949-87, the average summer (June, July, and August) temperature was about 15 ^{o}C, while the average winter (November through March) temperature was about -19 ^{o}C (Leslie, 1989). The record high temperature is about 36 ^{o}C, the record low temperature is -52 ^{o}C, and the mean annual temperature is -3.1 ^{o}C. The average annual precipitation is about 260 mm, most of which (approximately 170 mm on average) falls as snow. Evapotranspiration has not been quantified accurately, but probably ranges from 110 to 230 mm/yr (Nelson, 1978). Temperature, precipitation and snowfall data for the period 1949-87 are summarized in table 1.

Vegetation

The vegetation and land cover of the Fairbanks area consist mainly of broadleaf forest and some needle leaf forest on the ridges, and shrubland along the valley bottoms. The U.S. Geological Survey (1987) mapped vegetation and land use patterns for the entire Fairbanks 1:250,000 scale quadrangle. This vegetative ground cover was categorized and given as percentages is as follows: needle leaf forest 13.9 percent, broadleaf forest 14.4 percent, shrubland 63.5 percent, and wet herbaceous vegetation 2.9 percent. The percentage for land use classifications is urban land 1.1 percent; barren land, consisting of non-, or sparsely vegetated areas, 2 percent; and areas of surface water, 2.2 percent.

HYDROGEOLOGY

The Fairbanks area overlies two distinct terrains: the flood plain of the Tanana and Chena Rivers and the southern border of the Yukon-Tanana Upland (Wahrhaftig, 1965). The hydrogeology of the various FAA facilities located throughout the Fairbanks area is dependent on terrain type. Both the flood plain and the upland have unique hydrogeological features which are summarized below.

Flood Plain

The Tanana Lowland (south of the Yukon-Tanana Upland) consists of a wide, sediment-filled trough in which alluvial fans extending from the Alaska Range to the south have pushed northward forcing the Tanana River against the bedrock hills of the Yukon-Tanana Upland (Wahrhaftig, 1965).

Table 1. Mean monthly temperature, precipitation, and snowfall for the period 1949 to 1987, Fairbanks

[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	-18.6	-13.9	-4.8	4.8	15.2	21.3	22.2	19.1	12.5	0.3	-11.1	-17.7	2.4
	(Record maximum 35.6 °C, June 1969)												
Mean minimum	-28.4	-26.2	-19.6	-7.1	2.9	9.3	10.8	7.9	1.9	-7.9	-20.3	-26.8	-8.6
	(Record minimum -52.2°C, December 1961)												
Mean	-23.5	-20.1	-12.2	-1.1	9.1	15.3	16.5	13.5	7.2	-3.8	-15.7	-22.3	-3.1
Precipitation (mm of moisture)	14.0	10.4	9.4	7.1	14.5	32.8	46.7	46.2	25.9	20.6	17.0	18.5	263.4
Snowfall (mm)	259.1	213.4	162.6	88.9	12.7	0.0	0.0	0.0	22.9	264.2	320.0	317.5	1661.2

As discussed by Péwé and others (1976), the Fairbanks area has not been subjected to glaciation, although during glacial times, glaciers advanced northward from the Alaska Range to within about 80 km of Fairbanks. During these advances, thick layers of silt, sand, and gravel were deposited by the sediment-laden rivers. As the Tanana alluvial plain aggraded, as much as 90 m of sediment was deposited in creek valleys by the aggrading streams issuing from the unglaciated Yukon-Tanana Upland. Additional loess (wind-blown silt), ranging in thickness from 0.5 m on ridgetops to nearly 60 m on middle slopes, was deposited. Thickest deposits are near the Tanana River, and the loess blanket becomes progressively thinner to the north.

In Wisconsin time, along with the deposition of loess, much organic silt accumulated in the valley bottoms, became frozen, and formed large ground-ice masses. Frozen remains of now-extinct Pleistocene mammals have been found in this frozen silt.

The Fairbanks area is underlain by thick (hundreds of meters) glaciofluvial deposits of sand and gravel that contain some silt and organic matter. The U.S. Army Corps of Engineers (1974) reports that the hydraulic conductivity of deposits near Moose Creek Dam, about 26 km east of Fairbanks, is approximately 300 m/d. The hydraulic gradient is estimated between 0.37 to 0.75 m/km for the aquifer between the Chena and Tanana Rivers.

Upland

The bedrock hills of the Fairbanks region are composed of crystalline schists and gneiss domes (Robinson and others, 1990). In the Fairbanks region, bedrock consists of metamorphosed stratigraphic packages in apparent thrust-fault contact (Robinson and others, 1990). Extrusive and intrusive rock units are present within the metamorphic rocks. Small outcrops of tholeiitic basaltic rocks occur to the east of Fairbanks. Hornblende-bearing granodiorite is the dominant intrusive rock immediately north of Fairbanks in the vicinity of Pedro Dome. A second major intrusive rock unit consisting of porphyritic quartz monzonite occurs northeast of Fairbanks on Gilmore Dome. Small exposures of highly altered porphyritic dikes, plugs and breccia dikes are found on Ester Dome and near O'Connor Creek in the Goldstream Valley (Robinson and others, 1990).

Mineralization of the host rock of the aquifer plays a significant role in the water quality of the bedrock aquifer. Ground water, in contact with sulfide minerals such as iron pyrite (FeS) and arsenopyrite ($FeAsS$), weathers iron and arsenic from the minerals (Wilson and Hawkins, 1978). Concentrations of iron and arsenic vary from well to well; however, in some areas, well water has exceeded U.S. Environmental Protection Agency (USEPA) (1993) maximum contaminant levels (MCL) for arsenic (Johnson and others, 1978).

Water for most homes in the upland of the Fairbanks area is obtained from private wells in a bedrock aquifer. Ground water flows through faults and fractures which act as conduits to ground-water flow. Water yields in these areas vary and depend on the number and size of water-bearing faults and fractures that the well intersects.

Permafrost

The Fairbanks area is in the zone of discontinuous permafrost (perennially frozen ground). The presence of permafrost in the Fairbanks area presents challenges for construction of earthworks and for water supplies (Péwé and others, 1976). Péwé and Bell (1975) mapped the distribution of permafrost in the Fairbanks area. In the uplands, permafrost is common on north-facing slopes and in valley bottoms, while south- and west-facing slopes are likely to be free of permafrost (Nelson, 1978).

Permafrost acts as a confining layer under the lower hillslopes. Ground water flowing under the confining layer to the rivers in the valley bottoms is commonly under artesian conditions. Where thawed conduits or wells exist through the confining layer, ground water may flow upward to the land surface. Uncontrolled flow from wells in artesian aquifers have caused damage to property in the past (Péwé, 1982). If permafrost surrounding the well casing is allowed to melt, water can flow, uncontrolled, outside of the well casing and cause flooding—or in winter, icing—which can damage nearby property. The flowing water also locally melts the permafrost causing ground subsidence and eventual damage to structures.

On the alluvial plain, sand and gravel have high permeability and are commonly ice free. Much of the ground-water flow in the alluvial plain occurs in these layers. Fine-grained soils and highly organic slough deposits that fill in old channels tend to be ice rich and impermeable.

ENVIRONMENTAL CONDITIONS AT FAA FACILITIES

The FAA facilities of interest in this report are shown in figure 1. In the remainder of this report, an environmental description is provided for each site.

Fairbanks International Airport Facilities

The FAA facilities at the Fairbanks International Airport (fig. 2) are situated on the tongue of land between the Chena and Tanana Rivers. These facilities were constructed on alluvium in a region originally shrubland, like that southward across the Tanana River. The facilities lie within the valley-bottom, peat-muck and valley-bottom muck zones described by Péwé and Bell (1975). Permafrost is likely present in these organic-rich channels and overbank deposits. The alluvial gravel and sand deposits are well drained and are probably free of ice. The ground-water flow direction is predominantly westward (Nelson, 1978, fig. 6; 8). Local flow directions, however, are greatly influenced by stage in the rivers and backwater effects in the many sloughs and ditches. At scales of tens of meters and tens of hours, local directions of ground-water flow can vary through 360 degrees. Ground-water levels respond readily to changes in water level in the Tanana River (Nelson, 1978).

Production wells drilled in the alluvial gravels commonly have high yield of hard calcium bicarbonate water (Flynn, 1985). Wells drilled in organic-rich channels will have lower yields of hard, calcium bicarbonate water, which may be enriched in iron and hydrogen sulfide. Surface-water flooding of the general area could occur from the Tanana River, but is less likely from the Chena River because of the Chena Flood Control facility. However, ground-water levels could be elevated at this site for extended periods if releases of water from the Chena River dam were to maintain a high stage for an extended period of time. When simultaneous high discharges (2,500 m^3/s and 340 m^3/s respectively) occur on both the Tanana and Chena Rivers, resulting backwater effects on the Chena River extend upstream from the mouth of the Chena River. Backwater seasonally inundates low-lying areas south and west of the airport. In areas northwest of the airport, ground-water levels could rise by as much as 1.5 m. Under these conditions, ground-water levels are expected to be less than 1 m below land surface.

Under non-flood conditions, although the capacity of the aquifer to transmit water is high, wastes released to the ground water from the FAA facility will not migrate rapidly because of the low hydraulic gradient. Movement will be further reduced in fine-grained, organic-rich sediments.

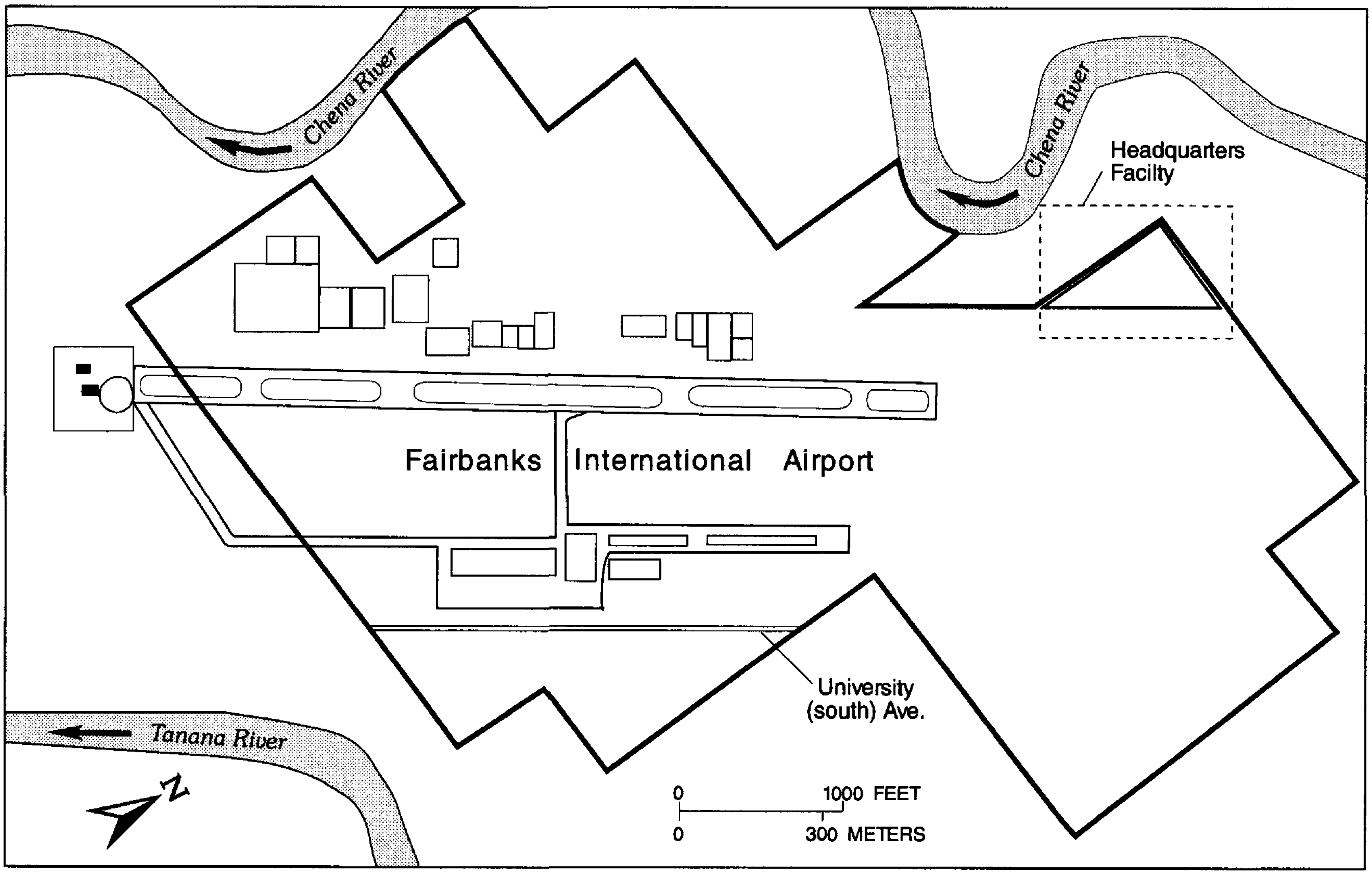

Figure 2. Location of main Federal Aviation Administration Station at Fairbanks International Airport (modified from Ecology and Environment, Inc., 1993).

Additionally, interaction of the fine-grained material with dissolved constituents can be expected to retard the rate at which solutes move through the system. Material that is spilled on the surface and does not infiltrate is likely to move laterally following the general topography and old channels. Vertical movement will be constrained locally by the thickness of the active layer, presence of permafrost, and fine-grained horizons between the land surface and the gravel aquifer. In the gravel aquifer, movement of solutes will be dominantly horizontal, following the general ground-water gradient. Although domestic water for the International Airport is supplied by College Utilities, many residents near the airport use ground water from private wells. Commercially available alternative sources of water for these residents are College Utilities, local water-supply trucks, or holding tanks. Several trucked-water vendors are located in the Fairbanks area.

Chena Ridge VORTAC Facility

This facility is a VHF (very high frequency) omnidirectional range and tactical (VORTAC) air navigation station located on 35 ha of FAA property on Chena Ridge (fig. 1). The site consists of a cinder-block building housing electronics, a generator, and air navigation equipment (Ecology and Environment, Inc., 1993). The site is constructed on a thick loess deposit (Robinson and others, 1990). Original vegetation was either needle-leaf or broadleaf forest (U.S. Geological Survey, 1987). Because of its southern exposure, this site is likely to be free of permafrost. Depth to ground water at this site is probably between 80 and 100 m (Weber and others, 1989). Well yield is low, about 0.7 L/s (Weber and others, 1989). Ground water is hard, calcium bicarbonate type. Arsenic concentrations are likely to be low, less than 10 µg/L (Krumhardt, 1980; Weber and others, 1989). Infiltration rates at this site will be slow because of fine-grained silt underlying the area (Nelson, 1978). Domestic wells are located near and down gradient from this site. No water distribution system is available in this area. Alternative water supplies consist of holding tanks and water supplied by tank truck.

Alder Creek NDB Facility

This facility consists of a nondirectional radio beacon (NBD) housed in a cinder-block building on 5 ha of land adjacent to the Fairbanks Nenana Road (Old Nenana Highway) (fig.1). Although apparently constructed on loess, this site is underlain by muscovite-quartz schist and micaceous quartzite (Robinson and others, 1990). Original vegetation was either needle-leaf forest or broadleaf forest (U.S. Geological Survey, 1987). Depths to ground water are probably between 80 and 100 m; wells have expected yields ranging from 0.3 to 1.0 L/s (Weber and others, 1989). Naturally occurring concentrations of arsenic as high as 50 to 100 µg/L are possible (Weber and others, 1989). Infiltration of surface water is dependent on the thickness of the loess blanket. Where the loess is thin, rapid communication with the ground water along bedrock fractures is possible (Nelson, 1978). An alternative source of water for down-gradient users is holding tanks and water supplied by tank truck.

Farmers Loop OM Facility

This is an outer marker (OM) facility located on 0.6 ha of land bordering Farmers Loop (fig. 1). The site consists of a plastidome building housing an antenna tuning unit, NDB transmitter and a marker beacon control unit (Ecology and Environment, Inc., 1993). It is constructed on loess (Robinson and others, 1990). Permafrost is possible at this site and vegetation is broadleaf forest (U.S. Geological Survey, 1987). Depths to ground water are less than 60 m. Wells have expected yields ranging from 1 to 1.25 L/s (Weber and others, 1989). Ground water is of the hard calcium bicarbonate type; expected arsenic concentrations are less than 10 µg/L (Johnson and others, 1978; Weber and others, 1989). Regional ground-water flow is to the south, in the same direction as the topographic gradient. The direction of ground-water flow is controlled by recharge from the upland slopes and discharge to nearby Jussila Creek. Domestic wells are located near the facility, and ground water discharges to wetlands 1 km south-southwest of this site. Surface-water sources in the vicinity freeze solidly during the winter and are not an alternative drinking-water supply. The only likely alternative source of domestic water for nearby residents is a holding tank with water supplied by tank truck.

Fox NDB Site

This site is located on the Steese Highway northeast of Fox (fig. 1) and consists of a plastidome transmitter building, antenna, and other electronic equipment (Ecology and Environment, Inc., 1993). The facility is constructed on reworked alluvium (dredge tailings). The original material of the site was unconsolidated silt (Robinson and others, 1990). This material had a high ice content and was removed hydraulically during the early days of placer mining in the region. Subsequently, the area was reworked by dredge, producing the tailings upon which the site is constructed. Surface water from the upper reach of Goldstream Creek flows close to the site.

During winter, icings occur along the stream. When the stream freezes to the bottom, the channel is unable to convey the remaining flow. The streamflow then breaks out to the surface, forming an overflow. Overflows occur repeatedly to form a massive icing. Conditions during the winter of 1993-94 resulted in the formation of several large icings on Goldstream Creek upstream from Goldstream Road near Fox (fig. 3).

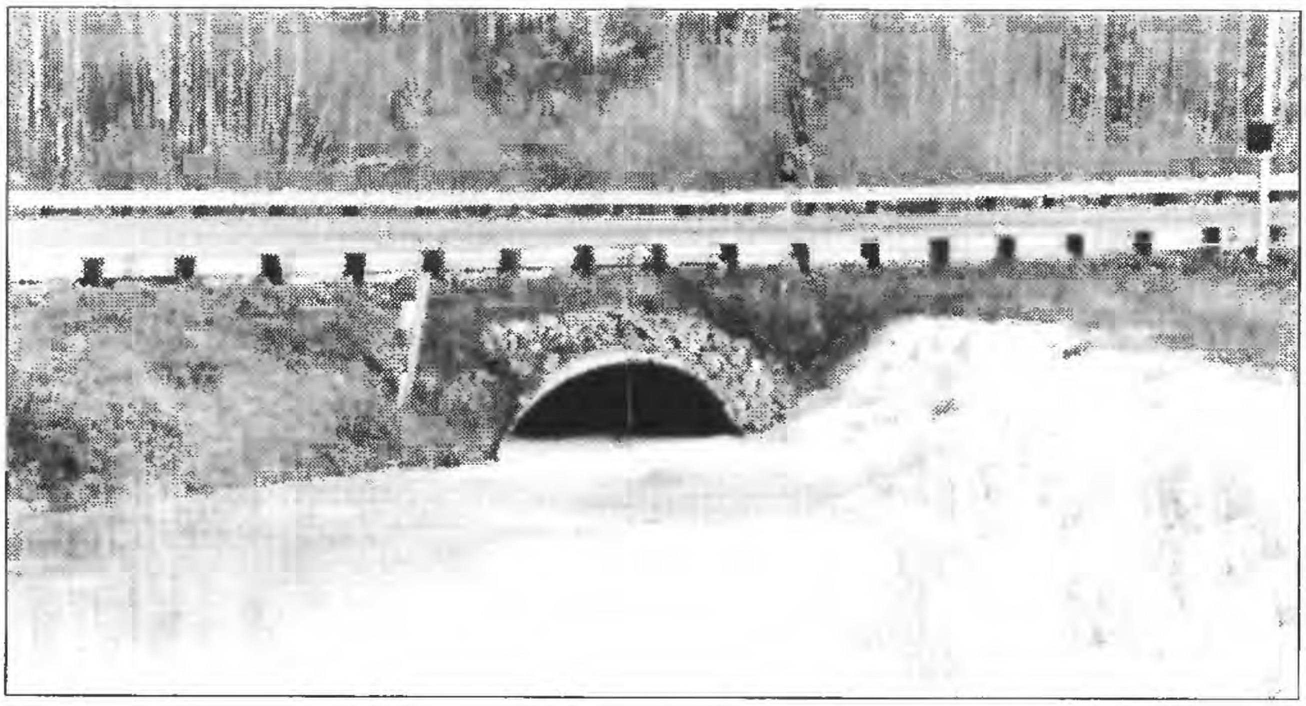

Figure 3. Icing on Goldstream Creek near Fox.

Depth to ground water is about 15 m, and typical well yields are about 0.8 L/s. Water quality is expected to be poor, and iron concentrations can be great enough to cause staining. Arsenic concentrations as high as 50 µg/L have been detected (Johnson and others, 1978; Hopkins and Maxwell, 1985). Permafrost is prevalent on the lower southeast-facing slope. Rapid communication between nearby surface water and underlying ground water is likely. Surface-water sources in the area are frozen or located at too great a distance from the facility for economic development. The alternative source of domestic water for residents of the area is a holding tank with water supplied by tank truck or water hauled by the residents themselves from the nearby Fox Spring.

Chena NDB Site

This site is on 6.3 ha of land along Badger Road on the alluvial plain of the Chena and Tanana Rivers (fig. 1). The site consists of a plastidome building, antenna, transmitter, and electrical navigational aid equipment (Ecology and Environment, Inc., 1993). The area is underlain by localized masses of permafrost and the water table in the high-transmissivity aquifer is generally shallower than 5 m (Krumhardt, 1982). The water table fluctuates seasonally about 0.6 m and slopes about 0.75 m/km to the northwest, which is also the principal direction of ground-water flow. Fluctuations in the water table are caused by changing stage in the Tanana River. Homes and businesses in the area are supplied by private wells. Septic tanks are also located in the upper part of the aquifer. The ground water is of the hard calcium bicarbonate type; moderately high concentrations of iron are common. Krumhardt (1982) gives numerous analyses of the ground water of the area, and concludes that ground-water quality is generally good and had not been degraded by household waste disposal at the time of her report. An alternative source of domestic water is a holding tank supplied by tank truck. Although the nearby Chena and Tanana Rivers are alternative water sources, a public distribution system would be required to tap these sources.

SUMMARY

The main FAA facilities are located at the Fairbanks International Airport near the confluence of the Tanana and Chena Rivers. Ground-water flow in this alluvial gravel aquifer is westerly, generally away from the Tanana River. Usually, the Tanana River recharges the aquifer and the Chena River serves as a drain. During periods of high flows, both streams recharge the aquifer. The gravel aquifer produces abundant, hard, calcium bicarbonate water, which sometimes contains excessive quantities of iron. The Chena Ridge and Farmer's Loop FAA facilities are located on loess-blanketed bedrock hillsides. Ground water under such conditions is often at depths near 60 m, and yields of about 0.7 L/s are common. Commonly, arsenic-rich waters stem from natural sulfide mineralization in the rocks. The Chena and Fox FAA facilities are located on fine alluvium and reworked gravel, respectively. In both places, the water table is within 15 m of land surface.

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