Overview of Environmental and Hydrogeologic Conditions at Dillingham, Alaska

By Betty B. Palcsak and Joseph M. Dorava

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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)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
liter per second (L/s)	0.1585	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
centimeter per hour (cm/h)	0.3937	inch per hour
kilometer per hour (km/h)	0.6214	mile per hour
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 units used in this report:

Chemical concentration is given in milligrams per liter (mg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Specific conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micro-mhos per centimeter at 25 degrees Celsius (mmho/cm), formerly used by the U.S. Geological Survey.

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Abstract

The remote city of Dillingham is at the northern end of Bristol Bay in southwestern Alaska. The hydrology of the area is strongly affected by the mild maritime climate and local geologic conditions. Dillingham residents obtain drinking water from both deep and shallow aquifers composed of gravels and sands and separated by layers of clay underlying the community. Alternative sources of drinking water are limited to the development of new wells because surface-water sources are of inadequate quantity or quality or are located at too great a distance from the population. The Federal Aviation Administration owns or operates airway support facilities in Dillingham and wishes to consider the severity of contamination and the current environmental setting when they evaluate options for compliance with environmental regulations at their facilities. This report describes the climate, vegetation, geology, soils, ground-water and surface-water hydrology, and flood potential of the areas surrounding the Federal Aviation Administration facilities near Dillingham.

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 substances have been spilled or disposed of at any of these 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 continue with these 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 facilities and nearby areas at Dillingham, Alaska. Also presented in this report is a brief description of the history, socioeconomics, and physical setting of the Dillingham area.

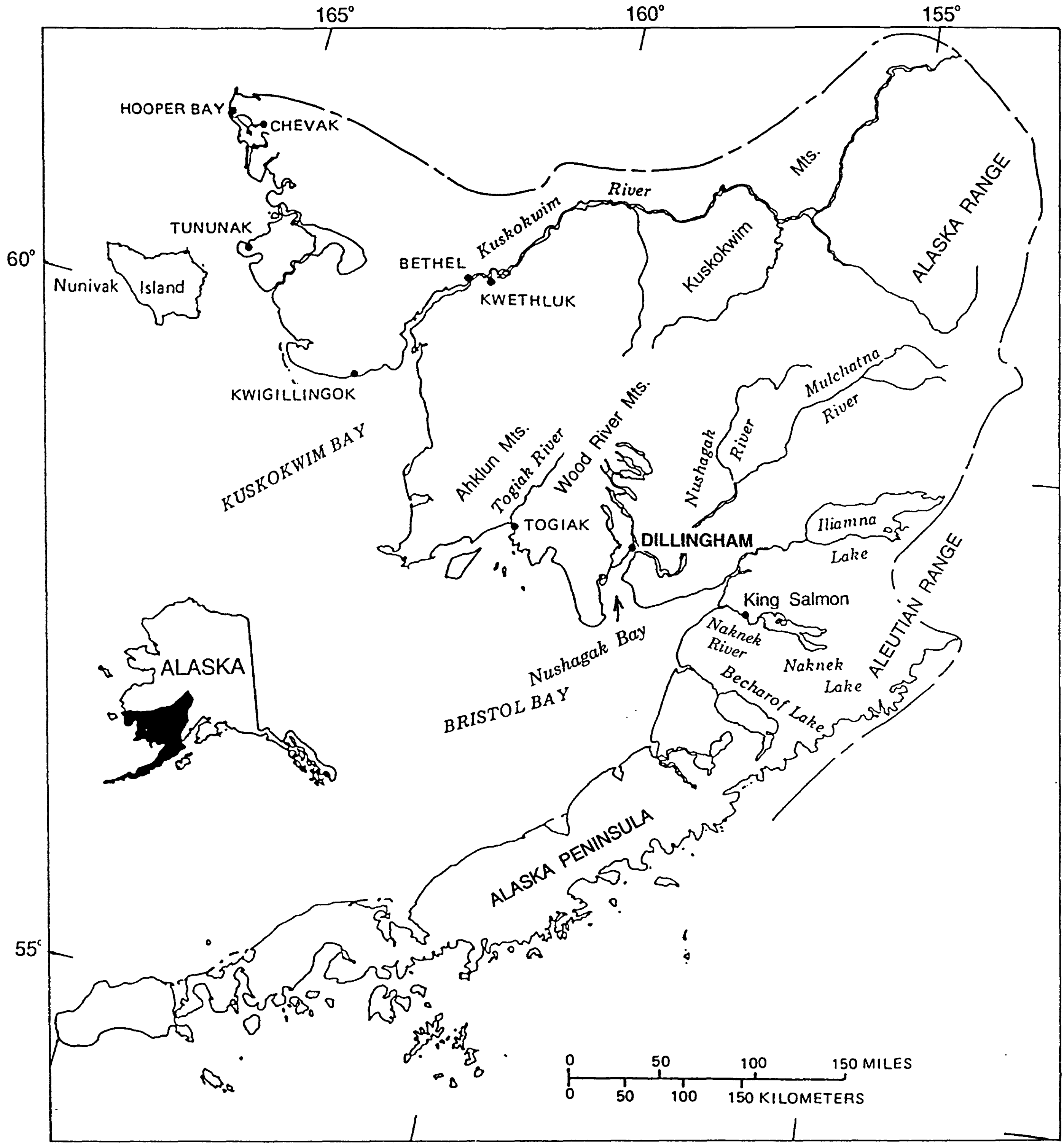

Figure 1. Location of Dillingham in southwestern Alaska.

BACKGROUND

Location

Dillingham is in southwestern Alaska (fig. 1) at latitude 59°02' N. longitude 158°27' W., approximately 530 km southwest of Anchorage. Dillingham is at the northern end of Nushagak Bay, a northern extension of Bristol Bay, near the confluence of the Wood and Nushagak Rivers (fig. 2).

History

The Nushagak Bay area was originally settled by Eskimos and various Indian groups. In 1818, Russian traders established a permanent post at the mouth of the Nushagak River (fig. 2), and by 1822, the post had become a major center of trade. Between 1890 and 1910, the population and economic activity shifted to the west side of the Nushagak Bay, where numerous canneries and a U.S. Post Office were constructed at Snag Point. In 1944, the name Dillingham was transferred to Snag Point from the original townsite. Dillingham was incorporated as a first class city in 1963 and remains the largest community in the Bristol Bay area (Alaska Department of Community and Regional Affairs, 1982, 1993).

In 1939, the population of Dillingham was 278; in 1950, it was 577; in 1960, it was 424. In 1970, the population, which by then included residents of three incorporated villages, was 914. In 1992, the population was 2,110 (Alaska Department of Community and Regional Affairs, 1993). During spring and summer, the population increases to about three times its usual size because of the influx of fishermen and cannery workers who come to work during the fishing season.

The FAA facility in Dillingham has been in operation since 1962, when the FAA built a Very High Frequency Omnidirectional Range Tactical (VORTAC) air navigation facility. The FAA facilities in Dillingham (fig. 3) include the following: a VORTAC facility, a utility building, and living quarters, which are approximately 6 km south of the airport; a navigational aid or localizer facility at the southwest corner of the runway, which trends northeast-southwest; and a directional finder antenna on the east side of the airport runway. Runway lighting is at the north end of the runway, and two visual approach slope indicators are at either end of the runway. The airport at Dillingham does not have a glide slope facility in operation, although the FAA still leases a parcel of land intended for its location. A detailed account of FAA-owned, -leased, or -transferred properties in Dillingham and a listing of suspected sources of contamination near these facilities can be found in an environmental compliance investigation report of the FAA facilities in Dillingham (Ecology and Environment, Inc., 1992). Also included in the environmental compliance investigation report is the identification of sensitive environments and the population living within a 6.4-km radius of the FAA station.

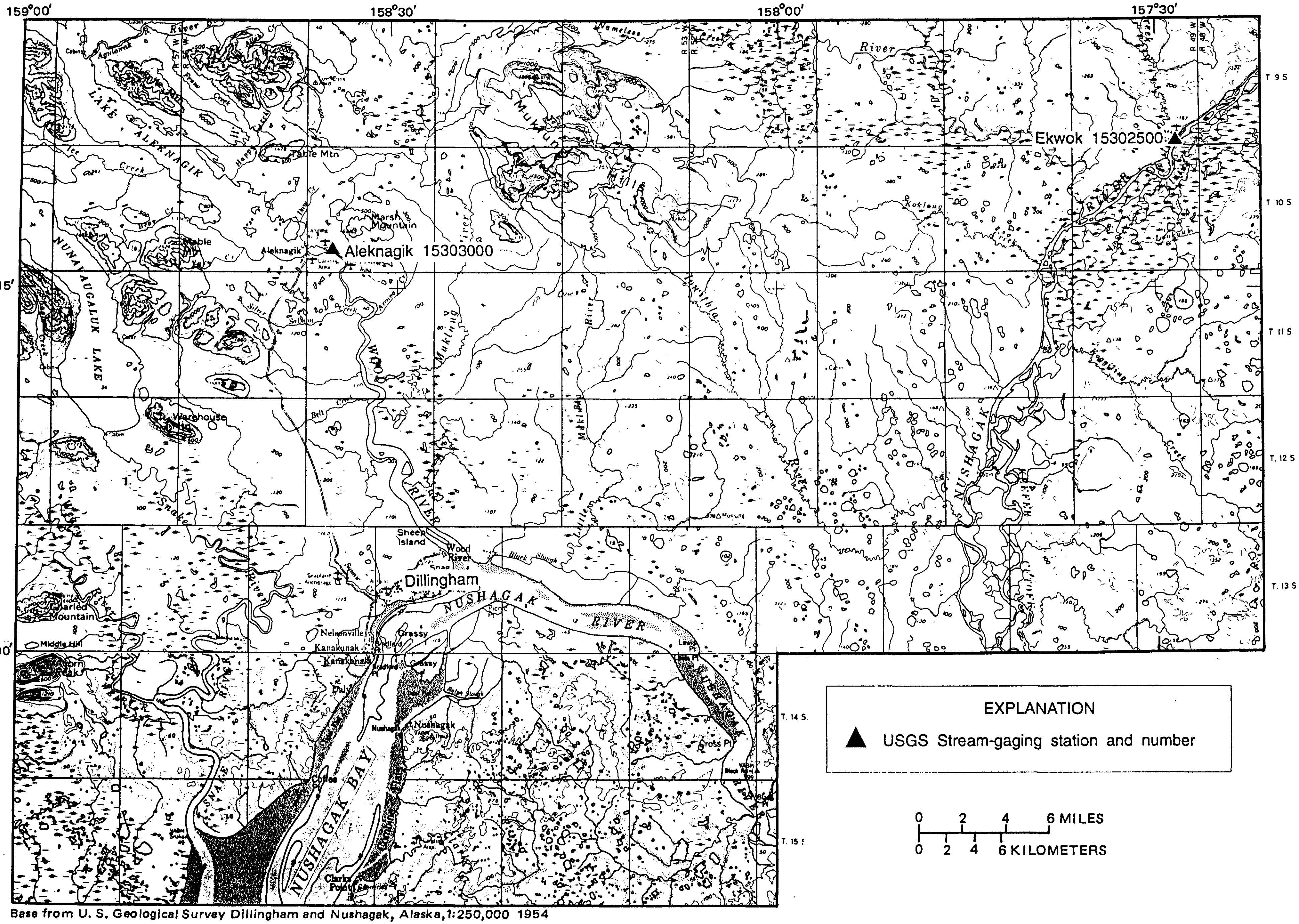

Figure 2. Location of Dillingham and surrounding area.

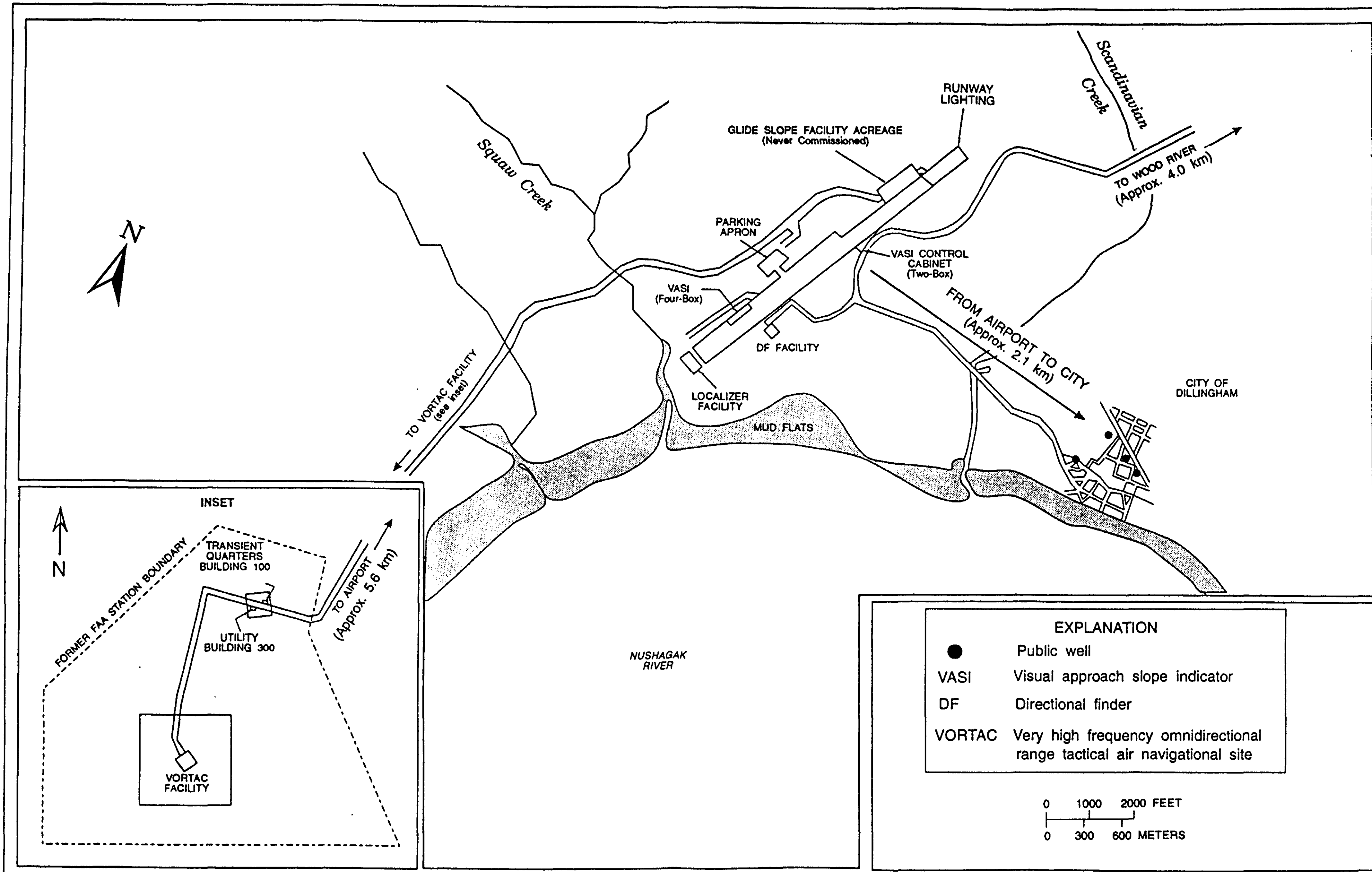

Figure 3. Location of Federal Aviation Administration Facilities near Dillingham, Alaska. (Modified from Ecology and Environment, Inc., 1992.)

Socioeconomics

Dillingham is the public service and economic center for the western Bristol Bay area. In 1990, about 56 percent of the population was Native American (Indian, Eskimo, or Aleut) (U.S. Bureau of Census, 1991). Dillingham's Native population is represented by a six-member traditional council that administers federally sponsored assistance programs. The city government consists of an elected mayor and a six-member city council; together they provide policy direction to the city manager, who is responsible for the daily operations of the city.

Dillingham can be reached from outside the local area only by air and by sea; only three roads connect the city to other nearby communities. The airport, which is publicly owned, has a 1,952-m-long gravel runway and operates year-round. Water transportation is possible only during the 5 or 6 months of the year that are ice free. The city of Dillingham operates a public water supply and a sewage collection and treatment system (Alaska Department of Community and Regional Affairs, 1982).

Fishing and fish processing are the primary economic bases of Dillingham: more than 40 percent of the full-time jobs in 1980 were associated with this industry (Alaska Department of Community and Regional Affairs, 1982). Although the fishing industry is the mainstay of the economy, Dillingham is also a regional service center for governmental activities and distribution of goods and services to western Bristol Bay area villages; diversified economic structure stabilizes the highly seasonal nature of the fishing industry (Tryck, Nyman and Hayes, 1985). Tourism and transportation industries also supplement the economic base to a minor extent.

Approximately half of the Dillingham population relies on some subsistence activities for various food sources. Fish species commonly harvested include salmon, grayling, pike, Dolly Varden, and rainbow trout. Other subsistence food sources include ptarmigan, bear, caribou, and moose, which migrate through the local area or live close by, and seasonal foods such as salmonberries, blueberries, blackberries, huckleberries, and cranberries (Alaska Department of Community and Regional Affairs, 1982).

PHYSICAL SETTING

Dillingham is in the southwestern part of the Nushagak-Bristol Bay Lowlands (Wahrhaftig, 1965). The lowlands are bounded by the Ahklun Mountains on the west, the Aleutian Range on the east, and the Nushagak-Big River Hills on the north (Wahrhaftig, 1965). The Wood River Mountains, which trend north-south, lie to the west and northwest of Dillingham. From the foothills about 25 km west of Dillingham, the terrain rises to peaks of about 610 m or more (U.S. Army Corps of Engineers, 1974). Surface features near Dillingham are characteristic of areas once covered by continental glaciers (Hartman and Johnson, 1984): mostly rolling hills with many irregularly shaped moraine knolls and ridges separated by flat wetlands and muskeg.

Climate

Dillingham is in the transitional climate zone and is influenced primarily by maritime climate from early spring to late fall and to a lesser extent by the continental climate of interior Alaska from late fall to early spring (Hartman and Johnson, 1984). Conditions are commonly cool and humid with cloudy skies and moderately heavy precipitation. Strong winds and fog are not unusual (Alaska Department of Community and Regional Affairs, 1982). Fog is most prevalent in summer, when moisture-laden air is warmer than the sea. Heavy fog (when visibility is reduced to 400 m) is most common during July and August. High-velocity winds, averaging 40 to 60 km/h, can continue for days or weeks at a time. Winds of about 95 to 115 km/h are not uncommon during December through March (Alaska Department of Community and Regional Affairs, 1982). Air temperatures range from a mean monthly maximum of 17.7 °C in July to a mean monthly minimum of -12.9 °C in December; mean annual temperature is 1.2 °C (table 1). Mean annual precipitation is about 640 mm; most rain falls from July through September. On average, approximately 1,850 mm of snow falls annually. Nushagak Bay is commonly ice covered from September through April of each year (Federal Emergency Management Agency, 1982).

Vegetation

The vegetation surrounding Dillingham consists of a mixture of moist tundra and closed spruce hardwood forest (Viereck and Little, 1972). The moist tundra is a wet mat of mosses, lichens, and tufted hair grass on which other plants grow. The closed spruce hardwood forests consist of white spruce and paper birch that cover many of the moraine hills (Viereck and Little, 1972; Federal Emergency Management Agency, 1982). Other common species of trees include quaking aspen, black spruce, and cottonwood (Alaska Department of Community and Regional Affairs, 1982). Dense stands of grass and older patches of white spruce are found along the rivers. Mosses and low-growing shrubs are dominant on intermediate slopes. Plains are almost entirely barren of vegetation except for low berry bushes, mosses, and grass (Federal Emergency Management Agency, 1982). Grasses and sedges are abundant, as are small crowberry, dwarf birch, willow, bog orchid, mosses, lichens, Labrador tea, blueberry, and numerous herbs and ferns. Wildflowers are abundant in spring and summer (Alaska Department of Community and Regional Affairs, 1982).

Geology

Bedrock exposures north of Dillingham consist of granitic rocks of Tertiary and Cretaceous age (Beikman, 1974). The depth to bedrock and its thickness are not known. The surficial geologic materials in the vicinity of the Dillingham are generally well-sorted Quaternary alluvial, glacial, and dune sand and silt deposits (Beikman, 1974). The alluvial and glacial deposits consist of gravels, sands, silts, and clays that extend to at least 63 m depth (Glass, 1987). The dune sands and silts are generally reworked deposits near the coast (Beikman, 1974). The upland hills are mantled by a thick layer of loess blown in from unvegetated flood plains and hills adjacent to the melting glaciers and volcanic ash from the Aleutian Range. These plains of silt, sand, and gravel extend from about 20 to 25 km northwestward to the Wood River Mountains and eastward to, and beyond, the Nushagak River.

Table 1. Mean monthly temperature, precipitation, and snowfall for the combined periods 1922-76 and 1985-87, Dillingham, Alaska

[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	-4.7	-3.9	-1.4	3.4	10.4	15.7	17.7	16.7	12.9	5.4	-0.8	-5.6	5.5
	(Record maximum 33.3 °C, June 1953)												
Mean minimum	-12.1	-11.9	-10.8	-5.1	.8	5.2	7.7	7.7	4.1	-2.7	-8.3	-12.9	-3.2
	(Record minimum -37.8 °C, January 1944)												
Mean	-8.4	-7.9	-6.1	-.8	5.7	10.5	12.7	12.2	8.6	1.4	-4.6	-9.3	1.2
Precipitation (mm of moisture)	43.2	32.8	38.4	29.5	40.1	44.2	70.9	99.8	87.1	65.8	47.0	41.7	640.5
Snowfall (mm)	355.6	271.8	358.1	137.2	10.2	0	0	0	2.5	50.8	292.1	373.4	1,851.7

Soils

Because of the cool, humid climate of the Dillingham area, rates of evapotranspiration are low. A large proportion of the annual precipitation percolates through the soil and is effective in leaching. As a result, well-drained soils are extremely acidic and have well-developed horizons. Poorly drained soils also are very acidic but have characteristics commonly associated with wet conditions (Rieger, 1965).

Five distinct soils series have been mapped in the Dillingham area (Rieger, 1965; Rieger and others, 1979). Aleknagik soils (approximately one-fourth of the total area) are commonly found on moraine hills and are generally well drained, extremely acidic soils in silty deposits overlying a gravelly substratum; Aleknagik soils are generally less than about 1 m thick. Kanakanak soils (approximately one-tenth of the total area) are generally well drained, extremely acidic, dark soils that are typically thick deposits over moraine hills near the rivers. Nushagak soils (approximately one-tenth of the total area) are very strongly acidic, silty soils, similar in composition to the Aleknagik and Kanakanak soils but poorly drained. These soils are generally frozen until midsummer, but permafrost does not develop in them. The water table is close to the surface. Nushagak soils occupy the lower slopes of moraine hills and ridges. A few small areas of Hyer soils are found on steep, north-facing slopes. These soils, which consist largely of poorly drained organic matter and peat are perennially frozen at depths below about 40 to 80 cm. Salamatof soils are the dominant soils in the Dillingham area (slightly more than half of the total area) and occupy nearly all of the low-lying areas. Salamatof soils consist of deep peat layers and muskegs and are generally more than 1 m thick. These soils are wet and are associated with many small lakes and ponds. Salamatof soils are generally frozen until midsummer, but permafrost does not develop in them. A detailed description of representative profiles of the soil series is given by Rieger (1965) and Rieger and others (1979).

The Dillingham area is underlain by isolated masses of permafrost (Ferrians, 1965), which where present, generally are at considerable depth and have been reported to be more than 50 m thick (Hartman and Johnson, 1984).

Permeability of the uncompacted materials of the Aleknagik and Kanakanak soils ranges from about 2.0 to 6.4 cm/h. The gravelly material underlying the Alegnagik soils and, at greater depths, the Kanakanak soils, is more permeable than either soil type (Rieger, 1965).

HYDROLOGY

The hydrology of the Dillingham area is strongly influenced by the maritime conditions of Bristol Bay. Streams in the area drain a broad lowland area south of the Kuskokwim River and west of the Alaska Range. Water resources of the Dillingham area are described in detail in a report by Glass (1987).

Surface Water

The Nushagak and Wood Rivers are the main rivers in the Dillingham area (fig. 2). Near Dillingham, the Nushagak River has an estimated drainage area of about 32,100 km^2. The drainage area of the Nushagak River at Ekwok (U.S. Geological Survey stream-gaging station No. 15302500; fig. 2) about 64 km northeast of Dillingham, is approximately 25,500 km^2 (U.S. Geological Survey, 1994). Since 1953, the maximum instantaneous discharge at the gaging station has been about 3,310 m^3/s; minimum daily mean discharge has been about 160 m^3/s, and the mean annual discharge has been about 670 m^3/s (U.S. Geological Survey, 1994).

The Wood River flows out of Lake Aleknagik about 30 km north-northeast of Dillingham. The drainage area of the Wood River at Aleknagik (USGS stream-gaging station No. 15303000; fig. 2) is approximately 2,880 km^2 (Glass, 1987). From 1957 to 1970, the mean annual discharge was about 137 m^3/s; maximum mean daily discharge was about 663 m^3/s; and an instantaneous peak flow rate of 708 m^3/s was recorded in June 1972 (Glass, 1987).

Floods

Flood hazards in Dillingham are rated low (U.S. Army Corps of Engineers, 1993). The largest flood, which occurred in 1981, was caused by wind-driven waves and inundated only one public facility (U.S. Army Corps of Engineers, 1993). In general, the lowlands (wetlands and muskeg) immediately west of the townsite are the primary areas in Dillingham where flood potential is significant (Alaska State Housing Authority, 1971; Tryck, Nyman and Hayes, 1985). Where development has taken place in flood-hazard areas, it has generally been limited to the tidal waterfront, the area adjacent to Scandinavian Creek, and to a minor extent, the area adjacent to Squaw Creek (fig. 3) (Federal Emergency Management Agency, 1982). The Federal Emergency Management Agency (1982) studied the peak-discharge frequencies for flooding sources affecting Dillingham. Flood boundaries have been identified by the U.S. Corps of Engineers (Alaska Department of Community and Regional Affairs, 1982).

Nushagak Bay, the northern extension of Bristol Bay, is subject to the influence of tide and wind; tidal range in Nushagak Bay is approximately 6.1 m, and the maximum significant wave with a 100-year return period is 22.5 m high (Brower and others, 1977). Dillingham is naturally protected from waves generated in Bristol Bay by the Nushagak Peninsula and by the scattered islands and mud-bar shallows in Nushagak Bay; however, the region is subject to sudden and violent storms during which locally generated waves can cause shoreline damage (Federal Emergency Management Agency, 1982). The city of Dillingham has no man-made protection against either tidal or river flooding or erosion (Federal Emergency Management Agency, 1982).

In general, flooding of Nushagak and Wood Rivers occurs in late summer or early fall from a combination of high tides and strong storm-winds from the south and southwest; flooding is generally in the flat areas to the south of Dillingham. More forceful storms may occur in the winter months; however, Nushagak Bay is ice covered and resistant to wave buildup from September through April of each year (Federal Emergency Management Agency, 1982). Extreme ice jamming is a remote possibility and has not been known to happen (Alaska State Housing Authority, 1971). None of the FAA facilities near Dillingham would be affected by flooding along the Nushagak and Wood Rivers (DOWL Engineers, 1981).

Significant coastal flooding may also be caused by tsunamis (seismic sea waves). However, the Tsunami Warning Station in Palmer, Alaska, reports that Dillingham is not in an area prone to tsunamis, nor is it on their list of hazard areas (DOWL Engineers, 1981). The Federal Emergency Management Agency (1982) also reports no known tsunamis for the Bristol Bay area. Yet, Lee (1989) reported depositional evidence that tsunami activity occurred about 3,500 years before present, along the northern shoreline of Bristol Bay. These tsunami deposits may reflect volcanic activity along the northern edge of the Aleutian Range about 240 km south of Dillingham.

Ground Water

On the basis of local and regional topography, shallow ground water in the Dillingham area generally flows south-southwest towards the Nushagak River and south-southeast towards the Wood River. Depth to the water table varies but generally ranges from 1 to 25 m below ground surface (Glass, 1987). Lithologic descriptions from drillers' logs indicate two or more sand and gravel aquifers separated by layers of clay (Glass, 1987).

Well depths in the Dillingham area range from about 6 to 65 m and yield from 0.32 to 14.2 L/s (Glass, 1987). Natural seasonal fluctuations of water levels are generally less than 1.8 m (Glass, 1987). Water levels in public-supply wells are lowest during June and July, when the demand for water is high because of intensive fish processing. Occasionally, water levels are low during the winter, possibly because of a seasonal decrease in recharge to the aquifer (Glass, 1987).

Ground-Water/Surface-Water Interaction

Adjacent to the local streams and rivers, shallow ground water flows into and out of the banks as the elevation of water in the river or stream (stage) rises and falls. Seasonally, the stream fluctuates from maximum flow and stage in late May or early June to minimum flow in late April or early May. The stream rises also during late-summer rainstorms. The water table generally rises and falls in response to these fluctuations. The water-table fluctuations, however, are attenuated with distance from the stream. This flow of water into and out of the aquifer in response to changing stage of the stream is termed "bank storage effects" (Linsley and others, 1982) (fig. 4).

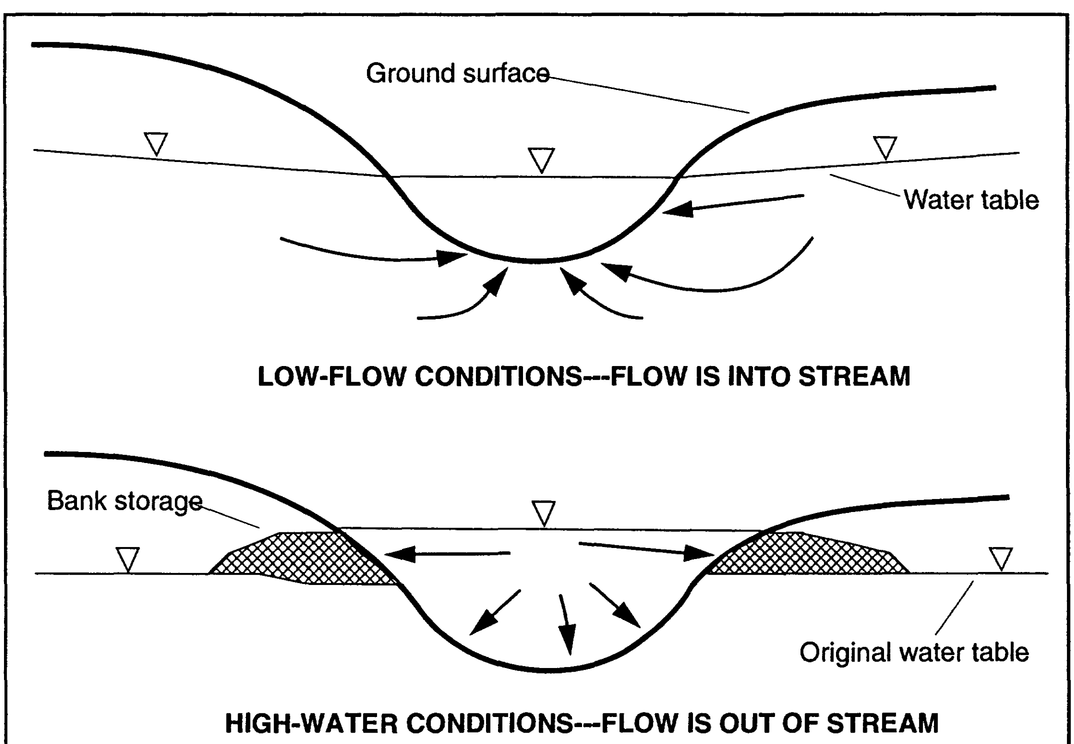

Figure 4. Ground-water/surface-water interactions.

During the height of the fish-processing season, in late June through mid-July, several wells in Dillingham within about 500 m of the Nushagak Bay estuary are heavily pumped; increased ground-water pumping might induce saltwater to migrate into freshwater aquifers that are used for public supply. When streamflow is low and tides are high in spring, salinity increases in the estuary. Ground-water levels that are near or below sea level are a cause for concern because increased pumping rates might produce a greater than normal drawdown and could possibly cause saltwater from the estuary to migrate into freshwater aquifers (Glass, 1987). The season of maximum ground-water use in midsummer coincides with high stream discharge and greater dilution of the estuary by freshwater. If pumping rates and durations remain at about the levels reported in 1987, then the threat of saltwater intrusion inland to the city's public-supply wells seems unlikely (Glass, 1987).

DRINKING WATER

Present Drinking-Water Supply

Ground water is the source of almost all water used in Dillingham for domestic, commercial, and industrial purposes. An estimated 400 to 500 wells have been drilled in the Dillingham area; locations of wells for which information is available are shown by Glass (1987). No private or public wells are within 6.4 km of the VORTAC facility (fig. 3) (Ecology and Environment, Inc., 1992).

The city of Dillingham's public-water-supply facilities consist of four wells (fig. 3), two storage tanks, and a public distribution system to supply water to about 150 residential and commercial buildings in the townsite area, which includes the airport facility (Ecology and Environment, 1992) and a nearby subdivision; private wells supply water to residential, commercial, and industrial water users outside the townsite area (Glass, 1987). Water from three of the public-supply wells is treated with chlorine and fluoride before it flows into storage tanks (Glass, 1987).

Average depth of the four public-supply wells is 28.6 m; average depth to water is 21.9 m. Water consumption in Dillingham averages approximately 322,000 L/d in winter and 492, 000 L/d in summer (Ecology and Environment, Inc., 1992). The highest rate of water use is in midsummer; in some years, the total midsummer use from combined public and private supply in the Dillingham area is about 3,785,000 L/d (Glass, 1987).

The city's water system is described in detail by Wince-Corthell and Associates (1974) and DOWL Engineers (1981).

Quality of the Present Supply

Water-quality data are scanty for the Dillingham area. Water-quality data for the public-water supply indicate that the ground water frequently contains high levels of dissolved iron and that color and taste problems are common; however, water delivered by the public-water supply is reliably pure (Tryck, Nyman and Hayes, 1985). Not many privately owned wells have been authorized by permit, and as a result, recorded data on the quality of water from these wells are scarce (Tryck, Nyman and Hayes, 1985).

Water with chloride concentrations less than 250 mg/L is suitable for most domestic and industrial uses (U.S. Environmental Protection Agency, 1993). Chloride concentrations in samples collected from city wells and a fish-processing plant well, during 1974-79, ranged from 3.7 to 21 mg/L (Glass, 1987). Wells in the Dillingham area commonly yield water that contains undesirable concentrations of iron and manganese; high concentrations of these constituents can cause water to have an unappealing taste and color and cause staining of plumbing fixtures, laundry, and cooking utensils but generally does not prevent the water from being used for drinking purposes (Glass, 1987).

For domestic uses and most commercial and industrial uses, water with dissolved-solids concentrations less than 500 mg/L is desirable (U.S. Environmental Protection Agency, 1993). In 1979, specific conductance of water from nine wells along the Nushagak River and within the townsite ranged from 65 to 700 μS/cm, an indication that the water has a dissolved-solids concentration ranging from about 45 to 500 mg/L (Glass, 1987).

In much of the Dillingham area, the potential for contamination of ground water is considerable because of the naturally high water table and the permeable geologic material. The shallowness of many of the wells make them susceptible to contamination from septic-systems seepage or surface spills.

Alternative Drinking Water Sources

Neither Squaw Creek nor Scandinavian Creek has an adequate flow for a year-round drinking water supply, and water from a lake large enough to supply Dillingham would have to be transported over too great a distance to provide an economically feasible public-water supply. The Nushagak and Wood Rivers are too turbid and are too high in salinity during tides for use as drinking water (Tryck, Nyman and Hayes, 1985).

Ground water may be a potential alternative drinking-water source, but protection from contamination from the surface would have to be ensured. Clay, which may form poorly permeable layers between aquifers used to supply drinking water, is noted in drillers' logs described in Glass (1987). If these clay layers separate the aquifers adequately, and if the hydraulic gradient is upward, deep ground water may be somewhat protected from potential contamination originating at land surface.

Quality of the Alternative Sources

The water quality of the Wood and Nushagak Rivers has been summarized by Glass (1987). The primary concern is the salinity and turbidity of these sources. An additional concern is contamination of surface water: untreated sewage is discharged directly into the Nushagak River (DOWL Engineers, 1982), and wastes from seafood-processing plants are discharged directly into the rivers (Glass, 1987). The quality of local alternative sources of ground water is also described by Glass (1987).

SUMMARY

Dillingham's remote location makes it dependent on the airport and the local watercourses for transportation. The subsistence lifestyle of many residents makes them dependent on a sustainable environment. The residents and industries of Dillingham use ground water for their water supply. Because the Nushagak and Wood Rivers are too turbid and are effected by tides, they do not represent an alternative drinking-water supply. Local lakes are either too distant or too small to supply drinking water to Dillingham. Squaw Creek and Scandinavian Creek have inadequate flows to supply Dillingham with year-round drinking water. Alternative drinking-water supplies may be found in deep ground water, but the ground-water system underlying Dillingham has not been defined in enough detail to determine if underlying aquifers yield water at sufficient rates and with adequate quality.

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