

CONVERSION TABLE

Multiply inch-pound units	By	To obtain metric SI units
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	0.0631	liter per second (L/s)

Micrograms per liter (µg/L) and milligrams per liter (mg/L) are standard reporting units.

ABSTRACT

The U.S. Geological Survey, in cooperation with the Fairbanks North Star Borough, is conducting a study of the geohydrology of the Fairbanks area. This study, begun in 1975, is designed to provide basic hydrologic data for land-use planning. Studies to date (1981) indicate that arsenic, nitrate, iron, and hardness in well water are concerns of local homeowners and planners. Arsenic and nitrate in water can affect human health, whereas iron and hardness can be aesthetically objectionable and can also impair plumbing systems.

This report represents all the arsenic, nitrate, iron, and hardness data collected in the Chena Hot Springs Road - Steele Creek Road - Gilmore Trail area [township one north (T. 1 N.), range one east (R. 1 E.), Fairbanks meridian] through October 1981. Two previous reports were compilations of all the data collected in the Fairbanks area (Johnson and others, 1978), and the Chena Ridge area (Krumhardt, 1980).

Within the study area, concentrations of arsenic ranged from 0 to 5,100 micrograms per liter, nitrate ranged from 0 to 53 milligrams per liter, iron ranged from 0 to 50 milligrams per liter, and hardness ranged from 12 to 1,000 milligrams per liter. For public water supplies, the U.S. Environmental Protection Agency recommends a limit of 50 micrograms per liter arsenic, 10 milligrams per liter nitrate, and 0.3 milligrams per liter iron. No recommended limit has been set for hardness.

INTRODUCTION

The U.S. Geological Survey, in cooperation with the Fairbanks North Star Borough, is conducting a study of the geohydrology of the Fairbanks area. This study, begun in 1975, is designed to provide basic hydrologic data for land-use planning.

Arsenic, nitrate, iron, and hardness in well water are the greatest concerns to homeowners and planners. Arsenic and nitrate in water can affect human health whereas iron and hardness can be aesthetically objectionable and can also impair plumbing systems.

This is the third map report to be published in cooperation with the Fairbanks North Star Borough describing water-quality data collected in the Fairbanks area. The first, by Johnson and others (1978) was a compilation of all the arsenic, nitrate, iron, and hardness data collected by various agencies through September 1978. Additional data collected by the U.S. Geological Survey in the Chena Ridge area through June 1979 were published in a second map report (Krumhardt, 1980). This map report presents all the arsenic, nitrate, iron, and hardness data collected through October 1981 in the Gilmore Trail - Steele Creek Road - Chena Hot Springs Road areas [township 1 north (T. 1 N.), range 1 east (R. 1 E.), Fairbanks meridian]. The data should not be used in place of sampling and analysis in the determination of water quality of unsampled wells or areas. However, the presence of contaminated wells in an area indicates that nearby wells also have a chance of being contaminated.

Data collection for this study was coordinated through a well inventory program. Samples were obtained only through solicitation of homeowners or at their request; therefore not all wells in the area were sampled. Additionally, sample sites tend to be concentrated in the areas of greatest development and are sparse in areas of little or no development.

At each site, the following determinations were made: temperature, pH, bicarbonate alkalinity, and specific conductance. Additionally, field tests for iron and nitrate were performed. Samples for iron or nitrate analysis were collected only if the field tests indicated that the levels of iron or nitrate may be above U.S. Environmental Protection Agency standards. Samples for arsenic and hardness were routinely collected during each site visit. Depths to static water level were also measured where possible. All data collected during this study are on file at the U.S. Geological Survey office in Fairbanks.

Physiography and Geology

The study area lies along the southern edge of northwest-trending hills known as the Yukon-Tanana uplands. These uplands are bordered by the Tanana River valley to the south and the Yukon River valley to the north. The headwaters of Steele Creek, Columbia Creek, Engineer Creek, and Isabella Creek are all located within the study area.

The uplands are composed primarily of a pelitic schist (metamorphosed marine mud deposit) and micaceous quartzite bedrock (Péwé and others, 1976). Blanketing the hills is an eolian (wind-blown) silt, or loess, originating from the Tanana River flood plain during the Quaternary period. This silt cover is thin or nonexistent at the ridgetops and gradually thickens downslope. Additionally, the silt cover is thickest on the hills adjacent to the Tanana River flood plain and gradually thins to little or no silt cover on hills to the north. On the lower slopes and valley floors, the loess has been reworked and is locally referred to as muck. This muck is perennially frozen and in places has a high ice content. It commonly overlies coarse gravel in the creek valley bottoms but rests directly on the bedrock on the upper slopes.

Uplands Hydrology

In the uplands, arbitrarily defined as those portions of the hills above an altitude of 500 ft, ground water is transmitted primarily through fractures and faults within the bedrock. Yields are generally low, often less than 5 gal/min, although drillers have reported yields as high as 15 gal/min from some wells. Recharge to the bedrock aquifer is local, occurring primarily at the ridgetops where the silt cover is thin or nonexistent. Gravel, found in the creek valleys in the uplands does not yield significant amounts of ground water.

On the lower slopes and valley bottoms, permafrost can act as a natural barrier permitting neither discharge from, nor recharge to, an aquifer. Where the ground water is confined by permafrost, water under a sufficient hydraulic head may flow at the surface through wells or other openings such as springs or seeps. This is known as the artesian zone. A few homeowners in the study area have successfully controlled this natural flow and incorporated it into the household plumbing systems. However, many drillers refuse to drill in the artesian zone because of the high risk of uncontrolled flow in the annular space around the casing. To regain control of the flow is often extremely difficult, if not impossible, and can be very costly.

CHEMICAL CHARACTERISTICS

Arsenic

Arsenic concentrations found to date in the ground water of the study area have ranged from 0 to 5,100 µg/L. The maximum recommended limit set by the Alaska Department of Environmental Conservation (1979) and EPA (1976a) is 50 µg/L. Thirteen percent of the wells sampled exceeded this limit.

A dose of 70,000 µg, or less than 1 ounce, of pure arsenic is toxic to humans (Luh and others, 1973). The toxic level may vary with the tolerance of the individual and probably depends on the chemical form of the arsenic (National Academy of Sciences, National Academy of Engineering, 1972). Smaller quantities taken over a long period of time can accumulate in the body and produce chronic or acute arsenic poisoning. Varied symptoms of arsenic poisoning include fatigue, skin growths, nervous system disturbances, and gastrointestinal, kidney, and liver ailments. In Taiwan, the consumption of water containing more than 300 µg/L arsenic has been correlated with increased incidences of skin cancer.

The primary source of arsenic and the mechanisms by which it enters ground water in the Fairbanks area have not been conclusively demonstrated. However, mineralized bedrock in the Fairbanks area commonly contains an arsenic-bearing mineral, arsenopyrite (FeAsS). Scorodite (FeAsO₄·2H₂O), a mineral formed by the weathering of arsenopyrite, may also be a source of arsenic within the bedrock. The distribution of wells containing water having arsenic concentrations above the recommended limit is sporadic. Additionally, arsenic-contaminated wells and wells in which water contains little arsenic are only a few hundred feet apart in many places. This may be caused by the presence of two or more zones within the aquifer bearing water having different concentrations of arsenic (Nelson, 1978). The concentration of arsenic in the well water depends on which zone is tapped. If two or more zones are tapped by a well, the arsenic concentrations may vary with the yield of each zone. The concentrations of arsenic may also vary with the duration of pumping, the settling time in a pressure tank, and precipitation reactions in the water. Arsenic dissolved in water is colorless, odorless, and tasteless, and is not removed by water treatment systems commonly used by homeowners.

Nitrate

Water sampled in the study area had nitrate [as nitrogen (N)] concentrations ranging from 0 to 53 mg/L. The recommended limit set by EPA (1976b) for nitrate as N in domestic water supplies is 10 mg/L. Fourteen percent of the water samples tested for nitrate exceeded the maximum recommended limit.

The element nitrogen (N) occurs in ground water in many forms, including nitrate (NO₃), nitrite (NO₂), and ammonium (NH₄). Nitrogen is most commonly found in ground water as nitrate (NO₃). Nitrate is colorless and odorless, and is not removed by conventional water treatment systems. In excessive amounts nitrate can cause water to taste bitter (Miller, 1980). Most samples analyzed at the U.S. Geological Survey central laboratory were analyzed for the sum of nitrate plus nitrite as nitrogen. The results may be reported as NO₃ or N. To convert a NO₃ value to its equivalent as N divide by 4.4. In this report, all nitrate values are reported as N.

Ingestion of water containing more than 10 mg/L of nitrate may be related to hypertension, cancer, and in some infants under 3 months of age, potentially fatal anemia. Bacterial conversion of the nitrate ion to the nitrite ion may occur in the digestive tract of infants less than 3 months of age (National Academy of Sciences, National Academy of Engineering, 1972). Nitrite absorbed into the bloodstream combines with the hemoglobin, reducing the oxygen-carrying capacity of the blood. The result, called methemoglobinemia, or most commonly "blue baby", is oxygen starvation and is a condition which can be recognized and reversed. However, many infants have consumed water containing more than 10 mg/L nitrate with no adverse effects. Factors which may affect susceptibility to nitrate poisoning include heredity, the ingestion of nitrate-rich vegetables and vitamin C-rich foods, and the use of certain medications which affect nitrate metabolism.

Metamorphic minerals such as those in bedrock in the Fairbanks area do not contain nitrates. Thus, in the Fairbanks area nitrate in the ground water probably originates near the surface where septic tank effluents, fertilizers, or natural soil nitrates are possible sources.

The occurrences of high nitrate concentrations in ground water in the area are unpredictable. Until the source of nitrate and the areas affected by high nitrate concentrations are better known, all homeowners using private wells should be aware of the potential health hazard.

Iron

Iron concentrations in the study area ranged from 0 to 50 mg/L. The EPA recommended limit of 0.3 mg/L is based on aesthetic considerations rather than health effects. The recommended limit was exceeded in 80 percent of the wells sampled. However, 58 percent of the wells sampled contained less than 1 mg/L. Twenty-five percent contained iron in concentrations from 1 to 3 mg/L, and 17 percent contained iron in concentrations over 3 mg/L.

Small amounts of iron create an unpleasant taste or odor in water and cause staining of laundry, appliances, and hair. Staining caused by water with iron concentrations of less than 1 mg/L can be effectively controlled by cleaning agents and bleaches. At concentrations between 1 and 3 mg/L, water may become unpalatable, and staining becomes more difficult to control. Water containing more than 3 mg/L of iron is aesthetically unpleasant to many people, turns alcohol and coffee black, and at this concentration staining is difficult to control without the use of iron filters. When iron-rich water is oxygenated as it is in home water systems, the iron precipitates and causes iron stains. Iron-removal systems which oxidize household water and filter the iron residue are commercially available. Based on these considerations, three ranges of concentrations are portrayed on the map: less than 1 mg/L, 1 to 3 mg/L, and more than 3 mg/L.

Generally, iron concentrations increase downslope. This increase may result from exposure of percolating ground water to buried organic debris in the hillsides and upper creek valleys. It also may result from inorganic oxidation reactions occurring as the water moves from the recharge areas towards the valleys.

The decomposition of organic matter in soils consumes oxygen from ground water and produces oxygen-deficient environments in which iron is more readily dissolved. Such conditions are common in the alluvium of the Tanana River flood plain and in creek valley bottoms. Iron concentrations in these areas are almost always more than 1 mg/L and usually more than 3 mg/L.

Certain bacteria speed the oxidation and precipitation of iron (Hem, 1970). These bacteria live in many wells and cause some of the iron to precipitate before it reaches the plumbing outlet. They produce a jelly-like slime that can eventually plug the pore space in the aquifer near the wells and slow the influx of water. Fragments from these bacterial growths can break loose and plug pipes and filters. Heavy chlorination of the wells at frequent intervals minimizes the development of iron bacteria; however, once the bacteria are established in an aquifer near a well, there is no known effective method of removing or destroying them.

Hardness

Hardness of ground-water samples taken from the study area ranged from 12 to 1,000 mg/L. Hardness was more than 200 mg/L in 69 percent of the wells sampled and less than 100 mg/L in only 13 percent.

Hem (1970) stated that waters containing less than 100 mg/L hardness are generally acceptable for domestic use although the optimum amount is a matter of consumer preference. At levels above about 200 mg/L, hardness becomes evident in all uses. The EPA provides no recommended maximum or minimum levels of concentration for hardness of water. In light of Hem's observations, three ranges of hardness are portrayed on the map: less than 100 mg/L, 100 to 200 mg/L, and more than 200 mg/L.

Hardness of water is caused mainly by the presence of dissolved calcium and magnesium and is expressed as an equivalent quantity of calcium carbonate. Hard water not only retards the cleaning action of soap and detergents, but can also form scale on cookware, in water heaters, and in boilers. However, the hardness of water can be controlled by commercially available softeners. Hard water may also have some beneficial effects. In the United States, a tentative correlation has been suggested between areas of hard water and areas where the death rate from cardiovascular diseases is lower than average (Muss, 1962).

The hardness of ground water depends on the length of time the water has been in contact with minerals, the nature of the minerals, and the corrosiveness (acidity) of the water. Calcite or calcium carbonate (CaCO₃), a common mineral in the bedrock of the Fairbanks area, is particularly susceptible to attack by acidic water and may contribute to the hardness of local ground water.

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CHEMICAL ANALYSES

a = field determination using Hach* test kit NI-12; b = field determination using Hach* test kit IR-18B; c = estimated from field bicarbonate alkalinity; d = arsenic and nitrate sample collected between February 1976 and September 1977.

* The use of brand names in this report does not imply endorsement by the U.S. Geological Survey

Map no.	Location	Arsenic (As) (µg/L)	Nitrate (NO ₃ as N) (mg/L)	Iron (Fe) (mg/L)	Hardness (as CaCO ₃) (mg/L)	Sampling date
	Sec. 3					
1		<1	<0.1	<1	<100	10/71
2		<1	0.2	<1	<100	d
3		<1	0.2	<1	<100	d
4		<1	<1	<1	<100	d
5		2	0.4	<1	<100	d
6		4	0.3	<1	<100	d
7		3	<1	<1	<100	d
	Sec. 4					
1		0	0	b 3.4	c-100	09/21/76
	Sec. 9					
1		1	0.1	<1	<100	d
2		1	0	b 2.5	c-100	09/29/76
3		3	0.29	b-1	c-100	10/26/76
4		4	0	b-1	c-100	10/26/76
5		5	0	b 1.4	c-100	11/03/76
6		0	0	b-1	c-100	d
	Sec. 11					
2		6	0.11	0.9	120	09/18/81
3		<1	0.23	0.08	120	10/28/81
	Sec. 13					
1		2	0	0.06	46	08/04/81
	Sec. 14					
1		150	0	2.6	250	08/04/81
2		6	0	0.04	110	08/10/81
	Sec. 15					
1		15	0	4.7	78	08/11/81
6		2	a 2	1.3	23	08/13/81
7		2	0	1.2	12	08/05/81
	Sec. 16					
1		<1	0.2	<1	<100	11/73
2		<1	0.3	<1	<100	11/73
3		<1	<0.1	<1	<100	11/73
4		<1	0.5	<1	<100	07/71
5		<1	0.4	<1	<100	07/71
6		6	0.4	<1	<100	d
7		1	0.5	<1	<100	d
8		7	0.2	<1	<100	d
9		12	<1	<1	<100	d
	Sec. 17					
1		<1	1.6	<1	<100	04/73
2		<1	15	<1	<100	06/72
3		32	<1	<1	<100	d
4		49	<1	<1	<100	d
5		54	<1	<1	<100	d
6		2	<1	<1	<100	d
7		18	0	b 1.8	c 200	09/27/76
8-1		<1	0	37	c-200	09/27/76
9		250	0	b-1	c-200	10/28/76
10		60	0	32	c-200	11/02/76
11		<1	<1	<1	<100	d
13		300	5.2	b 2.5	c-200	01/19/77
15		50	1.9	0.84	c-200	03/17/77
19		150	1.7	<1	c-200	07/21/77
20		300	8.2	<1	<100	07/21/77
	Sec. 18					
1		5,100	<1	<1	<100	d
2		0	a 2	b 3	c-200	09/29/76
3		<1	a 3	b 1.5	c 100	11/22/76
4		<1	<1	<1	<100	d
5		115	<1	<1	<100	d
6		<1	<1	<1	<100	d
7		380	<1	<1	<100	d
8		150	<1	<1	<100	d
9		<1	0	9	c-100	11/22/76
10		<1	<1	<1	<100	d
11		31	<1	<1	<100	d
12		2	0.10	b 2	c-200	01/18/77
13		0	4.6	1.6	c-200	04/06/76
14		<1	<1	<1	<100	d
	Sec. 19					
1		<1	12	<1	<100	04/73
2		<1	2.3	<1	<100	08/31/73
3		<1	6.2	<1	<100	09/71
4		5	1.4	2.0	230	07/71
5		<1	0.4	<1	<100	08/72
6		5	<1	<1	<100	d
7		17	0.4	<1	<100	08/26/75
8		17	0.4	<1	<100	d
9		<1	23	<1	<100	06/72
10		130	<1	<1	<100	10/72
22		0	a 2	0.54	270	08/23/79
24		5	1.4	2.0	c-200	03/28/77
25		6	0	b 2.3	c-200	03/28/77
26		13	2.1	b-1	c-200	04/05/77
27		6	1.8	b-1	c-200	03/28/77
28		1	1.3	b-1	c-200	03/