Form 9-014

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

GROUND-WATER INVESTIGATION FOR U.S. AIR FORCE LAUNCH CONTROL FACILITY 0-0, GRIGGS COUNTY, NORTH DAKOTA

Open-File Report 75-345

Prepared in cooperation with the
United States Air Force,
Grand Forks Air Force Base,
North Dakota

U. S. GOVERNMENT PRINTING OFFICE 16—68863-2
831-564

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July 1975

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SELECTED FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

A dual system of measurements--English units and the International System (SI) of units--is given in this report. SI is a consistent system of units adopted by the Eleventh General Conference of Weights and Measures in 1960. Selected factors for converting English units to SI units are given below.

Multiply English units	By	To obtain SI units
Acres	0.4047	hectares (ha)
Feet (ft)	.3048	metres (m)
Gallons (gal)	3.785	litres (l)
Gallons per minute (gal/min)	.06309	litres per second (l/s)
Inches (in)	25.4	millimetres (mm)
Miles (mi)	1.609	kilometres (km)

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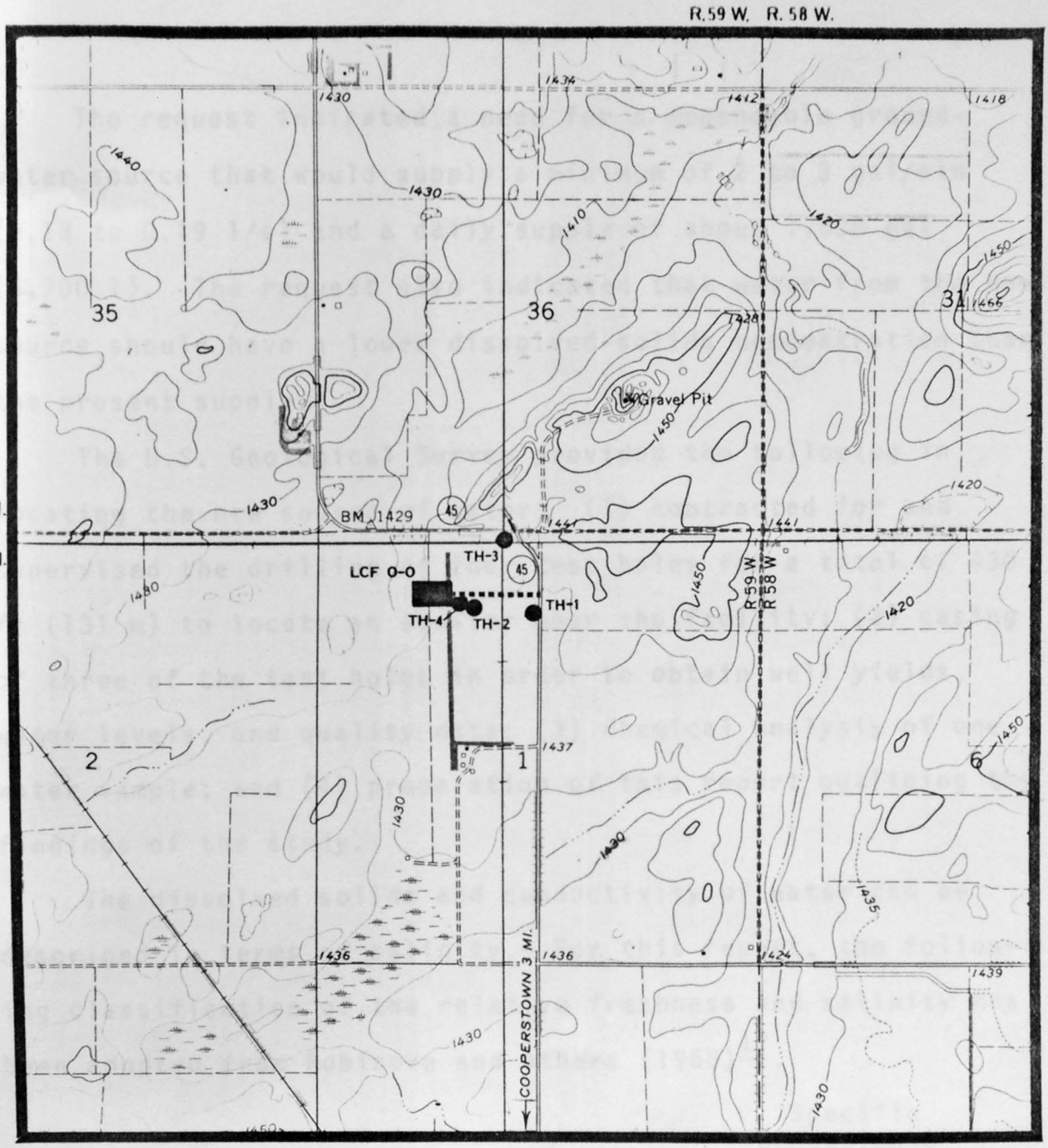
ABSTRACT

U.S. Air Force Launch Control Facility O-O is located about 3.6 miles (5.6 kilometres) north of Cooperstown, Griggs County, North Dakota. Test drilling indicates that a glacial-drift aquifer located within about 0.2 mile (0.3 kilometre) of the site will supply 2 to 3 gallons per minute (0.13 to 0.19 litre per second) of acceptable quality water for the facility.

INTRODUCTION

In response to a request from the U.S. Air Force, Grand Forks Air Force Base, North Dakota, in July 1974, the U.S. Geological Survey provided technical assistance in locating a ground-water supply for Air Force Launch Control Facility (LCF) O-O. The facility (fig. 1) is located about 3.6 mi (5.6 km) north of Cooperstown on North Dakota State Highway 45 in Griggs County, North Dakota.



BASE FROM U.S. GEOLOGICAL SURVEY
COOPERSTOWN EAST 1:24,000 1961
FINLEY N.E. 1:24,000 1967
LUVERNE N.W. 1:24,000 1967
SHARON 1:24,000

0 1/2 1 MILE
0 .5 1 KILOMETRE

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

EXPLANATION

TH-1
Test hole location and number

Location of Launch Control Facility 0-0

9½°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1961

NORTH DAKOTA
INDEX SHOWING LOCATION OF MAP AREA

FIGURE 1.--Location of Launch Control Facility 0-0 and test holes

The request indicated a need for a dependable groundwater source that would supply a minimum of 2 to 3 gal/min (0.13 to 0.19 l/s) and a daily supply of about 1,500 gal (5,700 l). The request also indicated that water from the new source should have a lower dissolved-solids concentration than the present supply.

The U.S. Geological Survey provided the following in locating the new source of water: (1) contracted for and supervised the drilling of four test holes for a total of 430 ft (131 m) to locate an aquifer near the facility; (2) casing of three of the test holes in order to obtain well yields, water levels, and quality data; (3) chemical analysis of one water sample; and (4) preparation of this report outlining the findings of the study.

The dissolved solids and conductivity of water can be described in terms of salinity. For this report, the following classification of the relative freshness and salinity has been adopted from Robinove and others (1958)[1/].

Class	Dissolved solids (milligrams per litre)	Specific conductance (micromhos per centimetre at 25°C)
Fresh	less than 1,000	less than 1,400
Slightly saline	1,000 to 3,000	1,400 to 4,000
Moderately saline	3,000 to 10,000	4,000 to 14,000
Very saline	10,000 to 35,000	14,000 to 50,000
Brine	more than 35,000	more than 50,000

1/ Robinove, C. J., Langford, R. H., and Brookhart, J. W., 1958, Saline-water resources of North Dakota: U.S. Geol. Survey Water-Supply Paper 1428, 72 p.

Well-Numbering System

The well-numbering system used in this report is based upon a system of land survey in use by the U.S. Bureau of Land Management. The first numeral denotes the township north of a base line; the second numeral denotes the range west of the fifth principal meridian; and the third numeral denotes the section in which the well is located. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section, quarter-quarter section, and quarter-quarter-quarter section (10-acre or 4-ha tract). Thus, well 146-059-01BAA is in the NE¼NE¼NW¼ sec. 1, T. 146 N., R. 59 W.

SUMMARY OF PREVIOUS GROUND-WATER-SUPPLY DEVELOPMENT

The present water supply for LCF 0-0 is obtained from a 1,230-ft (375-m) well tapping the Dakota aquifer that was drilled in 1963. The well is screened with a 12-slot stainless-steel screen set between 1,208 and 1,230 ft (368 and 375 m) below land surface. Water from the well has a dissolved-solids concentration of 3,800 mg/l (milligrams per litre).

GEOHYDROLOGIC SETTING

LCF 0-0 is located in the glaciated region of North Dakota and the surface deposits consist of glacial drift. Localized deposits of sand and gravel that will yield from 5 to 50 gal/min (0.3 to 3.2 l/s) of slightly saline water to wells occur within the drift in the study area.

The Pierre Shale directly underlies the glacial drift and consists of more than 200 ft (61 m) of light-gray to black shale, marlstone, and claystone. Yellowish to white bentonite layers occur in the lower part of the formation. The upper part of the Pierre Shale in the area of LCF 0-0 consists of a black fissile marine shale that has been extensively fractured, apparently by glacial action. The fractured shale forms an aquifer that is a source of 1 to 5 gal/min (0.06 to 0.3 l/s) of water for farms in the vicinity of LCF 0-0. Water quality from the Pierre Shale ranges from slightly saline to moderately saline. The water generally is a sodium bicarbonate sulfate type, and the principal ions are sodium, calcium, chloride, bicarbonate, and sulfate.

TEST DRILLING

Logs for test holes 1, 2, and 3 (fig. 1), drilled as a part of this project, and Air Force log 2321, drilled during construction of the facility, are shown in table 1.

Test hole 1 was drilled to a depth of 140 ft (43 m) and penetrated fractured Pierre Shale at 48 ft (15 m). Four feet (1.2 m) of fine to medium sand was encountered directly above the shale. A total of 140 ft (43 m) of 1¼-in (32-mm) plastic pipe with a 3-ft (1-m) screen was installed in the test hole, and the hole filled to about 10 ft (3 m) below land surface with fine gravel. The well was developed by airlift; however, yield from the fractured Pierre aquifer at this location was less than the required 2-3 gal/min (0.13-0.19 l/s).

Test hole 2 was drilled to a depth of 180 ft (55 m) near LCF 0-0 and a 1¼-in (32-mm) observation well screened from 109 to 115 ft (33 to 35 m) installed. Yield from this well also was insufficient.

Test hole 3, drilled northeast of LCF 0-0, penetrated the most promising aquifer. At this site two sand units were found in the interval from 33.5 to 78 ft (10 to 24 m) below land surface. The deepest sand, extending from 47.5 to 78 ft (14 to 24 m), consists of fine to very coarse subangular fragments interbedded with thin clay lenses from 50 to 60 ft (15 to 18 m). A 1¼-in (32-mm) observation well was screened in this unit and pumped by airlift for 14 hours at a rate of

2 to 3 gal/min (0.13 to 0.19 l/s). Static water level after pumping was 16 ft (5 m) below land surface.

Test hole 4 was drilled to a depth of 30 ft (9 m); however, due to difficult drilling conditions, the hole was abandoned.

Airlift was used to obtain water samples for chemical analysis. Although airlift introduces air into water samples, the effects of air on the unstable constituents were minimized by collecting, filtering, and acidifying a separate sample for analysis of these constituents. All water samples for chemical analysis were collected in polyethylene bottles.

RESULTS OF STUDY

Based on available data, the required supply of water for LCF 0-0 could be developed northeast of the low-frequency antenna site near test hole 3, approximately 0.2 mi (0.3 km) from LCF 0-0. A properly constructed and developed 6-inch (150-mm) diameter well tapping the buried sand deposit from 47.5 to 78 ft (14 to 24 m) below land surface at test hole 3 would probably yield water at a much greater rate than the 2 to 3 gal/min (0.13 to 0.19 l/s) specified. Analysis of water from test hole 3 indicates that the water quality is much better than that available from the present well tapping the Dakota aquifer (tables 2 and 3).

TABLE 1.--Logs of test holes

Test hole 1
146-059-01BAD

Altitude: 1,435 feet

Geologic source	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Loam, silty, black (topsoil)--	1	1
	Clay, silty, sandy, yellowish-brown, oxidized----------	7	8
	Clay, silty, sandy, pebbly, dark-yellowish-brown, oxidized (till)----------	16	24
	Clay, silty, sandy, pebbly, dark-gray (till)----------	20	44
	Sand, fine to medium, poorly sorted, subrounded; a large amount of shale fragments----------	4	48
Pierre Shale:			
	Shale, dark-grayish-black, highly fractured and crushed, moderately hard to hard----------	10	58
	Shale, dark-gray, slightly fractured, brittle, hard, bentonitic----------	82	140

Test hole 2
146-059-01BAC

Altitude: 1,430 feet

Geologic source	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, silty, dark-brown-------	2	2
	Clay, silty, sandy, yellowish-brown, oxidized---	14	16
	Clay, silty, sandy, pebbly, dark-gray (till)-----------	21	37
Pierre Shale:			
	Shale, dark-gray, highly fractured and crushed, moderately hard to hard-----	10	47
	Shale, dark-gray, slightly fractured, slightly bentonitic-----------------	93	140
	Shale, dark-gray, very hard, bentonitic-----------------	40	180

Test hole 3
146-059-01BAA

Altitude: 1,433 feet

Geologic source	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, silty, dark-brown-------	3	3
	Clay, silty, sandy, yellowish-brown, oxidized----------	11	14
	Clay, silty, sandy, pebbly, dark-olive-gray (till)------	12	26
	Silt, sandy, clayey, light-olive-gray-----------------	7.5	33.5
	Sand, fine to coarse, rounded, poorly sorted----------	3.5	37
	Clay, very sandy, silty, pebbly, olive-gray (till)---	10.5	47.5
	Sand, fine to very coarse, subangular, poorly sorted; small clay lenses 50-60 ft; increasing shale fragments 70-78 ft----------	30.5	78
Pierre Shale:			
	Shale, siliceous, dark-grayish-black, highly fractured and crushed, noncalcareous----------	2	80

USAF site 2321
(Log from U.S. Air Force)

Altitude:

Geologic source	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Loam, silty, slightly organic, brown----------	2	2
	Sand, very fine, clayey, silty, very dense, brown to gray-brown----------	10	12
	Clay, silty, sandy, pebbly, very dense, gray----------	15	27
	Clay, silty, pebbly, moderately hard, dark-gray; with angular to subrounded shale fragments (till)------	14	41
Pierre Shale:			
	Shale, thin-bedded, moderately fractured, moderately hard to hard, dark-gray----------	59	100

TABLE 2.--Chemical analyses of water

(Values are in milligrams per litre, except as noted)

Constituent or property	Present supply LCF 0-0 well August 25, 1971[1/]	146-059-01BAA Test hole 3 October 1974
Silica	9	29
Calcium	24	29
Magnesium	14	17
Sodium	1,400	370
Potassium	23	12
Bicarbonate	458	549
Carbonate	0	--
Sulfate	550	440
Chloride	1,500	49
Fluoride	.8	.1
Nitrate	4.3	.0
Iron (µg/l)[2/]	33,000	170
Manganese (µg/l)[2/]	130	960
Dissolved solids:		
Calculated	3,770	1,390
Residue on evaporation	3,800	1,280
Hardness as $CaCO_3$	120	860
Noncarbonate	0	400
Alkalinity as $CaCO_3$	376	--
Specific conductance (µmhos/cm at 25°C)[3/]	6,580	1,875
pH (units)	7.4	8.0
Temperature (°C)	--	7.0

1/ Data from Downey, Hutchinson, and Sunderland, 1973, Ground-water basic data for Griggs and Steele Counties, North Dakota: North Dakota Geol. Survey Bull. 64, pt. II, and North Dakota State Water Comm. County Ground-Water Studies 21, pt. II, 468 p.
2/ Micrograms per litre.
3/ Micromhos per centimetre at 25°C.

TABLE 3.--Trace element analysis of water from test hole 3

(Values are in micrograms per litre, unless otherwise noted)

Constituent	Value
Aluminum, dissolved	30
Arsenic, dissolved	3
Barium, dissolved	0
Beryllium, dissolved	0
Boron, dissolved	1
Bromide (mg/l)	.21
Cadmium, dissolved	0
Chromium, dissolved	0
Cobalt, dissolved	1
Copper, dissolved	2
Cyanide (mg/l)	.00
Iodide (mg/l)	.017
Lead, dissolved	2
Lithium, dissolved	180
Mercury, dissolved	.0
Molybdenum, dissolved	2
Nickel, dissolved	2
Phosphorus, dissolved, as P (mg/l)	.10
Selenium, dissolved	0
Silver, dissolved	1
Strontium, dissolved	440
Vanadium, dissolved	.5
Zinc, dissolved	100