

LITHOLOGIC LOGS OF OBSERVATION WELLS AND TEST HOLES DRILLED IN 1987 IN  
VALLEY FILL ALONG THE NORTH FLANK OF THE LITTLE ROCKY MOUNTAINS,  
FORT BELKNAP INDIAN RESERVATION, NORTH-CENTRAL MONTANA

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## CONVERSION FACTORS

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
acre	4,047	square meter
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
mile	1.609	kilometer

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ABSTRACT

Observation wells and test holes were drilled in 1987 in valley fill along the north flank of the Little Rocky Mountains as part of a water-resources investigation to determine, in part, the geometry (thickness and lateral distribution) of various valley-fill materials. The lithologic logs of the 66 observation wells and 44 test holes presented in this report were prepared as part of that study. Geologic units identified on the lithologic logs range in age from Jurassic to Holocene. The location of each observation well and test hole is shown on a map.

INTRODUCTION

In the southern part of the Fort Belknap Indian Reservation, surface-water supply is inadequate to meet the demands for potentially irrigable lands. Feltis (1983) indicated that ground-water supplies of sufficient quantity and quality for irrigation might be obtained from the shallow valley-fill aquifers along the north flank of the Little Rocky Mountains near the southern boundary of the reservation (fig. 1). The U.S. Geological Survey (USGS), in cooperation with the U.S. Bureau of Indian Affairs and the Fort Belknap Community Council, conducted a study (Briar and others, 1993) to evaluate the shallow ground-water conditions in the area. The objectives of the study were to describe the hydrology of the valley fill along the north flank of the Little Rocky Mountains and to assess the potential for additional water withdrawals from the valley fill.

This report presents the lithologic logs prepared for observation wells and test holes drilled as part of the overall study by Briar and others (1993). The report includes lithologic logs of 66 observation wells and 44 test holes drilled in 1987.

The observation wells and test holes were used to determine the geometry (thickness and lateral distribution) of valley fill. The observation wells, which were cased, also were used for water-level monitoring and water-quality sampling.

The authors wish to thank the Fort Belknap Community Council for their help in obtaining access to tribal land (used in common) and allotted land (owned by individuals) for test-drilling and water-level-monitoring activities. In addition, access to the Forest Fire Yard of the Tribal Forestry Department in Hays greatly aided the logistics of the project.

SITE-IDENTIFICATION SYSTEMS

A site number is used as the primary identification for wells and test holes referred to in this report. The site number consists of as many as four characters. The first two characters denote the site type: (O-) USGS observation well, (T-) USGS test hole. The next one or two characters denote a sequence number, which is assigned to each well or test hole within a site type on the basis of its location relative to the southwest corner of the study area.

A location number is used to identify the location of wells and test holes. The location number is based on the rectangular system for the subdivision of public lands (fig. 2). The number consists of 14 characters and is assigned according to the location of the site within a given township, range, and section. The first three characters specify the township and its position north (N) of the

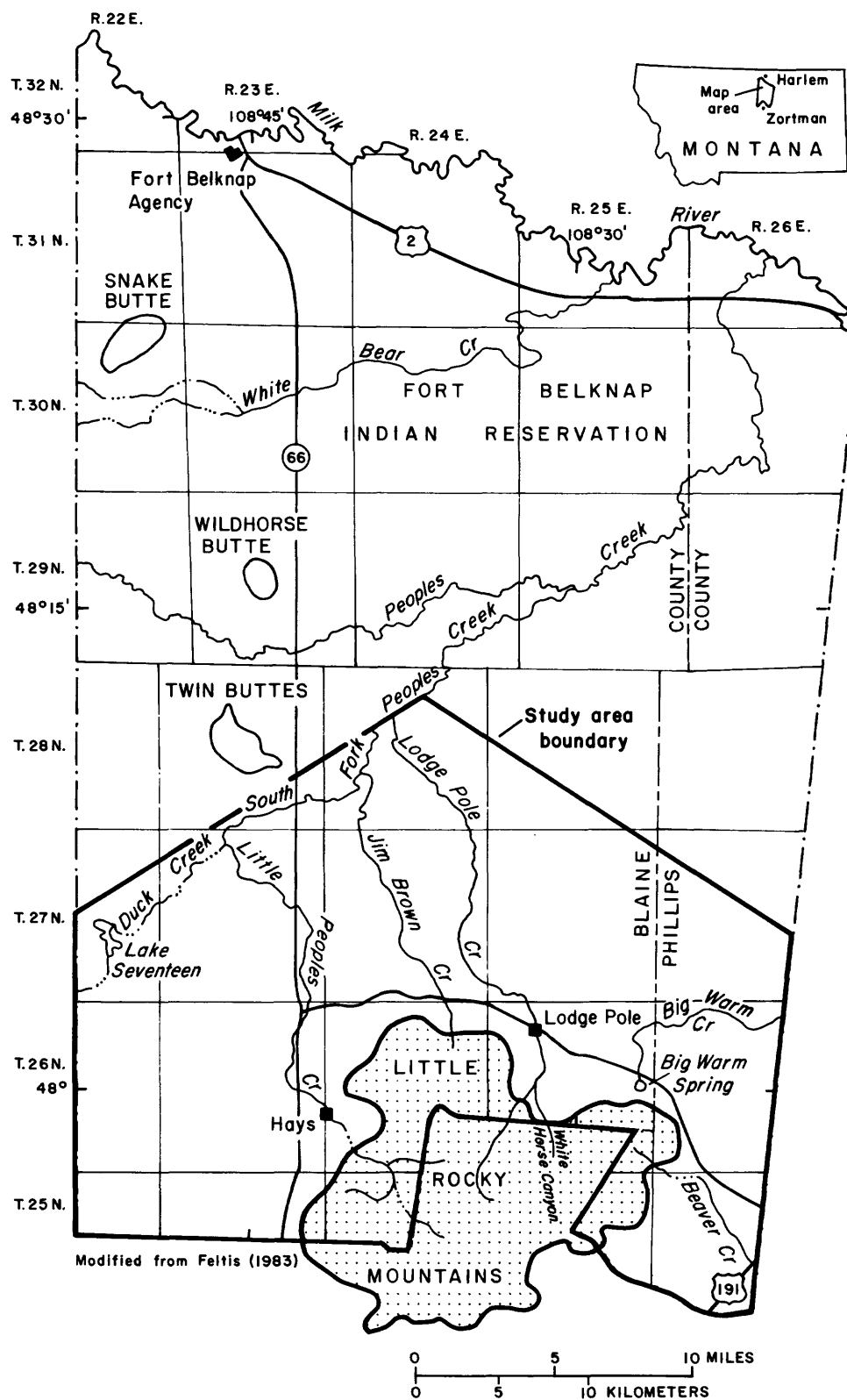


Figure 1.--Location of study area.

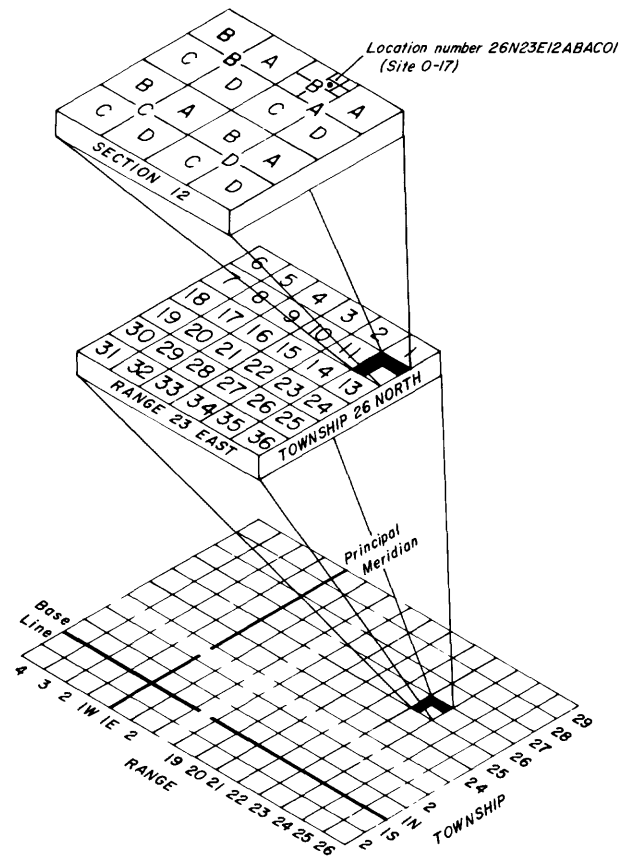


Figure 2.--Location numbering system

Montana Base Line. The next three characters specify the range and its position east (E) of the Montana Principal Meridian. The next two characters indicate the section. The next four characters indicate the position of the site within the section. The first letter denotes the quarter section (160-acre tract); the second, the quarter-quarter section (40-acre tract); the third, the quarter-quarter-quarter section (10-acre tract); and the fourth, the quarter-quarter-quarter-quarter section (2.5-acre tract). The subdivisions of the section are numbered A, B, C, and D in a counterclockwise direction beginning in the northeast quadrant. The last two characters form a sequence number based on the order of inventory in that tract. For example, location number 26N23E12ABAC01 (site O-17) represents the first well inventoried in the SW1/4 NE1/4 NW1/4 NE1/4 sec. 12, T. 26 N., R. 23 E.

### LITHOLOGIC LOGS

The geologic units penetrated during drilling and represented in the lithologic logs range in age from Jurassic to Holocene (table 1). The principal aquifer in the study area is layered sand and gravel that are common in the lower part of the valley-fill sequence underlying the principal valleys. Glacial deposits also yield water to wells. Terrace deposits and colluvium generally are not aquifers.

The lithologic logs included in this report (tables 2 and 3 in Data section at back of report) were prepared by hydrologists during onsite drilling. The observation wells and test holes were drilled using standard mud-rotary methods, and the lithology was determined from rock cuttings observed at the surface and from drilling characteristics. The location of the observation wells and test holes corresponding to the lithologic logs is shown in figure 3.

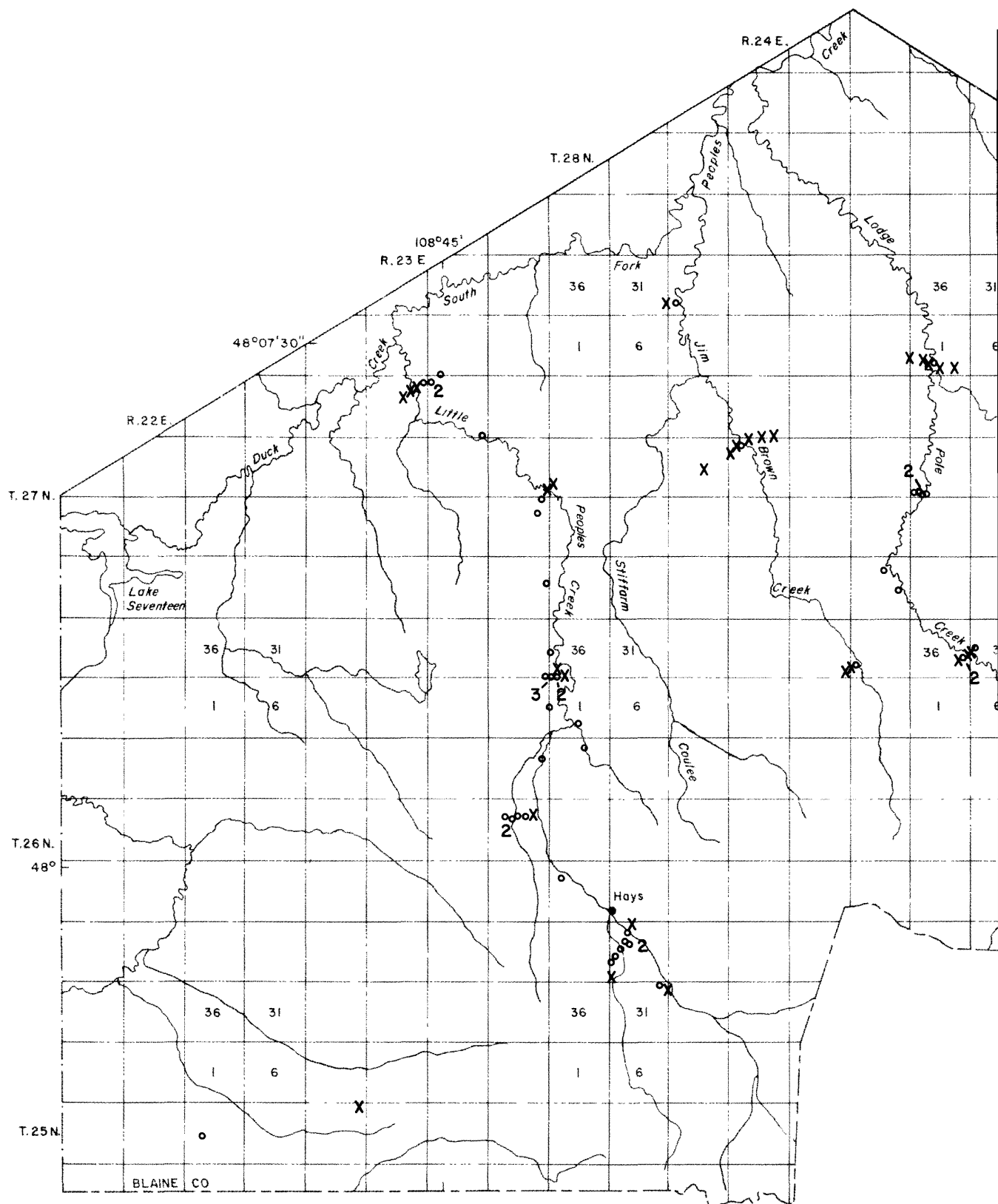
[Table modified from Feltis (1983); ft., feet; gal/min, gallons per minute]

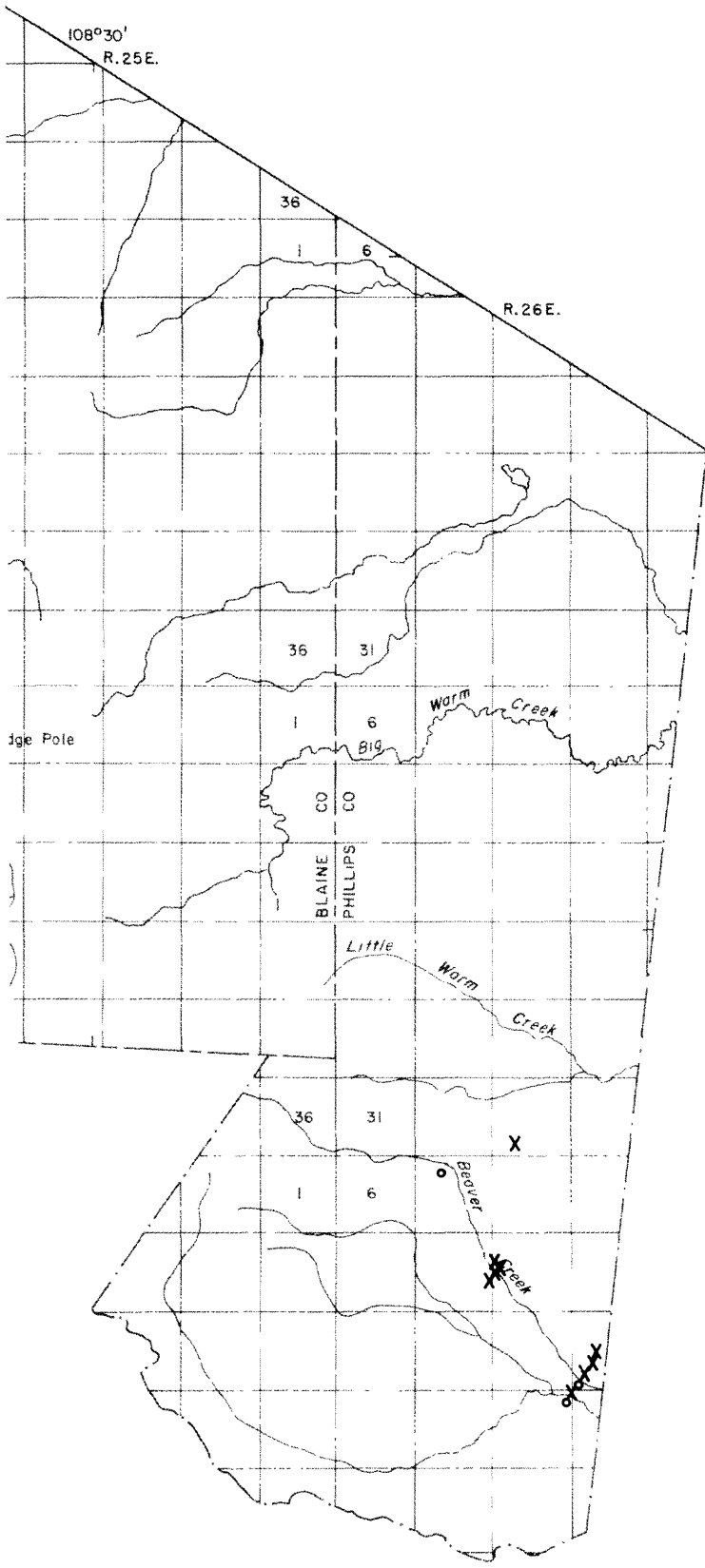
Erathem	System	Series	Formation or group	Approximate thickness (ft)	General character	Water-yielding properties	
Cenozoic	Quaternary	Holocene	Alluvium	0-90	Unconsolidated cobbles, gravel, sand, silt, and clay along coulees and stream channels.	A source of water in valleys of perennial streams. Yields 3 to about 500 gal/min to wells. Water quality suitable for most uses near the Little Rocky Mountains but deteriorates downstream.	
			Colluvium	0-65	Angular gravel in reddish-brown sandy-clay matrix; includes stringers of white clay. Occurs in valley-fill deposits adjacent to terraces.	Not an aquifer.	
		Pleistocene	Glacial deposits	0-130	Gravel, sand, silt, and clay intermixed. Occurs primarily as till; however, outwash deposits form localized sand and gravel lenses and beds.	A limited source of water except in outwash deposits. Yields 2 to 10 gal/min to wells. Water quality might be unsuitable for some uses.	
			Terrace deposits	0-60	Unconsolidated to consolidated gravel; contains sand and silt. Occurs as long, narrow remnants or wide tracts of several square miles around the flank of the Little Rocky Mountains.	Might contain small quantities of water suitable for most uses.	
	Tertiary	Pliocene through Paleocene (?)	Intrusive igneous rocks		Syenite porphyry and related rocks forming laccoliths, stocks, dikes, and sills.	Yields 2 to 25 gal/min of water suitable for most uses from fracture springs at Snake Butte, Wildhorse Butte, and Twin Buttes. Some water may be available from fault zones and fractures in the Little Rocky Mountains.	
			Unconformity				
Mesozoic	Cretaceous	Upper Cretaceous	Montana Group	Bearpaw Shale	500	Dark-gray marine shale; weathers light gray. Contains a few beds of bentonite and sandstone and many thin beds and lenses of cherty material and calcareous nodules.	Not an aquifer.
				Judith River Formation	360	Interbedded light-gray to buff, soft, fine-grained sandstone, shale, and clay. A few thin coal beds in upper part.	Yields 2 to 150 gal/min of water to many wells. Water under artesian pressure in some places. Water quality may be unsuitable for some uses.
				Claggett Shale	530	Dark-gray shale and siltstone; weathers to brownish gray. Contains a few beds of bentonite and beds containing large boulder-like septarian nodules.	Not an aquifer.

Table 1.--Generalized geologic units and water-yielding properties--Continued

Erathem	System	Series	Formation or group		Approximate thickness (ft)	General character	Water-yielding properties
Mesozoic	Cretaceous	Upper Cretaceous	Montana Group	Eagle Sandstone	260	Upper member: Chiefly gray shale with many thin beds of siltstone, sandy shale, and friable sandstone that weather reddish tan. Virgelle Sandstone Member: Yellow to buff, massive sandstone, gray siltstone, and gray shale.	Sandstone of lower member yields 2 to 10 gal/min of water to wells. Water under artesian pressure in some places. Water quality may be unsuitable for some uses.
				Colorado Group		1,740	Dark-gray to bluish-gray shale containing lenticular beds of limestone and calcareous sandstone.
		Lower Cretaceous	Kootenai Formation		180	Variegated argillaceous member: Clay, mottled maroon and gray, with a few thin beds and lenses of variable light-gray sandstone. Lower unit, or Third Cat Creek sandstone of drillers' usage: Largely sandstone, locally friable, light-gray, with a hard, coarse-grained, arkosic sandstone layer at the base and a layer of dense, light-gray limestone at the top.	Sandstone yields 10 gal/min of water to wells. Generally under artesian pressure but deeply buried in most of reservation. Water quality suitable for most uses.
	Unconformity						
	Jurassic	Upper Jurassic	Ellis Group	Swift Formation	210	Light- and dark-gray, gypsiferous shale containing numerous large, brown, calcareous concretions; layers of glauconitic sandstone, sandy mudstone, dark shale, and impure limestone in upper part.	Sandstone and limestone beds yield 2 to 5 gal/min to wells on the flank of the Little Rocky Mountains. Water quality suitable for most uses.
		Middle Jurassic		Rierdon Formation	200	Gray, limy shale and light- to dark-gray marly limestone.	Beds may yield water suitable for culinary use from fractures near the Little Rocky Mountains.
					Piper Formation	100	Alternating beds of shale, limestone, and calcareous sandstone. A brown, dense limestone, 60-ft thick, occurs at base.
		Unconformity					







- EXPLANATION
- 2. OBSERVATION WELL--  
 Numeral indicates  
 number of wells at  
 same general location
  - X TEST HOLE

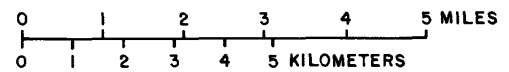


Figure 3.--Location of observation wells and test holes.

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- Feltis, R.D., 1983, Ground-water resources of the Fort Belknap Indian Reservation, north-central Montana: Montana Bureau of Mines and Geology Memoir 53, 36 p.
- National Research Council, 1947, Report of the Subcommittee on Sediment Terminology: American Geophysical Union Transactions, v. 28, no. 6, p. 936-938.

**DATA**

Table 2.--Lithologic logs of observation wells

[Particle-size descriptions are based on report of National Research Council (1947). Abbreviations: ft, feet; gal/min, gallons per minute; h, hours.]

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-1		
<u>Location number:</u> 25N22E12CABA01		
<u>Completed:</u> August 28, 1987		
<u>Terrace deposits:</u>		
Gravel, sand, and clay, tight; need pull-down to drill, abundant white clay with sand	18	18
Clay or sand(?), smooth; no returns.....	2	20
Gravel, sand, and clay, larger gravel than above; very coarse at 55 ft.....	37	57
<u>Ellis Group:</u>		
Shale, dark, tight, weathered on top; need pull-down to drill.....	23	80
<u>Remarks:</u> Set screen at 52-57 ft with 10 ft of tail pipe. Well would not produce water with compressed air.		
 <u>Site number:</u> O-2		
<u>Location number:</u> 26N24E31AAAA01		
<u>Completed:</u> July 7, 1987		
<u>Colluvium and alluvium:</u>		
Gravel, sand, and brown clay, tight; includes abundant white clay clumps and stringers 0-20 ft; drills with pull-down steady and slow; boulder of pink quartz at 42 ft.....	60	60
Gravel and sand; drilling indicates possible unconsolidated zone.....	18	78
<u>Ellis Group:</u>		
Shale, dark-gray to black, weathered at top.....	22	100
<u>Remarks:</u> Set screen at 68-78 ft with 5 ft of tail pipe. Well produced water with compressed air.		
 <u>Site number:</u> O-3		
<u>Location number:</u> 26N24E30CBAC01		
<u>Completed:</u> July 7, 1987		
<u>Alluvium:</u>		
Clay, brown.....	18	18
Gravel, angular; hole caving; losing circulation of drilling fluid.....	12	30
<u>Colorado Group:</u>		
Shale, black, tight.....	10	40
<u>Remarks:</u> Hole caved while inserting casing; thickened drilling fluid. Screened 23-28 ft. Well produced less than 1 gal/min with compressed air; well water would not clear.		
 <u>Site number:</u> O-4		
<u>Location number:</u> 26N24E30CBAA02		
<u>Completed:</u> July 8, 1987		
<u>Alluvium:</u>		
Soil and clay, dark-brown.....	8	8
Gravel, angular; very loose at 18-20 ft.....	17	25
<u>Colorado Group:</u>		
Shale, black, tight.....	15	40
<u>Remarks:</u> Set screen at 15-21 ft. Well produced less than 1 gal/min with compressed air; well water would not clear.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-5		
<u>Location number:</u> 26N24E30BDCB01		
<u>Completed:</u> July 8, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	7	7
<u>Colluvium and alluvium:</u>		
Gravel, sand, and brown clay, tight; includes abundant white clay clumps and stringers.....	34	41
Gravel, loose.....	4	45
Gravel, sand, and brown clay (as above).....	25	70
<u>Colorado Group:</u>		
Shale, black, tight.....	5	75
<u>Remarks:</u> Set screen at 40-45 ft; well water cleared quickly.		
<u>Site number:</u> O-6		
<u>Location number:</u> 26N24E30BDBA01		
<u>Completed:</u> July 8, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	10	10
Gravel, loose; zones of cobbles; caving down-hole; losing circulation of drilling fluid.....	40	50
<u>Colluvium:</u>		
Gravel and clay, tight; minor quantity of white clay; poor returns because of uphole wash-in.....	15	65
<u>Colorado Group:</u>		
Shale, black, tight.....	32	97
<u>Remarks:</u> Set 20-slot screen at 35-45 ft. Well produced water with compressed air but water cleared slowly.		
<u>Site number:</u> O-7		
<u>Location number:</u> 26N24E30BADB01		
<u>Completed:</u> July 9, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	18	18
Gravel, loose; losing circulation of drilling fluid.....	7	25
<u>Colluvium:</u>		
Gravel, sand, and clay, tight.....	10	35
<u>Colorado Group:</u>		
Shale, black; brittle and fractured at 35 ft; soft and smooth at 37-50 ft.....	25	60
<u>Remarks:</u> Set 20-slot screen at 20-25 ft with 9 ft of tail pipe. Well produced water with compressed air and water cleared quickly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-8		
<u>Location number:</u> 26N24E30BDAC01		
<u>Completed:</u> July 9, 1987		
<u>Alluvium:</u>		
Gravel, sand, and clay, tight.....	25	25
Gravel, loose; zones of cobbles; caving down-hole, losing drilling fluid.....	3	28
Clay, tight.....	2	30
Gravel, loose; fair potential for water production.....	18	48
Clay, tight; hard drilling.....	1	49
Gravel, loose; good potential for water production.....	6	55
<u>Colorado Group:</u>		
Shale, black, tight.....	5	60
<u>Remarks:</u> Set 20-slot screen at 44-54 ft. Well produced about 20 gal/min with compressed air.		
<u>Site number:</u> O-9		
<u>Location number:</u> 26N24E30BDAC02		
<u>Completed:</u> July 10, 1987		
<u>Alluvium:</u>		
Gravel, sand, and brown clay, tight.....	25	25
Gravel, loose.....	3	28
Clay, tight.....	2	30
Gravel, loose.....	18	48
Clay, tight; hard drilling.....	1	49
Gravel, loose.....	6	55
<u>Colorado Group:</u>		
Shale, black, tight.....	5	60
<u>Remarks:</u> Set 20-slot screen at 43-53 ft. Well produced about 40 gal/min with compressed air.		
<u>Site number:</u> O-10		
<u>Location number:</u> 26N23E24BDBB01		
<u>Completed:</u> July 10, 1987		
<u>Alluvium:</u>		
Clay, brownish-gray; drills smooth with moderate pull-down.....	19	19
Gravel, loose, more rounded than at previous sites; drills without pull-down, losing circulation of drilling fluid.....	22	41
<u>Colorado Group:</u>		
Shale, grayish-brown.....	29	70
<u>Remarks:</u> Set 20-slot screen at 30-35 ft with 5 ft of tail pipe. Developed well for 1 h with compressed air. Well water cleared quickly.		
<u>Site number:</u> O-11		
<u>Location number:</u> 26N23E14BDDBA01		
<u>Completed:</u> July 11, 1987		
<u>Alluvium:</u>		
Soil and brown clay.....	23	23
Gravel, loose.....	13	36
<u>Colorado Group:</u>		
Shale, gray.....	9	45
<u>Remarks:</u> Set 20-slot screen at 30-35 ft with 10 ft of tail pipe. Well produced water with compressed air; water moderately clear.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-12		
<u>Location number:</u> 26N23E14ACBB01		
<u>Completed:</u> July 10, 1987		
<u>Alluvium:</u>		
Clay, brown; includes minor quantity of white clay stringers.....	21	21
Gravel, loose; rounded to angular.....	21	42
<u>Colorado Group:</u>		
Shale, gray.....	10	52
<u>Remarks:</u> Set 20-slot screen at 35-40 ft with 8 ft of tail pipe. Well produced abundant water with compressed air.		
 <u>Site number:</u> O-13		
<u>Location number:</u> 26N23E14ACBB02		
<u>Completed:</u> August 28, 1987		
<u>Alluvium:</u>		
Soil and clay.....	21	21
Gravel and sand, loose; gravel 40 percent well-rounded, 40 percent subangular, and 20 percent subrounded.....	19	40
<u>Colorado Group:</u>		
Shale, gray.....	7	47
<u>Remarks:</u> Set 20-slot screen at 30-40 ft. Well produced about 40-50 gal/min with compressed air; well water cleared after developing 2.5 h.		
 <u>Site number:</u> O-14		
<u>Location number:</u> 26N23E14ABCD01		
<u>Completed:</u> July 11, 1987		
<u>Alluvium:</u>		
Soil and brown clay.....	10	10
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tight; some very angular pieces, very few rounded pieces; need pull-down to drill; grading to softer and more unconsolidated material at 20 ft.....	10	20
Gravel, loose, rounded; good potential for water production.....	21	41
<u>Colorado Group:</u>		
Shale, dark-gray.....	14	55
<u>Remarks:</u> Set 20-slot screen at 35-40 ft. Well produced abundant water with compressed air; well water was clear.		



Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-15		
<u>Location number:</u> 26N23E14ABDD01		
<u>Completed:</u> July 11, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	4	4
Gravel, angular.....	1	5
Clay, brown.....	10	15
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tight; some white clay stringers in brown clay matrix.....	10	25
Gravel, loose; fair potential for production.....	2	27
<u>Colorado Group:</u>		
Shale, dark-gray.....	13	40
<u>Remarks:</u> Set 20-slot screen at 22-27 ft with 8 ft of tail pipe. Casing separated at top of screen during development; produced about 1 gal/min with compressed air. Potentiometer installed.		
 <u>Site number:</u> O-16		
<u>Location number:</u> 26N23E11ADAA01		
<u>Completed:</u> July 11, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	5	5
Gravel, loose, angular.....	2	7
Clay, brownish-gray, soft; possible very fine sand.....	19	26
Gravel, loose.....	16	42
Gravel, tight but with no apparent clay; gravel rounded to angular.....	8	50
Gravel, loose; good potential for water production.....	5	55
Clay, smooth and soft.....	5	60
<u>Claggett Shale:</u>		
Shale, dark-grayish-brown.....	10	70
<u>Remarks:</u> Set 20-slot screen at 50-55 ft with 10 ft of tail pipe. Well produced about 20 gal/min with compressed air.		
 <u>Site number:</u> O-17		
<u>Location number:</u> 26N23E12ABAC01		
<u>Completed:</u> July 13, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown.....	30	30
Sand, dark-gray, fine grading to coarse.....	7	37
Clay, brown.....	3	40
Gravel, sand, and clay, dark-brown.....	2	42
Clay, brown.....	8	50
<u>Judith River Formation:</u>		
Shale, black.....	10	60
<u>Remarks:</u> Set 20-slot screen at 30-35 ft with 8 ft of tail pipe. Well produced about 5-10 gal/min with compressed air; water cleared poorly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-18		
<u>Location number:</u> 26N23E01DBCD01		
<u>Completed:</u> August 14, 1987		
<u>Alluvium:</u>		
Soil and clay, mottled grayish-brown, medium hard.....	21	21
Gravel, small, includes coarse sand.....	6	27
Clay, gray.....	14	41
Sand, includes minor quantities of gravel.....	2	43
Clay, gray.....	9	52
<u>Claggett Shale:</u>		
Shale, dark-gray, hard, gritty.....	8	60
<u>Remarks:</u> Set 20-slot screen at 22-27 ft. Well produced about 10 gal/min with compressed air; well water cleared slowly.		
 <u>Site number:</u> O-19		
<u>Location number:</u> 26N23E01BCCD01		
<u>Completed:</u> August 14, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown, sticky.....	14	14
Gravel, loose, small; broken pieces, iron stained.....	4	18
Clay, gray, soft; smooth drilling.....	8	26
Gravel, loose (as above).....	1	27
Clay, gray, gritty.....	13	40
Sand(?); no returns.....	2	42
Gravel, loose; larger and more rounded than above.....	7	49
<u>Judith River Formation:</u>		
Clay, soft; grading to hard at 52 ft; probably weathered shale.....	6	55
Shale.....	5	60
<u>Remarks:</u> Set 30-slot screen at 43-48 ft with 10 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water cleared quickly.		
 <u>Site number:</u> O-20		
<u>Location number:</u> 27N23E36CCCD01		
<u>Completed:</u> July 12, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, brown.....	12	12
Sand, fine, gray.....	3	15
Clay, brown.....	3	18
Gravel, loose.....	2	20
Clay, gray, sandy.....	10	30
Gravel, loose.....	5	35
<u>Judith River Formation:</u>		
Shale, light-bluish-green, tight, sandy.....	20	55
<u>Remarks:</u> Set screen at 30-35 ft. Well produced about 10 gal/min with compressed air; well water cleared poorly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-21		
<u>Location number:</u> 27N23E36CCDC01		
<u>Completed:</u> July 12, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, sandy, brown.....	18	18
Gravel, hematite stained.....	3	21
Clay, gray, sticky, gritty.....	34	55
Sand(?), no returns.....	5	60
Gravel, loose; losing circulation of drilling fluid.....	15	75
<u>Judith River Formation:</u>		
Shale, sandy, gray, very soft; drills similar to clay.....	20	95
<u>Remarks:</u> Set screen at 69-74 ft with 8 ft of tail pipe. Well produced about 40 gal/min with compressed air; well water cleared quickly.		
 <u>Site number:</u> O-22		
<u>Location number:</u> 27N23E36CCDC02		
<u>Completed:</u> July 13, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, medium-brown.....	16	16
Gravel, loose.....	3	19
Clay, medium-brown; grading to sandy.....	36	55
Sand, poor returns.....	5	60
Gravel, loose.....	15	75
<u>Judith River Formation:</u>		
Shale, bluish-gray, sandy; very soft.....	20	95
<u>Remarks:</u> Set 20-slot screen at 65-75 ft with 10 ft of tail pipe. Well produced more than about 50 gal/min with compressed air but well water cleared slowly because of loss of 8-10 bags of bentonite into aquifer during drilling.		
 <u>Site number:</u> O-23		
<u>Location number:</u> 27N23E36CCDC03		
<u>Completed:</u> October 14, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay.....	18	18
Gravel, loose.....	3	21
Clay, medium-brown.....	31	52
Sand.....	8	60
Gravel, loose.....	17	77
<u>Judith River Formation:</u>		
Shale, bluish-gray, sandy; very soft.....	10	87
<u>Remarks:</u> Set 60-slot stainless-steel screen at 62-77 ft with 10 ft of tail pipe.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-24		
<u>Location number:</u> 27N23E36CCDD01		
<u>Completed:</u> July 12, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown.....	23	23
Gravel, small, sandy.....	5	28
Clay, brown, soft.....	17	45
Gravel, loose.....	2	47
Clay, brown.....	10	57
Sand, fine.....	3	60
Gravel, loose.....	3	63
<u>Colluvium:</u>		
Gravel, sand, and clay, tight.....	15	78
<u>Judith River Formation:</u>		
Shale, gray, sandy; soft weathered zone at top is clay.....	12	90
<u>Remarks:</u> Set 20-slot screen at 60-65 ft with 8 ft of tail pipe. Well produced about 5 gal/min with compressed air; well water would not clear.		
 <u>Site number:</u> O-25		
<u>Location number:</u> 27N23E36CCDD02		
<u>Completed:</u> July 13, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown.....	24	24
Gravel, small, loose.....	4	28
Clay, tight.....	12	40
<u>Remarks:</u> Set screen at 23-28 ft. Well produced little water with compressed air; well water would not clear.		
 <u>Site number:</u> O-26		
<u>Location number:</u> 27N23E36CBBA01		
<u>Completed:</u> August 14, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown; stiff, gray at base.....	19	19
Gravel, small to coarse, broken pieces.....	3	22
Clay, gray, silty; includes small gravel and coarse sand; softer than upper clay, grading to harder; drilling requires hard pull-down.....	58	80
Gravel, loose, small to coarse; losing circulation of drilling fluid.....	14	94
<u>Claggett Shale:</u>		
Shale, dark-gray, hard.....	16	110
<u>Remarks:</u> Set 30-slot screen at 85-90 ft with 10 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water cleared quickly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-27		
<u>Location number:</u> 27N23E25BCCD01		
<u>Completed:</u> July 21, 1987		
<u>Glacial deposits:</u>		
Clay, brown.....	35	35
Clay, gray; increasing quantity of small rounded gravel at 40-85 ft, included in matrix boulder at 65 ft.....	50	85
Gravel, loose; minor quantity of white clay, tighter at 90-95 ft.....	10	95
<u>Judith River Formation:</u>		
Shale, bluish-gray, sandy.....	25	120
<u>Remarks:</u> Set 20-slot screen at 85-90 ft with 20 ft of tail pipe. First three attempted drill holes at the site were abandoned owing to lost circulation of drilling fluid in fractured till. Some drilling fluid escaped to surface through cracks.		
 <u>Site number:</u> O-28		
<u>Location number:</u> 27N23E23AAD01		
<u>Completed:</u> July 15, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, dark-brown at surface, gray at 15-73 ft; contains small pebbles and coarse sand; drills smoothly with occasional gravel lenses and rocks.....	73	73
Gravel, sand, and clay, very hard and tight; need maximum pull-down drill rig can provide to drill.....	14	87
Gravel, sand, and clay; more coarse than above, very tight.....	6	93
<u>Judith River Formation:</u>		
Shale, hard, bluish-gray, sandy; very slow drilling; possible coal seams.....	77	170
Coal.....	1	171
Shale, sandy.....	9	180
<u>Remarks:</u> Set 20-slot screen at 120-130 ft.		
 <u>Site number:</u> O-29		
<u>Location number:</u> 27N23E23AAAA01		
<u>Completed:</u> July 14, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, brown; with small rounded pebbles and coarse sand.....	30	30
Clay, gray; with small rounded pebbles and coarse sand.....	26	56
Sand.....	6	62
Gravel, loose; good potential for water production.....	18	80
Clay, bluish-gray, very sandy.....	60	140
<u>Judith River Formation:</u>		
Shale, dark-brown.....	10	150
<u>Remarks:</u> Set 20-slot screen at 70-80 ft with 8 ft of tail pipe. Well produced more than 10 gal/min with compressed air; well water cleared quickly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-30		
<u>Location number:</u> 27N23E10DDDD01		
<u>Completed:</u> July 21, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, medium-brown, smooth; small pebbles and coarse sand in matrix.....	80	80
Gravel, loose.....	5	85
Gravel, tight.....	2	87
Clay, tight, hard; possible weathered shale.....	10	97
<u>Judith River Formation:</u>		
Shale, dark-brown; very hard drilling.....	13	110
<u>Remarks:</u> Set 20-slot screen at 80-85 ft with 12 ft of tail pipe.		
<u>Site number:</u> O-31		
<u>Location number:</u> 27N23E09AADA01		
<u>Completed:</u> July 23, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, includes small gravel and coarse sand.....	108	108
Gravel, loose; mostly rounded, some angular.....	7	115
<u>Judith River Formation:</u>		
Shale, hard, tight.....	20	135
<u>Remarks:</u> Set 20-slot screen at 110-115 ft with 8 ft of tail pipe.		
<u>Site number:</u> O-32		
<u>Location number:</u> 27N23E10BBBD01		
<u>Completed:</u> July 23, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-30 ft then gray at 30-105 ft; possible sand layer at 65-70 ft.....	105	105
Gravel, loose, mostly well-rounded; smaller gravel than in other holes nearby, white clay stringers.....	17	122
Clay, gray, very sandy.....	10	132
<u>Judith River Formation:</u>		
Shale, black, hard.....	8	140
<u>Remarks:</u> Set 20-slot screen at 115-120 ft with saw cuts at 110-115 ft and 8 ft of tail pipe.		
<u>Site number:</u> O-33		
<u>Location number:</u> 27N23E10BBBD02		
<u>Completed:</u> July 24, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-42 ft then gray at 42-83 ft; fine, gray sand at 50-70 ft.....	95	95
Gravel, loose.....	20	115
Clay, tight.....	3	118
Gravel, loose.....	5	123
<u>Judith River Formation:</u>		
Shale, black, hard.....	12	135
<u>Remarks:</u> Set 20-slot screen at 110-120 ft.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-34		
<u>Location number:</u> 27N23E03CDCC01		
<u>Completed:</u> July 24, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-42 ft then gray at 42-83 ft, few cobbles.....	83	83
Gravel, loose; losing circulation of drilling fluid.....	12	95
Clay, gray with blue tint, soft, very sandy.....	50	145
<u>Judith River Formation:</u>		
Shale, soft; grading to harder.....	5	150
<u>Remarks:</u> Set 20-slot screen at 90-95 ft with saw slots at 85-90 and 10 ft of tail pipe.		
 <u>Site number:</u> O-35		
<u>Location number:</u> 27N24E35CCAB01		
<u>Completed:</u> August 13, 1987		
<u>Alluvium:</u>		
Clay, silty, soft, sandy in parts; black at 0-5 ft, oxidized grayish-brown at 5-15 ft, gray at 15-55 ft; sandy and pebbly at 20-30 ft, siltier at 30-55 ft.....	55	55
Gravel, small to coarse; broken pieces, coarser at base.....	7	62
<u>Ellis Group:</u>		
Shale, dark-gray, firm; drilling with pull-down, possible sandstone at 70-72 ft.....	10	72
<u>Remarks:</u> Set 30-slot screen at 57-62 ft with 10 ft of tail pipe. Well would not produce water with compressed air; water level 3 ft above bottom of screen.		
 <u>Site number:</u> O-36		
<u>Location number:</u> 27N24E16BABC01		
<u>Completed:</u> August 18, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, brown, sandy.....	11	11
Gravel, loose.....	3	14
Clay, brown, very sandy with small gravel.....	15	29
<u>Judith River Formation:</u>		
Shale, very sandy .....	11	40
<u>Remarks:</u> Set saw slots at 11-14 ft with 10 ft of tail pipe. Well would not produce water with compressed air.		
 <u>Site number:</u> O-37		
<u>Location number:</u> 28N24E32CCAA01		
<u>Completed:</u> August 25, 1987		
<u>Glacial deposits:</u>		
Clay, silty, sandy, pebbly, soft; brown and oxidized at 0-60 ft, gray at 60-93 ft; drills harder at 15-93 ft; sandier in parts.....	93	93
Gravel, loose, small to coarse, subangular, interbedded with clay.....	9	102
<u>Judith River Formation:</u>		
Shale, dark-gray, silty, firm.....	18	120
<u>Remarks:</u> Set screen at 97-103 ft with saw cuts at 94-97 ft and 10 ft of tail pipe. Well produced less than 1 gal/min with compressed air.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-38		
<u>Location number:</u> 26N25E20BABA02		
<u>Completed:</u> August 30, 1987		
<u>Alluvium:</u>		
Gravel, sand, and clay, tight.....	20	20
Gravel, loose, small, angular to rounded.....	2	22
Clay, very tight.....	5	27
Gravel, loose, small, angular to rounded.....	5	32
Clay, tight; drills like shale.....	2	34
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tight, grading to very tight at 60 ft; abundant white clay...	45	79
Gravel, loose; poor returns, drills easily.....	1	80
Gravel, sand, and clay (as above).....	4	84
<u>Ellis Group:</u>		
Shale, bluish-gray, very sandy.....	6	90
<u>Remarks:</u> Set 30-slot screen at 27-32 ft. Well produced less than 1 gal/min with compressed air; well water would not clear.		
 <u>Site number:</u> O-39		
<u>Location number:</u> 26N25E17DACB01		
<u>Completed:</u> July 25, 1987		
<u>Alluvium:</u>		
Gravel.....	15	15
Clay, sandy.....	8	23
Gravel, loose; small to medium size; well rounded to very angular.....	4	27
Clay, grayish-brown.....	14	41
Gravel, loose.....	5	46
Gravel, sand, and clay, tight.....	22	68
<u>Colorado Group:</u>		
Shale, black, tight, hard.....	7	75
<u>Remarks:</u> Set screen at 40-45 ft with 10 ft of tail pipe.		
 <u>Site number:</u> O-40		
<u>Location number:</u> 26N25E17BAAA01		
<u>Completed:</u> July 25, 1987		
<u>Colluvium and alluvium:</u>		
Gravel and clay, gray.....	8	8
Gravel, includes many layers of interbedded grayish-brown clay with white clay stringers.....	7	15
Clay, light-brown; includes coarse sand.....	26	41
Gravel, sand, and clay, includes white clay pieces.....	9	50
Gravel, loose; mostly rounded, some angular; includes white clay pieces.....	4	54
<u>Colorado Group:</u>		
Shale, black, medium-hard, dry.....	16	70
<u>Remarks:</u> Set 20-slot screen at 50-55 ft with 10 ft of tail pipe.		



Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-41		
<u>Location number:</u> 26N25E17ABBB01		
<u>Completed:</u> July 25, 1987		
<u>Colluvium and alluvium:</u>		
Soil and clay, medium-brown.....	8	8
Gravel, loose.....	13	21
Clay, medium-brown, soft.....	1	22
Gravel, sand, and clay, tight; need pull-down to drill.....	7	29
Clay, soft, gray with brown layers; includes coarse sand.....	6	35
Gravel, sand, and clay, tight.....	14	49
Gravel, loose.....	6	55
<u>Colorado Group:</u>		
Shale, black, hard.....	5	60
<u>Remarks:</u> Set 20-slot screen at 50-55 ft.		
 <u>Site number:</u> O-42		
<u>Location number:</u> 26N25E17ABBB02		
<u>Completed:</u> August 27, 1987		
<u>Alluvium:</u>		
Clay, dark-brown, silty, stiff, carbonaceous in parts.....	10	10
Gravel, loose.....	1	11
Clay, brown, silty, soft.....	11	22
Gravel, loose.....	1	23
Clay, brown, silty, soft.....	2	25
Gravel, loose.....	2	27
Clay, gray, stiff.....	8	35
Gravel, loose, fine to coarse; broken, subangular cobbles in part.....	19	54
<u>Colorado Group:</u>		
Shale, firm; slow drilling.....	2	56
<u>Remarks:</u> Set 20-slot screen at 44-54 ft. Well produced about 80 gal/min with compressed air; well water cleared after developing 1.5 h.		
 <u>Site number:</u> O-43		
<u>Location number:</u> 26N25E08DCDC01		
<u>Completed:</u> July 27, 1987		
<u>Colluvium and alluvium:</u>		
Soil and clay, medium-brown.....	12	12
Gravel, loose.....	6	18
Clay, soft.....	8	26
Gravel, sand, and clay, tight; includes white clay stringers; gravel is angular.....	14	40
Gravel, loose grading to tighter by 45 ft.....	7	47
<u>Colorado Group:</u>		
Shale, dark-brown, tight, weathered at top.....	13	60
<u>Remarks:</u> Set 20-slot screen at 40-45 ft with 10 ft of tail pipe.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-44		
<u>Location number:</u> 26N25E08BDAC01		
<u>Completed:</u> July 26, 1987		
<u>Colluvium and alluvium:</u>		
Soil and clay, medium-brown; soft zone of possible sand at 10-12 ft.....	30	30
Gravel, loose.....	3	33
Gravel, sand, and clay, tight; hard pull-down needed to drill.....	5	38
Gravel, loose.....	1	39
Gravel, sand, and clay, tight; hard pull-down needed to drill.....	5	44
Gravel, loose.....	6	50
<u>Ellis Group:</u>		
Shale, medium-gray and sandy at 50 ft; hard drilling; grading to harder and more brittle (almost sandstone) at 70 ft.....	20	70
<u>Remarks:</u> Set 20-slot screen at 45-50 ft with 10 ft of tail pipe. Well produced about 20-25 gal/min with compressed air; well water was clear.		
 <u>Site number:</u> O-45		
<u>Location number:</u> 26N25E05CAA03		
<u>Completed:</u> August 12, 1987		
<u>Alluvium:</u>		
Clay, gray, smooth.....	10	10
Gravel, fine to coarse, subangular.....	5	15
Clay, gray.....	5	20
Sand, fine; no returns.....	5	25
Clay, brown grading to gray, soft, gritty.....	15	40
Gravel (as above).....	1	41
Clay, gray.....	4	45
Sand, fine; poor returns.....	9	54
Gravel (as above).....	4	58
<u>Claggett Shale:</u>		
Shale, hard, black.....	13	71
<u>Remarks:</u> Set 20-slot screen at 50-55 ft with saw cuts at 55-58 ft and 10 ft of tail pipe. Well flowed barely at top of casing; produced about 30 gal/min with compressed air.		
 <u>Site number:</u> O-46		
<u>Location number:</u> 26N25E05CAA04		
<u>Completed:</u> August 12, 1987		
<u>Alluvium:</u>		
Soil and clay; possible sand.....	40	40
Gravel, fine to coarse, subangular.....	1	41
Clay, gray.....	12	53
Gravel, loose.....	4	57
<u>Claggett Shale:</u>		
Shale, black, hard.....	3	60
<u>Remarks:</u> Set 20-slot screen at 50-60 ft.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-47		
<u>Location number:</u> 26N25E05CACA01		
<u>Completed:</u> August 13, 1987		
<u>Alluvium:</u>		
Soil and clay.....	9	9
Gravel, loose.....	1	10
Clay.....	2	12
Gravel and sand; alternating layers of gravel and sand; losing circulation of drilling fluids.....	11	23
Clay, gray, sticky; harder at 31 ft.....	11	34
<u>Claggett Shale:</u>		
Shale, hard, tight; includes sandstone ledges.....	26	60
<u>Remarks:</u> Set 20-slot screen at 18-23 ft. Well produced about 20 gal/min with compressed air; well water cleared quickly.		
 <u>Site number:</u> O-48		
<u>Location number:</u> 26N25E05CABD01		
<u>Completed:</u> August 12, 1987		
<u>Alluvium:</u>		
Soil and clay.....	25	25
Sand(?); no returns.....	1	26
Clay, tight; need pull-down to drill.....	15	41
Gravel, loose.....	3	44
Sand, gray, very fine; few thin clay layers; drills smooth, bit falls without pull-down.....	12	56
Gravel, loose.....	4	60
<u>Claggett Shale:</u>		
Shale, black, hard; need hard pull-down to drill.....	10	70
<u>Remarks:</u> Set 30-slot screen at 56-61 ft with 8 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water was clear.		
 <u>Site number:</u> O-49		
<u>Location number:</u> 26N25E05CAAA01		
<u>Completed:</u> July 28, 1987		
<u>Alluvium:</u>		
Soil and clay.....	9	9
Gravel and sand, loose, angular to rounded.....	6	15
Clay, sandy at 15 ft, grading to smooth by 25 ft.....	19	34
Gravel, loose.....	5	39
Clay, smooth grading to sandy by 45 ft.....	13	52
Gravel, loose.....	4	56
<u>Claggett Shale:</u>		
Shale, black, hard, gritty.....	9	65
<u>Remarks:</u> Set 20-slot screen at 51-56 ft with 8 ft of tail pipe. Well flowed at about 20 gal/min.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-50		
<u>Location number:</u> 26N25E05CAAA02		
<u>Completed:</u> July 28, 1987		
<u>Alluvium:</u>		
Soil and clay.....	9	9
Gravel and sand, loose, angular to rounded.....	6	15
Clay, sandy at 15 ft, grading to smooth at 25-34 ft.....	19	34
Gravel, loose.....	5	39
Clay, smooth grading to sandy at 45 ft.....	13	52
Gravel, loose.....	4	56
<u>Claggett Shale:</u>		
Shale, black, hard, gritty.....	9	65
<u>Remarks:</u> Set 20-slot screen at 35-40 ft. Well produced about 15 gal/min with compressed air; well water was fairly clear.		
<u>Site number:</u> O-51		
<u>Location number:</u> 27N24E36DAAC02		
<u>Completed:</u> July 26, 1987		
<u>Alluvium:</u>		
Soil and clay, black, hard.....	5	5
Clay, brown, soft and sticky.....	15	20
Sand and fine gravel, drills easily.....	20	40
Gravel, loose; angular and broken rounded.....	3	43
Clay, medium-brown; soft and sticky; coarse sandy at 43-55 ft; smooth at 55-70 ft....	27	70
Gravel, loose, very angular to well rounded.....	5	75
<u>Claggett Shale:</u>		
Shale, black, hard, tight.....	15	90
<u>Remarks:</u> Set 20-slot screen at 70-75 ft with 10 ft of tail pipe. Well flowed at about 2 gal/min.		
<u>Site number:</u> O-52		
<u>Location number:</u> 27N24E36DAAC03		
<u>Completed:</u> July 27, 1987		
<u>Alluvium:</u>		
Clay, black, hard.....	20	20
Gravel, loose, coarse.....	5	25
Clay, brown.....	5	30
Gravel, loose, sandy.....	14	44
<u>Remarks:</u> Set 20-slot screen at 38-43 ft.		
<u>Site number:</u> O-53		
<u>Location number:</u> 27N25E31BCCD01		
<u>Completed:</u> July 27, 1987		
<u>Alluvium:</u>		
Soil and clay, brown, soft, sticky at 0-20 ft; grading to gray and slightly harder but still no grit at 30 ft; getting harder and darker at 60 ft.....	83	83
Gravel, loose.....	6	89
<u>Claggett Shale:</u>		
Clay, grading to shale.....	5	94
Shale, black, hard, tight.....	14	108
<u>Remarks:</u> Set 20-slot screen at 84-89 ft with 8 ft of tail pipe.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-54		
<u>Location number:</u> 27N24E26ADCD01		
<u>Completed:</u> July 27, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, medium-brown.....	13	13
Gravel, tight.....	2	15
Clay, gray, sandy, soft but not sticky; includes small gravel.....	14	29
Gravel, loose.....	1	30
Clay, gray, sandy (as above).....	30	60
Sand; poor returns.....	9	69
Clay, gray, sandy (as above).....	6	75
Gravel, loose.....	4	79
<u>Claggett Shale:</u>		
Shale, dark-gray to black, very fine sandy.....	11	90
<u>Remarks:</u> Set 20-slot screen at 74-79 ft with 7.5 ft of tail pipe.		
 <u>Site number:</u> O-55		
<u>Location number:</u> 27N24E26ABDC01		
<u>Completed:</u> August 19, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, black; carbonaceous.....	12	12
Gravel, loose.....	2	14
Clay, medium-hard; very fine sandy with small pebbles, same appearance top-to-bottom; need pull-down to drill.....	57	71
Gravel, loose, very angular to well rounded.....	4	75
<u>Judith River Formation:</u>		
Shale, dark-gray, weathered on top.....	15	90
<u>Remarks:</u> Set 30-slot screen at 71-76 ft with 10 ft of tail pipe. Well flowed at about 80 gal/min; well water was clear.		
 <u>Site number:</u> O-56		
<u>Location number:</u> 27N24E13CCDB03		
<u>Completed:</u> July 28, 1987		
<u>Alluvium and glacial deposits:</u>		
Gravel, small, loose.....	10	10
Clay, smooth, soft.....	12	22
Gravel (as above).....	1	23
Sand, fine.....	3	26
Clay, soft, smooth.....	4	30
Gravel, loose.....	1	31
<u>Judith River Formation:</u>		
Shale, dark-gray, hard, tight.....	9	40
<u>Remarks:</u> Set saw-slot screen at 26-31 ft with 7 ft of tail pipe. Well produced about 15 gal/min with compressed air; well water cleared slowly.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-57		
<u>Location number:</u> 27N24E13CCDB01		
<u>Completed:</u> August 11, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay.....	5	5
Gravel, loose, small.....	8	13
Clay, gray, gritty; includes coarse sand and small gravel.....	32	45
Gravel, loose, small, rounded to angular.....	7	52
<u>Judith River Formation:</u>		
Shale, dark-gray, gritty, hard.....	8	60
<u>Remarks:</u> Set 30-slot screen at 45-50 ft with 3.5 ft of tail pipe. Well produced about 15-20 gal/min with compressed air; well water was clear.		
<u>Site number:</u> O-58		
<u>Location number:</u> 27N24E13CCDB02		
<u>Completed:</u> August 11, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay.....	5	5
Gravel, loose, small.....	8	13
Clay, gray, gritty; includes coarse sand and small gravel.....	32	45
Gravel, loose, small, rounded to angular.....	7	52
<u>Judith River Formation:</u>		
Shale, dark-gray, gritty, hard.....	8	60
<u>Remarks:</u> Set 20-slot screen at 45-55 ft. Well produced about 50 gal/min with compressed air.		
<u>Site number:</u> O-59		
<u>Location number:</u> 27N24E13CCDA01		
<u>Completed:</u> July 28, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay.....	6	6
Gravel, loose.....	4	10
Clay, gray; includes coarse sand and fine gravel, few pieces of large gravel.....	42	52
Gravel, loose; poor returns, losing circulation of drill fluids.....	5	57
<u>Judith River Formation:</u>		
Shale, dark, hard, gritty; weathered at 57-60 ft.....	17	74
<u>Remarks:</u> Set 20-slot screen at 52-57 ft with 8 ft of tail pipe. Well produced about 20 gal/min with compressed air.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-60		
<u>Location number:</u> 27N24E13CDCB01		
<u>Completed:</u> August 11, 1987		
<u>Alluvium and glacial deposits:</u>		
Gravel, loose.....	3	3
Clay, gray; includes coarse sand and small rounded gravel.....	10	13
Gravel, loose.....	4	17
Clay, light-brown, very sandy; includes minor gravel; gray zone at 30 ft then back to light brown, drills smoothly, back to gray sandy at 45 ft, grading to very tight at 70 ft.....	53	70
<u>Judith River Formation(?):</u>		
Shale(?), gray; need hard pull-down to drill, cuttings are sandy clay; hard ledge or boulder 100-101 ft.....	65	135
Sand and gravel; coarse sand and small gravel.....	25	160
Shale, sandy shale or muddy sandstone, medium-gray; need very hard pull-down to drill, poor returns; coal chips but no dark shale as drilled in well O-59.....	20	180
<u>Remarks:</u> Set 30-slot screen at 155-160 ft with saw cuts at 150-155 ft and 10 ft of tail pipe. Well produced about 25 gal/min of bad-tasting water with compressed air.		
 <u>Site number:</u> O-61		
<u>Location number:</u> 27N24E01CDAA01		
<u>Completed:</u> August 15, 1987		
<u>Glacial deposits:</u>		
Soil and clay, brown, hard, brittle, gritty.....	10	10
Gravel, sand, and clay, tight.....	6	16
Clay.....	24	40
Gravel, sand, and clay, tight; need pull-down to drill; few large cobbles; weathered rocks in returns, white clay as at well O-2, small broken gravel pieces..	30	70
<u>Judith River Formation:</u>		
Shale, dark-gray, gritty; weathered on top.....	10	80
<u>Remarks:</u> Set 20-slot screen at 60-65 ft with 10 ft of tail pipe. Well produced about 1 gal/min with compressed air even after multiple backflushes; well water would not clear.		
 <u>Site number:</u> O-62		
<u>Location number:</u> 27N25E29CDD01		
<u>Completed:</u> August 17, 1987		
<u>Glacial deposits:</u>		
Gravel, loose; coarse sand to fine gravel, 10 percent angular, 40 percent subrounded, and 50 percent rounded.....	31	31
Clay and gravel; alternating thin layers, gravel loose, hole caving during drilling..	19	50
Gravel, sand, and clay, tight; includes clay lenses; need pull-down to drill.....	8	58
Gravel, sand, and clay lenses; drilled soft, gravel minor (20 percent); clay contains very coarse sand, grading to minor quantities of gravel; clay sticky at 110-120 ft, hole stays open.....	65	123
<u>Colluvium:</u>		
Gravel, sand, and clay, very tight; includes abundant white clay; need hard pull-down to drill; drilling chatter, broken rock pieces.....	8	131
<u>Judith River Formation:</u>		
Shale, dark-gray, hard.....	9	140
<u>Remarks:</u> Set 20-slot screen at 58-63 ft with 10 ft of tail pipe and packer installed below wash-down valve. Well produced about 8-10 gal/min with compressed air; well water was clear.		

Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-63		
<u>Location number:</u> 27N25E29BDBA01		
<u>Completed:</u> August 17, 1987		
<u>Glacial deposits:</u>		
Soil and clay, light-brown.....	3	3
Gravel, sand, and clay; angular, iron-stained rock chips; need pull-down to drill....	17	20
Sand and gravel, loose; minor quantity of clay.....	12	32
Gravel, sand, and clay (as above), grading harder at 55 ft.....	28	60
Gravel, sand, and clay, very hard, abundant white clay; drilling chatter; need very hard pull-down to drill; mud is dark yellowish-brown at 100 ft.....	44	104
Clay, gray, medium soft; includes coarse sand and small pebbles.....	14	118
Gravel, loose.....	4	122
<u>Judith River Formation:</u>		
Shale; weathered sandstone(?) at 122-127 ft; grading to hard brittle bluish-gray sandstone at 127-142 ft; extremely hard drilling, some clay or shale in sandstone..	20	142
<u>Remarks:</u> Set 30-slot screen at 118-123 ft with 10 ft of tail pipe. Developed well with compressed air for 2 h. Well took about 30 gal/min from water truck but only produced about 1-2 gal/min with compressed air.		
 <u>Site number:</u> O-64		
<u>Location number:</u> 25N26E05BADB01		
<u>Completed:</u> August 27, 1987		
<u>Alluvium:</u>		
Soil, sand.....	5	5
Clay, brown, soft, sticky.....	14	19
Gravel, loose, small, subangular to subrounded.....	7	26
Clay.....	2	28
Gravel, loose (as above).....	2	30
Clay, as above.....	2	32
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tighter; abundant white clay.....	8	40
Gravel, loose (as above).....	3	43
Clay .....	1	44
Gravel, loose (as above).....	8	52
<u>Colorado Group:</u>		
Shale, very silty, medium-bluish-gray; need maximum pull-down to drill.....	18	70
<u>Remarks:</u> Set screen at 47-52 ft with 10 ft of tail pipe. Well produced about 25 gal/min with compressed air; well water was clear.		
 <u>Site number:</u> O-65		
<u>Location number:</u> 25N26E22BBBB01		
<u>Completed:</u> August 26, 1987		
<u>Alluvium:</u>		
Soil, clay, dark-gray; appears similar to shale.....	9	9
Gravel, loose.....	1	10
Clay, brown, sticky.....	5	15
Gravel, sand, and clay.....	4	19
Gravel, loose, large, very angular pieces.....	5	24
<u>Bearpaw Shale:</u>		
Shale, dark-gray.....	16	40
<u>Remarks:</u> Set 20-slot screen at 18.5-23.5 ft with 10 ft of tail pipe. Well produced about 2 gal/min with compressed air; well water was fairly clear.		



Table 2.--Lithologic logs of observation wells--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> O-66 <u>Location number:</u> 25N26E15CCCA01 <u>Completed:</u> August 26, 1987		
<u>Alluvium:</u>		
Soil, clay.....	9	9
Gravel, sand, loose, subangular to subrounded.....	4	13
<u>Bearpaw Shale:</u>		
Shale, medium-gray, soft; drills easily, smooth; layer of bentonite 30-35 ft.....	47	60
<u>Remarks:</u> Set screen at 9-14 ft with 3 ft of tail pipe and packer installed below wash-down-valve; well produced about 1-2 gal/min with compressed air; well water would not clear.		

Table 3.--Lithologic logs of test holes

[Particle-size descriptions are based on report of National Research Council (1947). Abbreviations: ft, feet; gal/min, gallons per minute. Symbol: <, less than]

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-1		
<u>Location number:</u> 25N23E08AAAA01		
<u>Completed:</u> August 28, 1987		
<u>Terrace deposits:</u>		
Soil and clay, brown.....	4	4
Gravel, sand, and clay, tight.....	13	17
Clay or sand(?), smooth; no returns.....	4	21
Gravel, sand, and clay (as above).....	4	25
Clay, light-brown, smooth pull-down.....	5	30
<u>Judith River Formation:</u>		
Shale, weathered on top, light-gray with tan tint and streaks; gray at 60 ft.....	30	60
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-2		
<u>Location number:</u> 26N24E32BBBB01		
<u>Completed:</u> July 6, 1987		
<u>Colluvium:</u>		
Gravel, sand, and brown clay, tight; includes abundant white clay clumps and stringers; drills with slight chatter, hole stays open with no loss of circulation or thinning of drilling fluid.....	65	65
<u>Ellis Group:</u>		
Shale, dark-gray, tight; no water; drills hard and smooth.....	15	80
<u>Remarks:</u> Hole produces <0.5 gal/min with compressed air; back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-3		
<u>Location number:</u> 26N24E30CCAC01		
<u>Completed:</u> July 7, 1987		
<u>Alluvium:</u>		
Clay, brown; smooth drilling.....	28	28
Gravel, angular; brown clay; hole caving from 28 ft.....	12	40
<u>Colorado Group:</u>		
Shale, black; drills smoothly.....	20	60
<u>Remarks:</u> Hole would not produce water with compressed air. Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-4		
<u>Location number:</u> 26N24E30BAAA01		
<u>Completed:</u> July 9, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	7	7
<u>Colluvium:</u>		
Gravel, sand, and clay, tight.....	14	21
<u>Colorado Group:</u>		
Shale, black, tight; fractured at top, smoother drilling with depth.....	19	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-5		
<u>Location number:</u> 26N23E14AACD01		
<u>Completed:</u> July 11, 1987		
<u>Alluvium:</u>		
Soil and clay, brown.....	12	12
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tight.....	6	18
<u>Colorado Group:</u>		
Shale, dark-gray.....	2	20
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-6		
<u>Location number:</u> 27N23E36CCDA01		
<u>Completed:</u> July 12, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, medium-brown, soft.....	23	23
Gravel, small; drills easily.....	7	30
Clay, brown, soft.....	31	61
Gravel, small, rounded to subangular, loose.....	21	82
<u>Judith River Formation:</u>		
Shale, very soft; possible weathered zone on top appears as extremely sandy gray clay.....	48	130
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-7		
<u>Location number:</u> 27N23E36CDCD01		
<u>Completed:</u> July 13, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, tight gravel at 15-16 ft; rock or thin gravel layer at 23 ft.....	50	50
Gravel, sand, and clay, tight.....	8	58
<u>Judith River Formation:</u>		
Shale; smooth drilling with light pull-down at 60 ft grading to harder but still smooth at 70 ft.....	22	80
<u>Remarks:</u> Back-filled and cemented hole to stop artesian flow.		
<u>Site number:</u> T-8		
<u>Location number:</u> 27N23E13CCBC01		
<u>Completed:</u> July 21, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, brown.....	21	21
Gravel, small.....	1	22
Clay, gray; very smooth at 40 ft.....	49	71
Gravel(?), poor returns but rig chatters.....	1	72
Clay, gray.....	6	78
<u>Judith River Formation:</u>		
Shale, dark-brown; need very hard pull-down to drill.....	2	80
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-9		
<u>Location number:</u> 27N23E13CCAB01		
<u>Completed:</u> July 21, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay, brown.....	10	10
Gravel, dry.....	2	12
Clay, dark-brown.....	13	25
<u>Judith River Formation:</u>		
Shale, sandy, blue.....	35	60
Shale, hard.....	20	80
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-10		
<u>Location number:</u> 27N23E09ACAD01		
<u>Completed:</u> July 23, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-25 ft then gray at 25-103 ft.....	108	108
Clay, as above but grading harder.....	10	118
<u>Judith River Formation:</u>		
Shale, black, hard.....	7	125
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-11		
<u>Location number:</u> 27N23E09ADBB01		
<u>Completed:</u> July 23, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-25 ft then gray at 25-103 ft.....	103	103
Gravel, loose, coarse, cobbles.....	12	115
Clay, soft sandy; poor returns.....	10	125
<u>Judith River Formation:</u>		
Shale, black, very hard; dry.....	5	130
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-12		
<u>Location number:</u> 27N23E09AADCO1		
<u>Completed:</u> July 22, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, silty, olive-brown, soft; some pebbles and sand; coal and sandstone pebbles in lower part.....	98	98
Gravel, loose; includes very fine to coarse sand.....	9	107
<u>Judith River Formation:</u>		
Shale, dark-gray; firm.....	23	130
<u>Remarks:</u> Set 20-slot screen at 100-105 ft but could not control artesian flow. Removed casing and cemented hole.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-13		
<u>Location number:</u> 27N24E35CCBB01		
<u>Completed:</u> August 19, 1987		
<u>Terrace deposits:</u>		
Gravel, sand, and clay, tight.....	7	7
Clay, tight; includes minor quantity of gravel; need pull-down to drill.....	8	15
<u>Ellis Group:</u>		
Shale, dark-gray, hard, tight.....	25	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-14		
<u>Location number:</u> 27N24E35CCBA01		
<u>Completed:</u> August 13, 1987		
<u>Alluvium:</u>		
Clay, silty, soft; dark-brown at 0-15 ft, mottled grayish-brown at 5-15 ft.....	15	15
Gravel and sand, loose; interbedded with gray silty clay, gravel fine to coarse, broken pieces.....	8	23
<u>Ellis Group:</u>		
Shale, dark-gray, hard, tight.....	17	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-15		
<u>Location number:</u> 27N24E17DBAB01		
<u>Completed:</u> August 18, 1987		
<u>Glacial deposits:</u>		
Soil and clay.....	5	5
Gravel, loose; large cobbles.....	2	7
Clay, hard, tight; includes coarse sand and gravel.....	14	21
Gravel, sand, and clay; more gravel than at 5-7 ft.....	6	27
Clay (as above).....	38	65
<u>Judith River Formation:</u>		
Shale.....	15	80
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-16		
<u>Location number:</u> 27N24E16BBDC01		
<u>Completed:</u> August 18, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay.....	88	88
<u>Judith River Formation:</u>		
Shale.....	11	99
Sandstone; drilling chatter; bluish-gray chips in returns.....	21	120
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-17		
<u>Completed:</u> August 18, 1987		
<u>Local number:</u> 27N24E16BBDA01		
<u>Glacial deposits:</u>		
Gravel, sand, and clay; 95 percent clay, brown at 0-35 ft, gray at 35-79 ft, few cobble and gravelly zones.....	79	79
<u>Judith River Formation:</u>		
Shale and sandstone; light-bluish-gray sandy shale and dirty sandstone.....	11	90
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-18		
<u>Location number:</u> 27N24E16BBD02		
<u>Completed:</u> August 18, 1987		
<u>Alluvium and glacial deposits:</u>		
Clay, brown, sandy.....	10	10
Gravel, sand, and clay, clay in layers.....	6	16
Clay, tight.....	19	35
<u>Judith River Formation:</u>		
Shale and sandstone.....	5	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-19		
<u>Location number:</u> 27N24E16BBD01		
<u>Completed:</u> August 18, 1987		
<u>Alluvium and glacial deposits:</u>		
Gravel and clay, tight; need pull-down to drill, big cobbles roll into hole behind bit.....	9	9
Clay, tight, gray; includes coarse sand and small pebbles, few cobbles, tighter at 40 ft.....	31	40
Clay, soft, sandy.....	12	52
Clay, as above but need pull-down to drill (possible weathered shale).....	3	55
<u>Judith River Formation:</u>		
Shale, hard, medium-gray, very sandy; includes layers of silty light-bluish-gray sandstone.....	25	80
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-20		
<u>Location number:</u> 27N24E16BAAC01		
<u>Completed:</u> August 18, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay.....	16	16
<u>Judith River Formation:</u>		
Shale and sandstone.....	24	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-21		
<u>Location number:</u> 28N24E32CCBB01		
<u>Completed:</u> August 25, 1987		
<u>Glacial deposits:</u>		
Clay, brown, silty, sandy, soft.....	10	10
Sand(?), poor returns, gravel at base.....	5	15
Clay, silty, brown.....	5	20
Clay, silty, sandy, slightly pebbly; brown at 0-54 ft, gray at 54-89 ft, firmer at 60 ft, rocky at 35-40 ft.....	89	109
Gravel, very fine to coarse.....	6	115
<u>Judith River Formation:</u>		
Shale .....	15	130
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-22		
<u>Location number:</u> 26N25E17CDCC01		
<u>Completed:</u> August 30, 1987		
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, tight.....	11	11
Clay, smooth.....	3	14
Gravel, sand, and clay (as above); gravel small, angular to subrounded.....	16	30
<u>Ellis Group:</u>		
Shale, black, tight.....	5	35
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-23		
<u>Location number:</u> 26N25E05ACCB01		
<u>Completed:</u> July 26, 1987		
<u>Colluvium and alluvium:</u>		
Gravel, sand, and clay, gravel, angular.....	7	7
<u>Claggett Shale:</u>		
Shale, soft and brown grading to hard and black at 20 ft.....	28	35
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-24		
<u>Location number:</u> 27N24E36DADB01		
<u>Completed:</u> August 19, 1987		
<u>Colluvium and alluvium:</u>		
Clay, black, very hard; drills like shale.....	7	7
Clay, softer, brown, sticky.....	19	26
Sand and gravel, loose.....	2	28
Clay, medium hard.....	4	32
<u>Claggett Shale:</u>		
Shale, dark-grayish-brown, tight, hard; some cream-white shale layers.....	28	60
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-25		
<u>Location number:</u> 27N25E31CBBB01		
<u>Completed:</u> July 27, 1987		
<u>Alluvium:</u>		
Soil and clay, black.....	18	18
Sand and gravel, loose.....	2	20
Clay, sandy.....	5	25
Sand and gravel.....	5	30
Gravel, loose.....	5	35
Gravel, sand, and clay, loose.....	5	40
Clay, soft, gray, sticky; sandy at 40 ft grading smooth at 60 ft.....	29	69
Gravel, loose.....	5	74
<u>Claggett Shale:</u>		
Shale, black, hard, tight.....	6	80
<u>Remarks:</u> Back-filled hole with cuttings; bentonite at 50 ft and 12 ft; water level in upper zone 7 ft below land surface after lower zone was plugged.		
 <u>Site number:</u> T-26		
<u>Location number:</u> 27N25E31CBBA01		
<u>Completed:</u> July 27, 1987		
<u>Alluvium:</u>		
Soil and clay, medium-brown, soft.....	61	61
Sand, includes minor quantity of gravel.....	7	68
Gravel, loose.....	4	72
<u>Claggett Shale:</u>		
Shale, black, hard, tight.....	8	80
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-27		
<u>Location number:</u> 27N24E01CBCD01		
<u>Completed:</u> August 16, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay; soft sand at 70-73 ft, boulder gravel at 106-109 ft.....	115	115
<u>Judith River Formation:</u>		
Shale.....	5	120
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-28		
<u>Location number:</u> 27N24E01CACC01		
<u>Completed:</u> August 15, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay; appears similar to till in nearby cutbank.....	87	87
Clay, gray, tight, no pebbles.....	11	98
Gravel, sand, and clay, very tight; need pull-down to drill.....	6	104
<u>Judith River Formation:</u>		
Shale; weathered at top grading to dark-gray, hard, and gritty.....	16	120
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		



Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-29		
<u>Location number:</u> 27N24E01CDAB01		
<u>Completed:</u> August 15, 1987		
<u>Alluvium and glacial deposits:</u>		
Soil and clay.....	3	3
Gravel, loose.....	7	10
Clay, gray; includes coarse sand and fine gravel; gets hard at 15-20 ft, need hard pull-down to drill.....	30	40
Gravel, sand, and clay, loose at 41-42 ft; tight, need hard pull-down to drill.....	23	63
<u>Judith River Formation:</u>		
Shale, gray, hard, tight, gritty.....	2	65
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-30		
<u>Location number:</u> 27N24E01DCBC01		
<u>Completed:</u> August 15, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay; rocky zones at 7-13 ft, 23-26 ft, and others; brown clay matrix at 0-75 ft and gray at 75-91 ft.....	91	91
Gravel, sand, and clay; similar to above but very hard and tight; need hard pull-down to drill.....	32	123
<u>Judith River Formation:</u>		
Shale.....	17	140
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-31		
<u>Location number:</u> 27N24E01DDBC01		
<u>Completed:</u> August 16, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay; mostly sandy clay with few gravel layers; brown at 0-75 ft and gray at 75-110 ft; gray clay is similar to shale bedrock but is softer and includes small pebbles.....	110	110
<u>Judith River Formation:</u>		
Shale, gritty, sandy; same color as overlying deposits but harder with no pebbles; hard sandstone(?) layers at 152-153 ft, 161-162 ft, 176-177 ft.....	80	190
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-32		
<u>Location number:</u> 27N25E29CDCD01		
<u>Completed:</u> August 17, 1987		
<u>Glacial deposits:</u>		
Clay, grayish-tan; consistent medium-soft, sticky; includes small gravel and coarse sand, thin rocky zone at 18-19 ft, otherwise smooth drilling, grading slightly harder at 75-100 ft, all 113 ft look virtually the same.....	113	113
Gravel, sand, and clay, very tight, small broken pieces; includes abundant white clay; need pull-down to drill.....	5	118
<u>Judith River Formation:</u>		
Shale, dark-gray, very hard, sandy.....	12	130
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-33		
<u>Location number:</u> 27N25E19AABC01		
<u>Completed:</u> August 29, 1987		
<u>Glacial deposits:</u>		
Soil and clay, brown, tight.....	10	10
Gravel, sand, and clay, tight.....	5	15
Clay, light-grayish-brown, includes coarse sand and pebbles, few cobbles, medium-gray sandy at 40-94 ft; drilling smooth, clay sticky.....	79	94
Gravel, sand, and clay, gravel small and angular, abundant white clay; need pull-down to drill.....	8	102
Clay, gray, soft.....	11	113
<u>Judith River Formation:</u>		
Shale, medium-gray; similar to clay above but harder and more brittle without pebbles.....	17	130
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-34		
<u>Location number:</u> 27N25E19ABDB01		
<u>Completed:</u> August 29, 1987		
<u>Glacial deposits:</u>		
Soil and clay, minor small gravel; brown at 0-50 ft and gray below 50 ft; very sandy with pebbles and few rocks; extremely hard gneiss or quartzite boulder at 63-64.5 ft, ruined drill bit, very slow penetration with new bit.....	72	72
Gravel, sand, and clay, tight.....	4	76
Clay, gray (as above) but gravel slightly smaller.....	39	115
<u>Judith River Formation:</u>		
Shale, dark-gray, tight.....	5	120
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-35		
<u>Location number:</u> 27N25E19AAAA01		
<u>Completed:</u> August 29, 1987		
<u>Glacial deposits:</u>		
Gravel, sand, and clay, varying quantities of small angular gravel.....	45	45
Clay, brown, with pebbles.....	10	55
Gravel, sand, and clay, almost loose at places.....	10	65
Clay, gray, with sand and pebbles; losing circulation of drilling fluid.....	51	116
Gravel, sand, and clay, tight; need pull-down to drill, poor returns.....	14	130
<u>Judith River Formation:</u>		
Shale.....	2	132
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-36		
<u>Location number:</u> 25N26E09CBBB01		
<u>Completed:</u> August 27, 1987		
<u>Colluvium and alluvium:</u>		
Cobbles and clay.....	2	2
Clay, tight.....	3	5
Gravel, sand, and clay .....	6	11
<u>Colorado Group:</u>		
Shale.....	9	20
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-37		
<u>Location number:</u> 25N26E09BCCD01		
<u>Completed:</u> August 27, 1987		
<u>Colluvium and alluvium:</u>		
Clay .....	3	3
Gravel, sand, and clay, small very angular chips; need pull-down to drill; no water, minor white clay.....	12	15
<u>Colorado Group:</u>		
Shale.....	5	20
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-38		
<u>Location number:</u> 25N26E09BCBD01		
<u>Completed:</u> August 27, 1987		
<u>Colluvium and alluvium:</u>		
Clay .....	5	5
Gravel, sand, and clay.....	8	13
<u>Colorado Group:</u>		
Shale .....	7	20
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-39		
<u>Location number:</u> 25N26E09BCDB01		
<u>Completed:</u> August 27, 1987		
<u>Colluvium and alluvium:</u>		
Soil and clay, gray, soft, sticky.....	10	10
Gravel, sand, and clay; gravel small, with clay, gray with some white pieces; need pull-down to drill.....	10	20
<u>Colorado Group:</u>		
Shale, black, hard.....	10	30
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
 <u>Site number:</u> T-40		
<u>Completed:</u> August 26, 1987		
<u>Local number:</u> 25N26E15CCAD01		
<u>Alluvium:</u>		
Soil and clay, dark-gray.....	15	15
Gravel, loose, small.....	1	16
<u>Bearpaw Shale:</u>		
Shale; bentonite layer at 30-32 ft.....	24	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		

Table 3.--Lithologic logs of test holes--Continued

Description	Thick- ness pene- trated (ft)	Bottom of interval below land surface (ft)
<u>Site number:</u> T-41		
<u>Location number:</u> 25N26E15CACA01		
<u>Completed:</u> August 26, 1987		
<u>Alluvium:</u>		
Soil and clay, medium-brown.....	10	10
Gravel, loose.....	6	16
<u>Bearpaw Shale:</u>		
Shale, medium-gray; grading harder at 25 ft, bentonite layer at 30-32 ft is light grayish-green, sticky.....	24	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-42		
<u>Location number:</u> 25N26E15BDDD01		
<u>Completed:</u> August 26, 1987		
<u>Alluvium:</u>		
Soil and clay.....	5	5
Gravel, loose.....	5	10
<u>Bearpaw Shale:</u>		
Shale.....	30	40
<u>Remarks:</u> Bentonite layer missing at site. Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-43		
<u>Location number:</u> 25N26E15ACBC01		
<u>Completed:</u> August 26, 1987		
<u>Alluvium:</u>		
Soil and clay.....	3	3
Gravel, loose.....	2	5
<u>Bearpaw Shale:</u>		
Shale.....	15	20
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		
<u>Site number:</u> T-44		
<u>Location number:</u> 26N26E33CDBD01		
<u>Completed:</u> August 27, 1987		
<u>Terrace deposits:</u>		
Gravel, sand, and clay, 20 percent white clay, identical to and significantly more abundant than at other sites, gravel is angular.....	35	35
<u>Colorado Group:</u>		
Shale, black, tight.....	5	40
<u>Remarks:</u> Back-filled hole with cuttings and bentonite.		