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Geohydrologic Conditions at the Nuclear-fuels Reprocessing Plant and Waste-management Facilities at the Western New York Nuclear Service Center, Cattaraugus County, New York

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(in pocket)

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CONVERSION FACTORS AND ABBREVIATIONS

Factors for converting the metric (International System) units used in this report to inch-pound units are shown below.

Divide metric units	By	To obtain inch-pound units
	Length	
centimeter (cm)	2.54	inch (in)
meter (m)	.3048	foot (ft)
kilometer (km)	1.609	mile (mi)
	Area	
square kilometer (km^2)	2.59	square mile (mi^2)
hectare (ha)	0.405	acre (a)
	Flow	
liter per second (L/s)	28.32	cubic foot per second (ft^3/s)
liter per second (L/s)	0.06309	gallon per minute (gal/min)
liter per second (L/s)	43.81	million gallons per day (Mgal/d)
cubic meters per second (m^3/s)	0.0283	cubic foot per second (ft^3/s)
	Hydraulic Units	
meter per day (m/d)	0.3048	hydraulic conductivity, foot per day (ft/d)
meter per kilometer (m/km)	0.1894	foot per mile (ft/mi)

Geohydrologic Conditions at the Nuclear-Fuels Reprocessing Plant and Waste-Management Facilities at the Western New York Nuclear Service Center, Cattaraugus County, New York

By

Marcel P. Bergeron, William M. Kappel, and Richard M. Yager

Abstract

The Western New York Nuclear Service Center near West Valley, N.Y., contains a nuclear-fuels-reprocessing plant, a high-level radioactive-liquid-waste-tank complex, and waste facilities. All are within about 100 hectares on a fairly level plateau on the western flank of the Buttermilk Creek valley. The plateau is underlain by a sequence of glacial and postglacial deposits that fill an ancestral bedrock valley.

The main facilities are on an elevated area referred to as the north plateau, which is mantled by alluvial and fluvial silty sand and gravel that range from 1 to 10 meters thick. Ground water in the north plateau moves laterally within the sand and gravel from an area southwest of the main building to the northeast, east, and southeast, where the sand and gravel either pinches out or is cut off by deeply incised stream-channel banks. The hydraulic conductivity of the sand and gravel, calculated from slug-test data, ranges from 0.1 to 7.9 meters per day.

Two separate burial grounds--a 2.2-hectare disposal area previously licensed by the U.S. Nuclear Regulatory Commission for use by the site operator and a 4-hectare area licensed by the State of New York for disposal of commercial waste--are about 320 meters from the main building. The burial grounds are excavated in a sequence of clay-rich till that ranges from 22 to 28 meters thick. Northward migration of an organic solvent from the disposal area for about 18 meters at shallow depths in the till suggests that the shallow, fractured, oxidized, and weathered till is a significant pathway for lateral movement of ground water. Below this zone, ground water moves vertically downward through the till to recharge saturated lacustrine silt and fine sand and kame-delta deposits. Limited potentiometric-head data suggest that some of the water entering the fine sand and silt may continue downward to recharge lower units. Heads within the saturated parts of the silt and fine sand indicate that ground water moves laterally under a gradient of 0.02 meter per meter to the northeast and toward Buttermilk Creek.

Vertical hydraulic conductivity of the silty clay till, estimated from laboratory permeability analysis, ranges from 1.8×10^{-5} to 1.0×10^{-4} m/d. Permeability of weathered, oxidized till and unweathered till samples averages 4.2×10^{-5} and 2.45×10^{-5} m/d, respectively. Horizontal hydraulic conductivity of the till, estimated from analyses of recovery-test data, ranges from 6.9×10^{-6} to 8.64×10^{-5} m/d and averages 1.7×10^{-5} m/d.

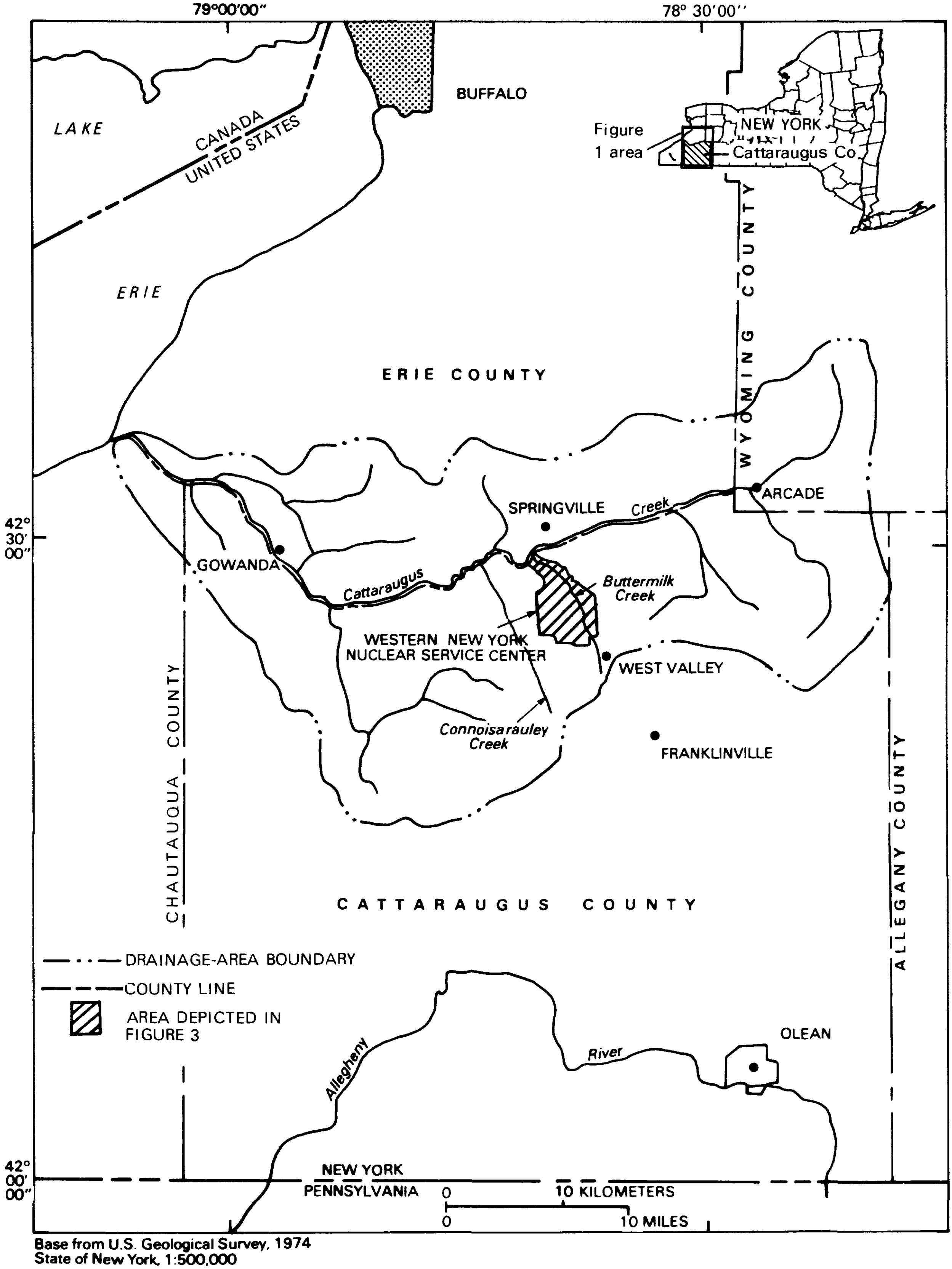


Figure 1.--Location of the Western New York Nuclear Services Center.

INTRODUCTION

In 1961, the New York State Office of Atomic Development acquired 1,350 ha of undeveloped land near the village of West Valley in northern Cattaraugus County, about 48 km south of Buffalo (fig. 1), for development of a nuclear-fuel-reprocessing plant and waste-management facilities. The land was subsequently named the Western New York Nuclear Service Center. In 1963, the U.S. Atomic Energy Commission issued a permit to a private operator authorizing development of about 100 ha of the site for construction of a reprocessing plant and supporting facilities (fig. 2).

The supporting facilities include a structure for receiving and storage of irradiated fuel before reprocessing, an underground storage-tank complex for liquid high-level radioactive wastes generated by reprocessing, and a low-level radioactive-wastewater-treatment plant. The site also includes two separate burial grounds for shallow burial of solid radioactive wastes--a 4-ha area licensed by the State of New York for burial of commercial low-level radioactive wastes (not operating at present), and a 2.2-ha disposal area licensed by U.S. Nuclear Regulatory Commission for wastes with higher radioactivity. The locations of these facilities are shown in figure 3.

During 1975-80, two studies were done to evaluate the extent of and potential for radionuclide movement from the State-licensed waste-disposal area. One was by the U.S. Geological Survey; its purpose was to identify the principal hydrologic and geologic factors that control subsurface movement of radioisotopes from the burial ground. The other was done by the New York State Geological Survey under contract with the U.S. Environmental Protection Agency and, later, the U.S. Nuclear Regulatory Commission, to evaluate all processes of radioisotope migration at the burial site.

Since 1980, the U.S. Geological Survey has conducted studies to complement efforts by the New York State Geological Survey to evaluate the geology, surface and subsurface hydrology, and the extent and potential for radioisotope migration from the other facilities. Both studies were funded under mutual financial agreements with the U.S. Nuclear Regulatory Commission, and many elements of the two studies were jointly planned and completed by the two Surveys.

Purpose and Scope

This report summarizes the hydrogeologic conditions at the fuel reprocessing plant and waste-management facilities. The geologic and hydrologic information presented was obtained largely from studies conducted since 1980, but data from previous investigations are also included. The report includes maps and several geologic cross sections that illustrate the stratigraphic relationships of the glacial deposits and the underlying bedrock and describe ground-water flow patterns and hydraulic properties of the sediments. It a includes (1) descriptions of the surface-water-drainage areas and characteristics, with results of inventories of ground-water seepage to the surfa (2) hydrologic information from wells and borings drilled during 1980-83, including locations and depths of wells, water levels, and general well-construction data; and (3) natural gamma and neutron-moisture logs of selected test holes.

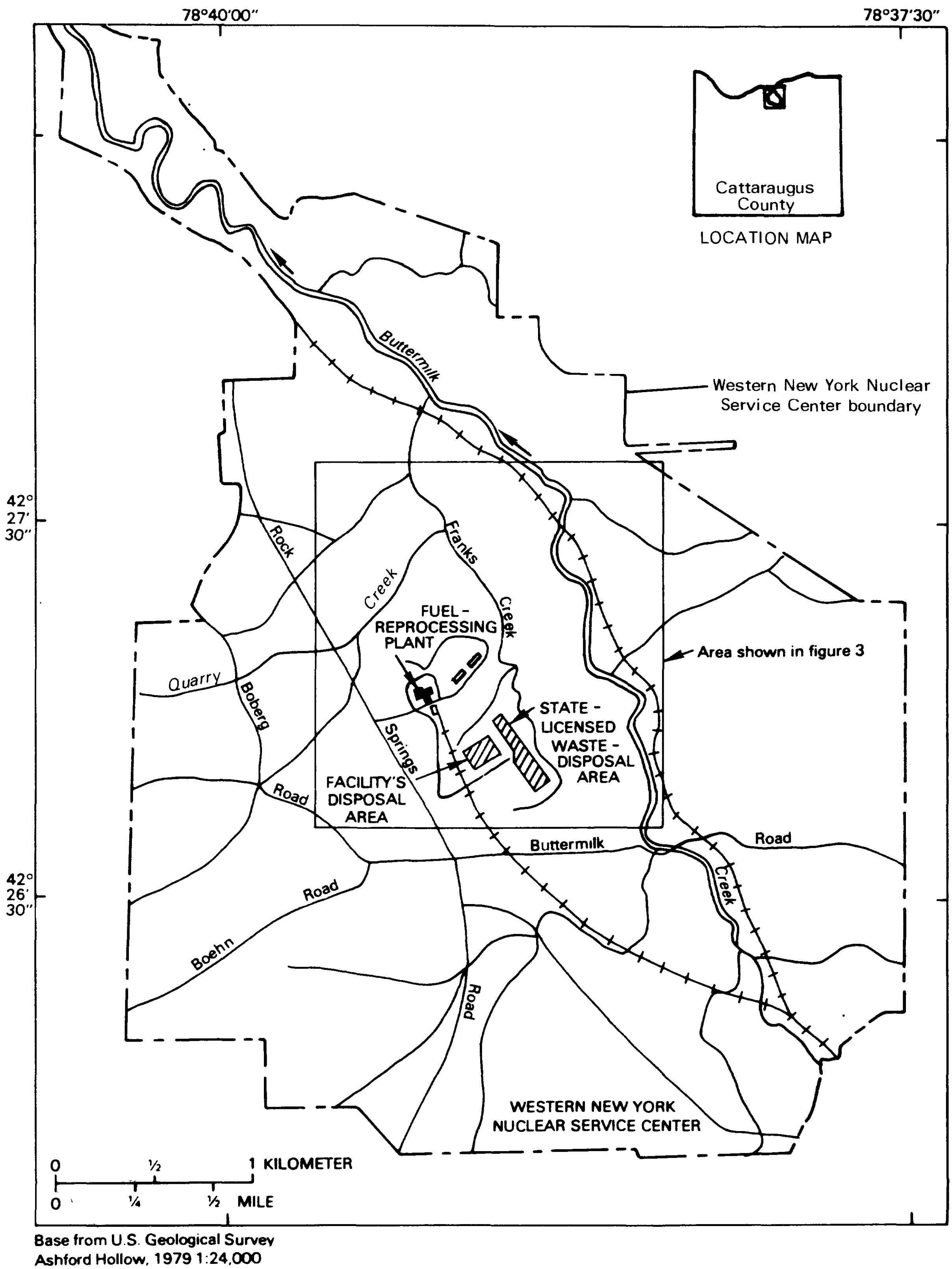
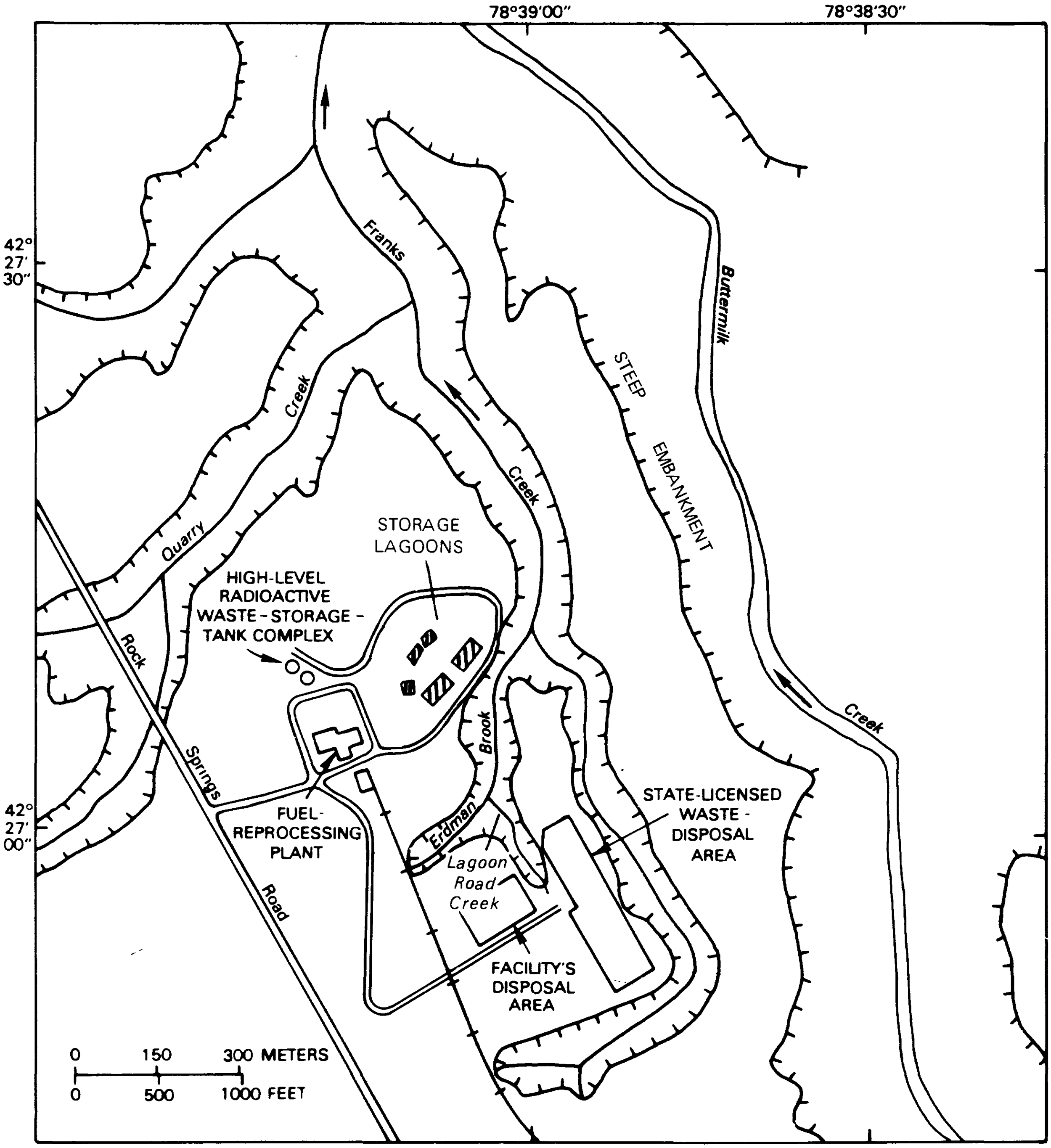


Figure 2.--Location of the nuclear-fuels-reprocessing plant and related waste-management facilities within the Western New York Nuclear Service Center. (Location is shown in fig. 1.)

Geologic Setting

The Western New York Nuclear Service Center is within the glaciated Allegheny section of the Appalachian Plateau physiographic province. The building and burial grounds are on a sequence of glacial and postglacial deposits that form a fairly level plateau at an altitude of 420 m on the west flank of the Buttermilk Creek Valley (fig. 3).



Base from U.S. Geological Survey
Ashford Hollow, 1979 1:24,000

Figure 3.--Detail of figure 2 showing relative position of nuclear-fuels-reprocessing plant and related waste-management facilities.

The glacial geology and stratigraphy at the Western New York Nuclear Service Center and vicinity have been examined by several investigators, most notably LaFleur (1979). Geologic studies indicate that the site overlies a complex of till and lacustrine, morainal, outwash, alluvial fan, and fluvial deposits that fill a buried preglacial bedrock valley. A generalized section showing the stratigraphic relationships of these deposits is given in figure 4.

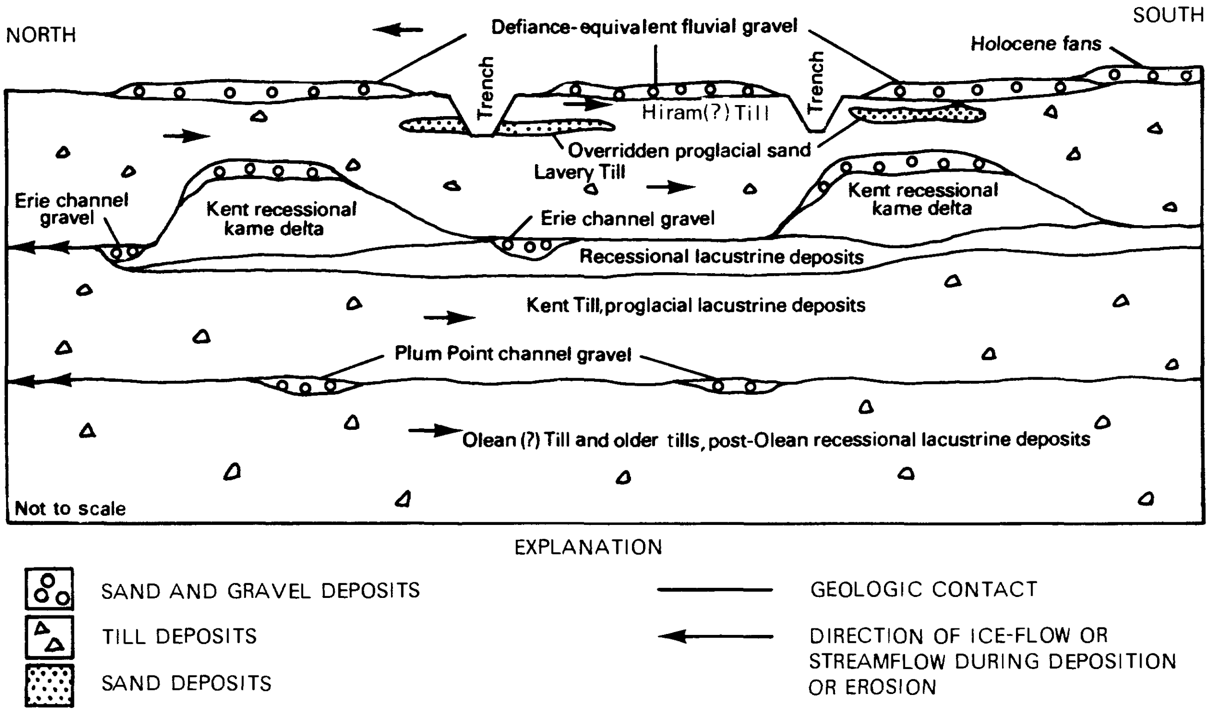


Figure 4.--Generalized stratigraphic section of the West Valley site. (Modified from LaFleur, 1979, p. 13.)

The fuel-reprocessing plant and related facilities are built on an elevated plateau, referred to as the north plateau. This area is underlain by a thin alluvial fan deposit that is composed primarily of silty sand and gravel. The fan deposit overlaps onto a fluvial gravel deposit approximately 260 m northeast of the main plant building. An isopach map of these surficial deposits (fig. 5) indicates that the thickness of the surficial gravel ranges from slightly more than 9 m just southwest of the main plant to less than 3 m along the adjacent stream-channel walls of Quarry Creek to the north and Franks Creek (fig. 6) to the east. The surficial gravel pinches out along the west tributary of Franks Creek about 250 m southeast of the plant (fig. 6).

Beneath the surficial gravel of the north plateau and underlying the facilities is the Lavery Till (LaFleur, 1979), the host formation for wastes buried at both burial grounds. Till in the burial-ground vicinity is mainly silt and clay and ranges from 22 to 28 m thick (fig. 6). Its pebble content ranges from 5 to 20 percent. The upper 3 to 4 m of till is chemically oxidized and weathered and includes fractures and root tubes that provide secondary porosity near the surface. The till contains slightly to severely deformed, discontinuous pods, lenses, and stringers of silt to fine sand and, rarely, coarse sand and gravel. These bodies range from less than 1 cm to 2 m in length.

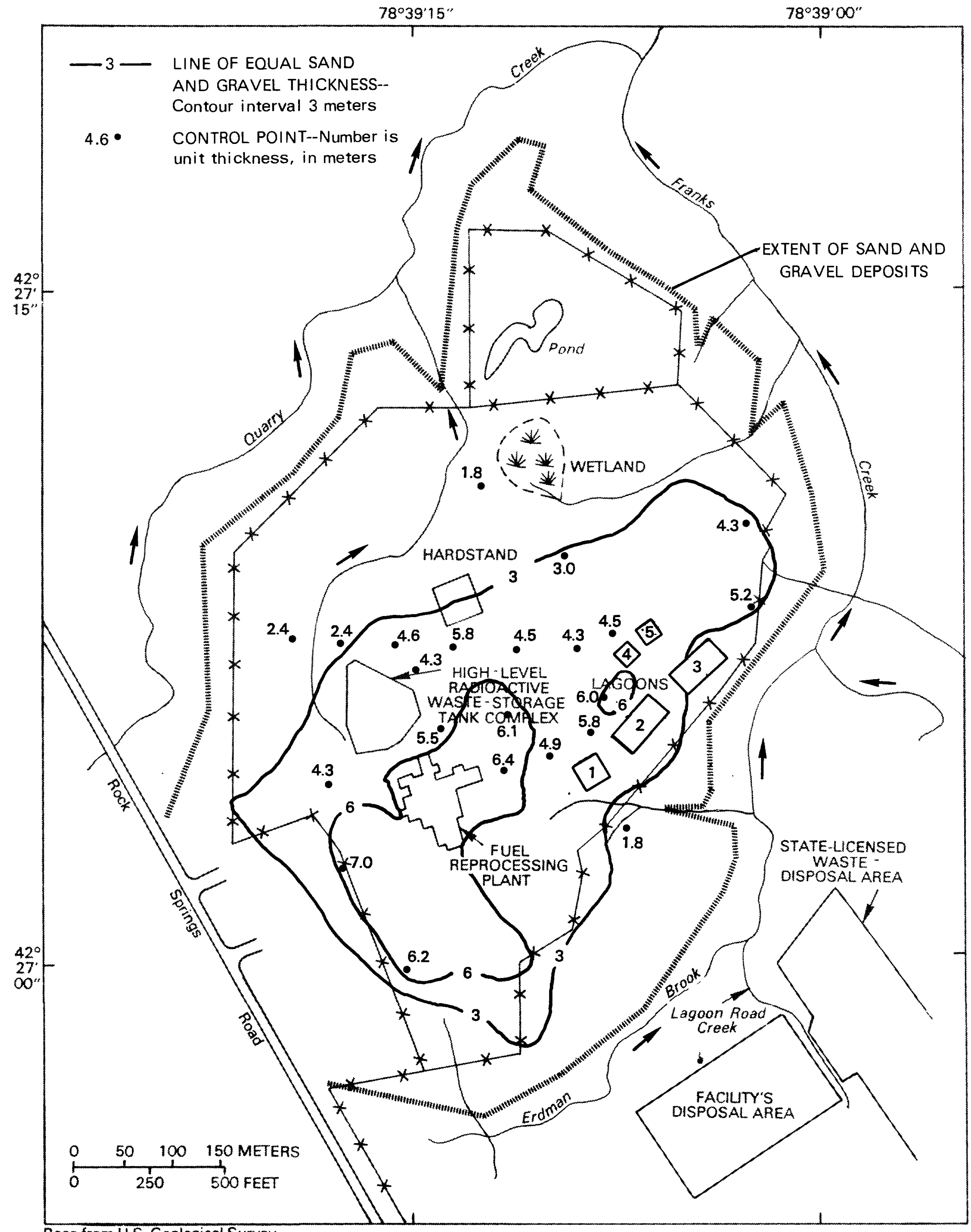


Figure 5.--Thickness of surficial sand and gravel in the north plateau area. (Modified from Albanese and others, 1983.)

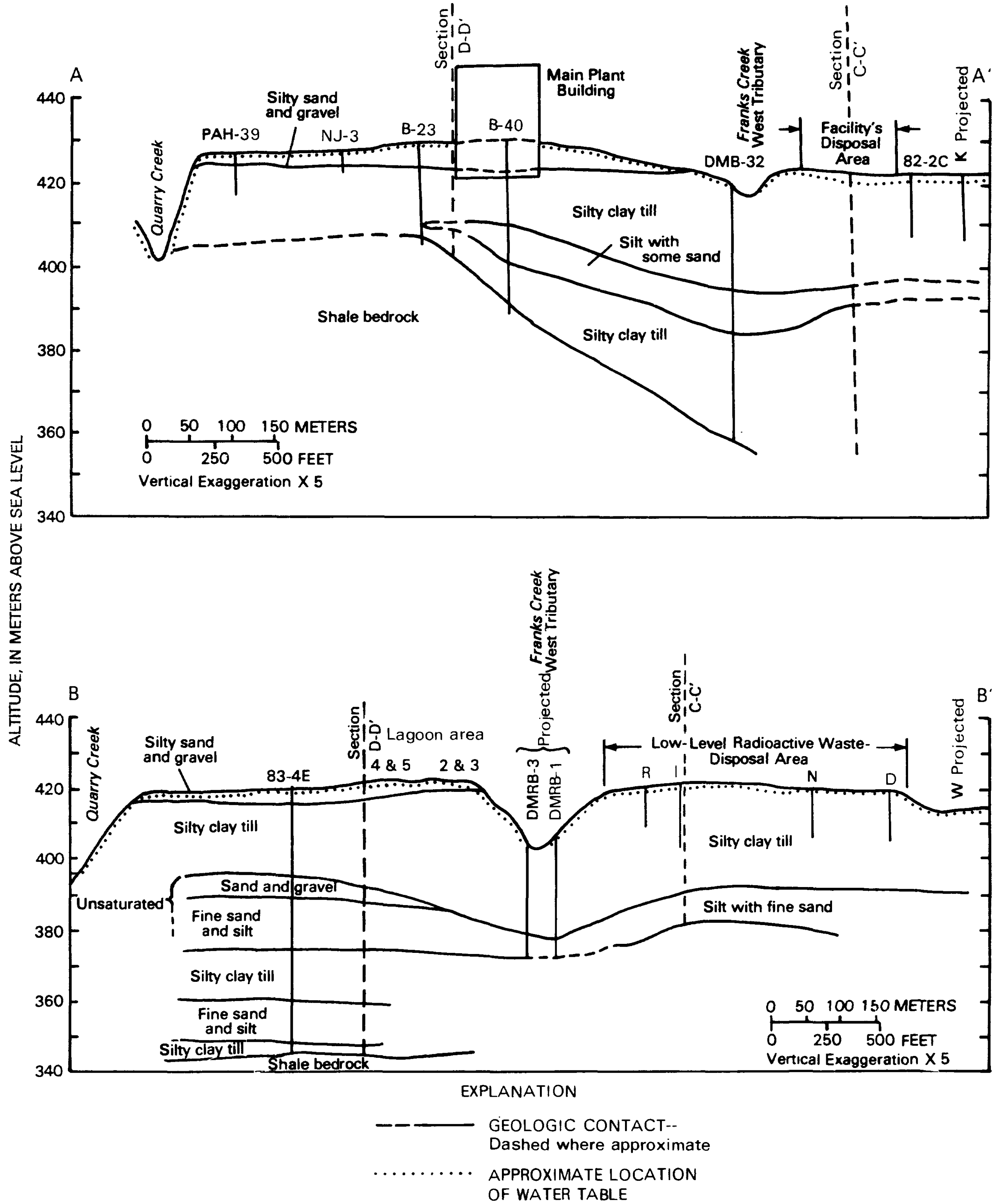


Figure 6.--Section A-A' through main plant area and facility's disposal area; and section B-B' through storage lagoon area and State-licensed waste-disposal area. (Location of sections is shown on pl. 1.)

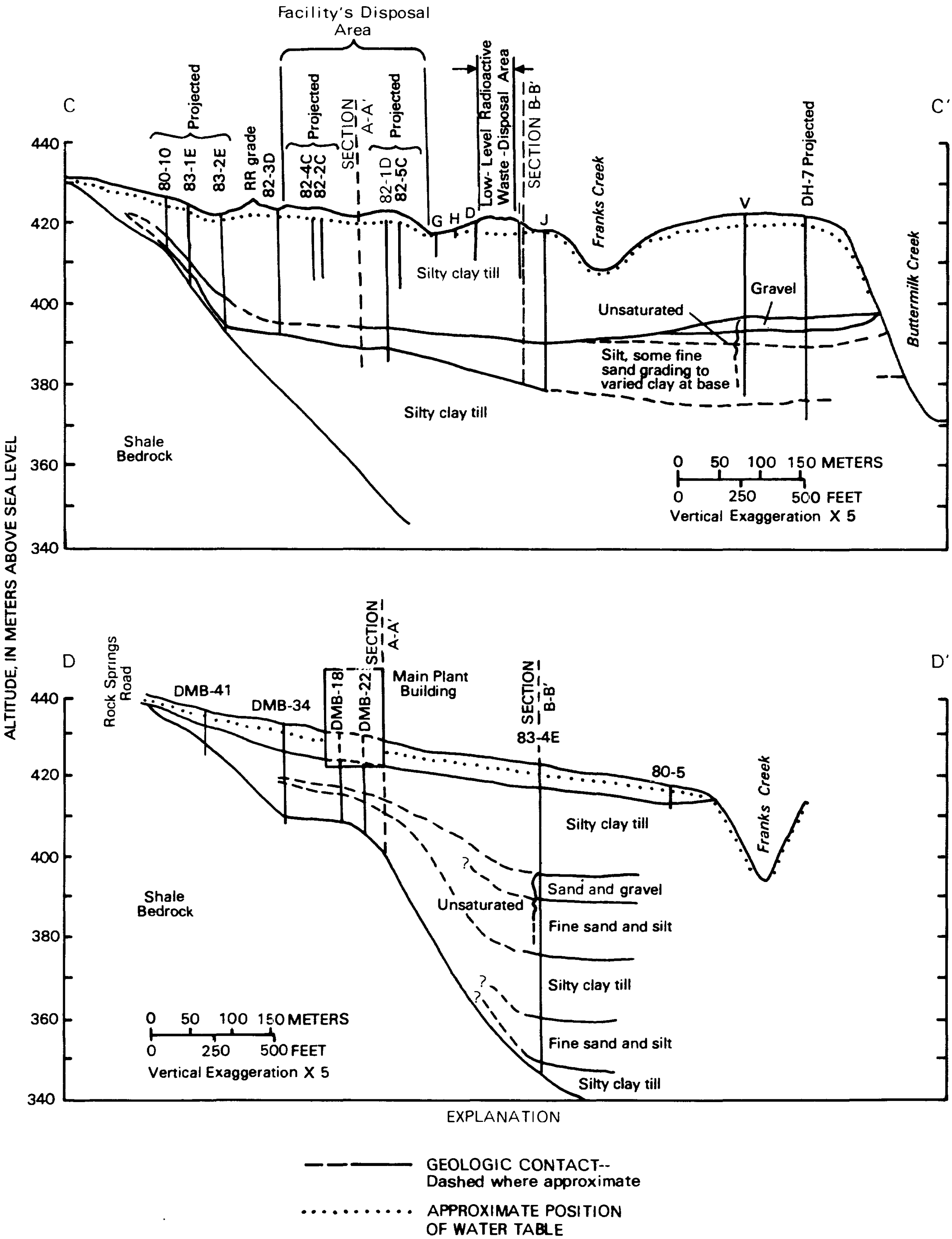


Figure 6 (continued).--Section C-C' through main plant area to Franks Creek and section D-D' through facility's and State-licensed waste-disposal areas to Buttermilk Creek. (Location of sections is shown on pl. 1.)

Beneath the Lavery Till is a sequence of recessional lacustrine and kame-delta deposits of post-Kent Till age that consist of laminated silt and clay grading upward into fine to coarse sand and silt. In two boreholes (hole V and DH-7) east of the low-level waste-burial site (see fig. 6), the upper, sandy part of the unit is capped by gravel. Evidence from regional stratigraphy and a bedrock test hole at the site indicates that post-Kent recessional deposits are underlain by at least two older, clayey-silt tills--the Kent Till and the Olean(?) Till (LaFleur, 1979). In borehole 83-4, about 150 m from the main plant facilities (pl. 1), two silty-clay till sequences separated by 12 m of saturated fine sand and silt were penetrated below post-Kent deposits before shale bedrock was encountered at 5.2 m. (See fig. 5.) These tills are presumed to be Kent Till and Olean(?) Till separated by post-Olean recessional lacustrine deposits. The post-Kent and Kent Tills are exposed in the steep valley walls of Buttermilk Creek.

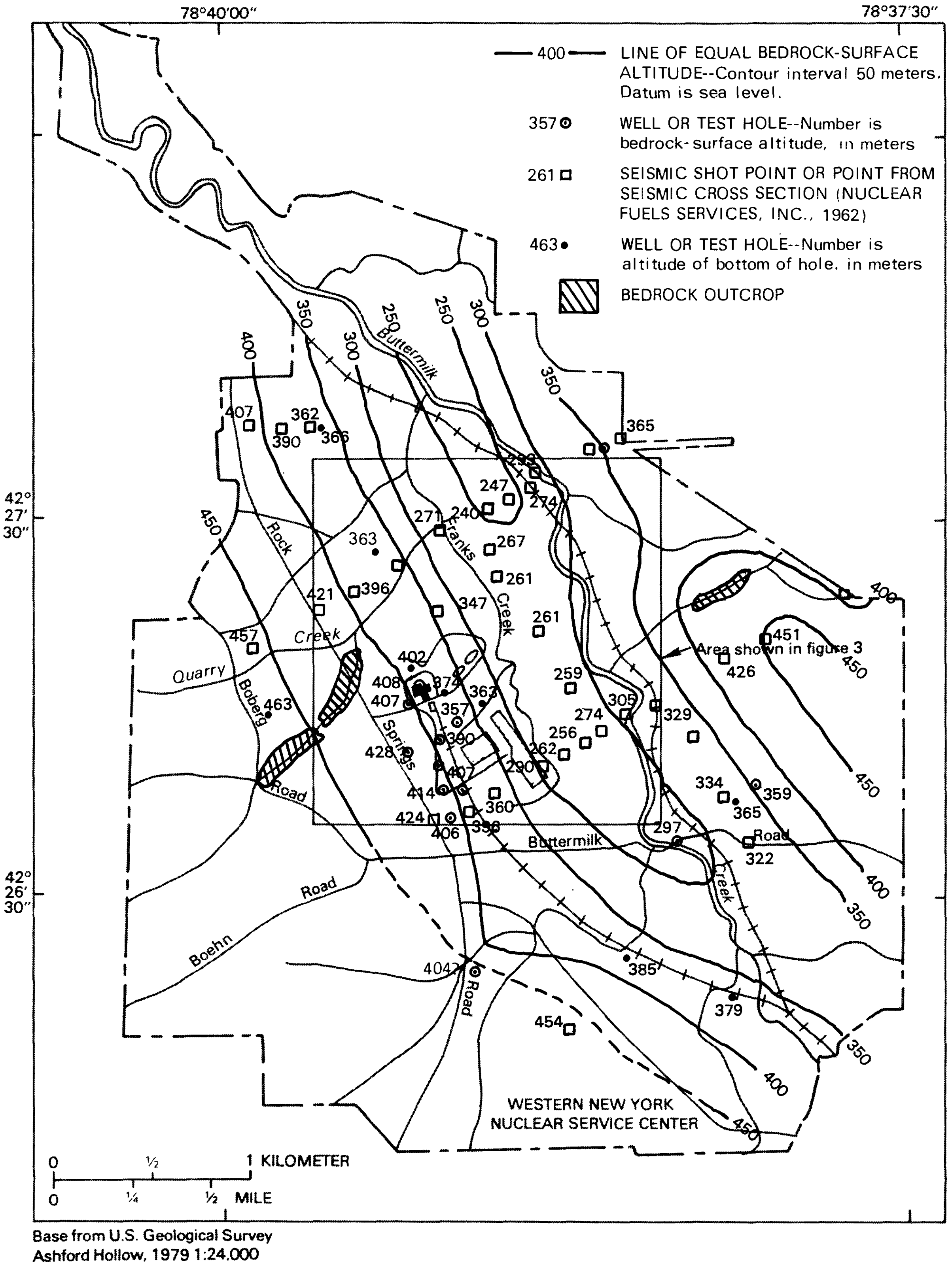
The bedrock underlying the area is shale and sandstone of the Upper Devonian Canadaway and Conneaut Groups (Rickard and Fisher, 1970). The bedrock-surface altitude, shown in figure 7, ranges from about 250 m about 1 km northeast of the main plant facilities to about 450 m east and west of the site along the flanks of the Buttermilk Creek valley. Depth to bedrock ranges from about 150 m in the deepest part of the bedrock valley to less than 1 m along the hillsides of Buttermilk Creek valley west of the plant. A test hole drilled by the U.S. Geological Survey about 200 m northeast of the main reprocessing plant encountered bedrock at a depth of about 75 m. Bedrock is exposed in the upland stream channels along Quarry Creek northwest of the site, in hilltops west and south of the site, and in the steep-walled gorges cut by Cattaraugus Creek to the north and by Connoisserauley Creek to the west (both off the map in fig. 7).

Climate

The climate of western New York State is classified as moist continental. Precipitation and temperature are typically a function of the type and direction of movement of air masses that pass over the region. Dry, cool air masses enter from Canada, and warm, moist air originates from the Gulf of Mexico. In southwestern New York, the weather is also affected by Lake Erie, which has a moderating effect on temperature and provides additional moisture to the air (Harding and Gilbert, 1968). Orographic effects of the area's topography further affect the precipitation pattern in this area.

Previous site operators collected meteorological data from 1963 to the present, but no long-term meteorologic data are available because most records are discontinuous and unreliable. Regional analyses of meteorological data by Dethier (1966) and Harding and Gilbert (1968) indicate that extreme temperatures in the West Valley area range from -35° to +35°C. The average annual temperature is 7.2°C; the lowest average monthly temperature is -5.7°C in February, and the highest average monthly temperature is 19.6°C in July. The frost-free period extends for approximately 110 days from late May through early September.

Average annual precipitation is approximately 105 cm/yr, and monthly precipitation is roughly equal throughout the year. Snowfall usually starts in early November, and the regional snowpack lasts through March.



Base from U.S. Geological Survey
Ashford Hollow, 1979 1:24,000

Figure 7.--Bedrock-surface altitude within the Western New York Nuclear Service Center.

Average annual evapotranspiration is approximately 48 cm. Evapotranspiration is greatest during June through August, approximately 10 cm/mo, and is minimal from December through March, aproximately 1 cm/mo.

SURFACE-WATER HYDROLOGY

Drainage-Area Characteristics

Surface runoff from the plant facilities drains to Franks Creek on the east and south side of the facility and to Quarry Creek on its northwest edge (fig. 8). Franks Creek (drainage area 6.32 km^2) drains into the upper third of the 80.0-km^2 Buttermilk Creek basin, which lies north of the site. Buttermilk Creek flows into Cattaraugus Creek (drainage area 1,450 km^2) near Springville, and Cattaraugus Creek flows to Lake Erie near Silver Creek (fig. 1).

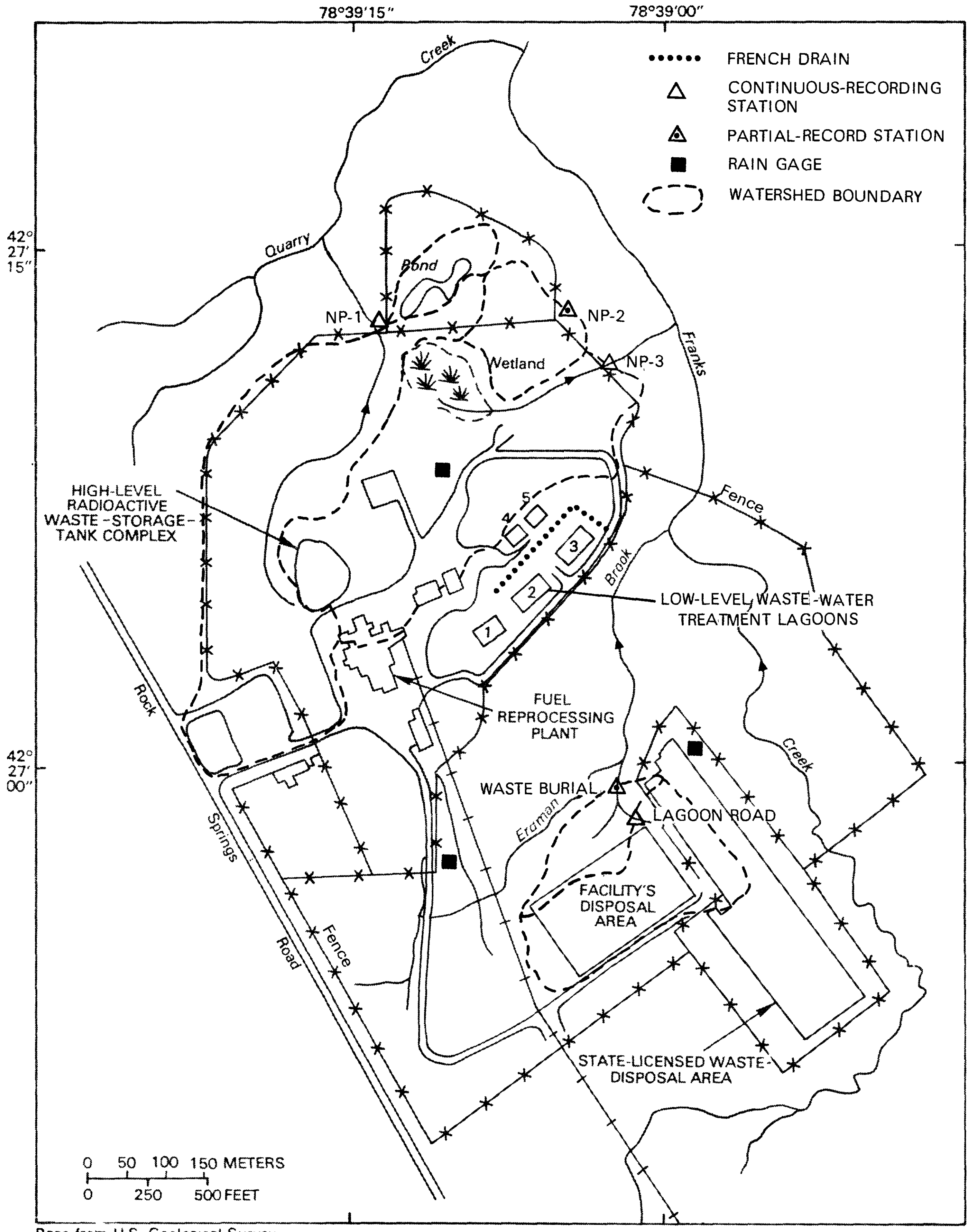
The quantity of surface water leaving the site was monitored between October 1980 and October 1983 at three gaging stations--Lagoon Road, north plateau 1 (NP1), and north plateau 3 (NP3). Locations and drainage areas of these stations are shown in figure 8. The Lagoon Road station receives flow from a 4.40-ha area, parts of which drain both burial areas. The NP3 station receives flow from a 9.83-ha area that lies between the reprocessing plant and a drained wetland area on the north plateau. The NP1 station receives flow from the western flank of the plateau, which has a drainage area of 10.4 ha.

Peak-flow data were also collected at a small drainage area designated as north plateau 2 (NP2). Before construction of the reprocessing facility and subsequent draining of the north plateau wetland, this channel carried a perennial stream. Its present surface watershed is 1.81 ha, but its flow is supported mainly by ground-water discharge. Eighteen ground-water seepage faces surrounding the north plateau were also monitored, generally during base-flow periods. (Descriptive data on these seepage faces are given in Appendix A.)

Streamflow Monitoring

Flow data from the NP1 and NP3 stations were obtained at streamflow-monitoring stations that were constructed on each stream channel. Each station was sheltered by a large enclosure spanning the width of the stream. Deep snow and ice had prevented collection of winter discharge data in previous years; therefore, these enclosures were heated to keep the measurement section free of snow and ice throughout the winter. A typical enclosure is illustated in figure 9.

A similar attempt to gage flow downstream from the Lagoon Road station at a site called Waste Burial 1 (fig. 8) with an enclosure was less successful because the channel was unstable (the clay soil under the enclosure alternately slumped and eroded from the measurement section); therefore, this station was discontinued. The station just upstream from the enclosure was operated for approximately 9 months each year. During mid-winter, generally December through mid-March, attempts were made to gage flows during periods of thaw or rain. Attempts to maintain the measurement section during the spring thaw period were marginally successful.



Base from U.S. Geological Survey
Ashford Hollow, 1979 1:24,000

Figure 8.--Tributary streams to Franks Creek and drainage-area boundaries above streamflow-monitoring stations.

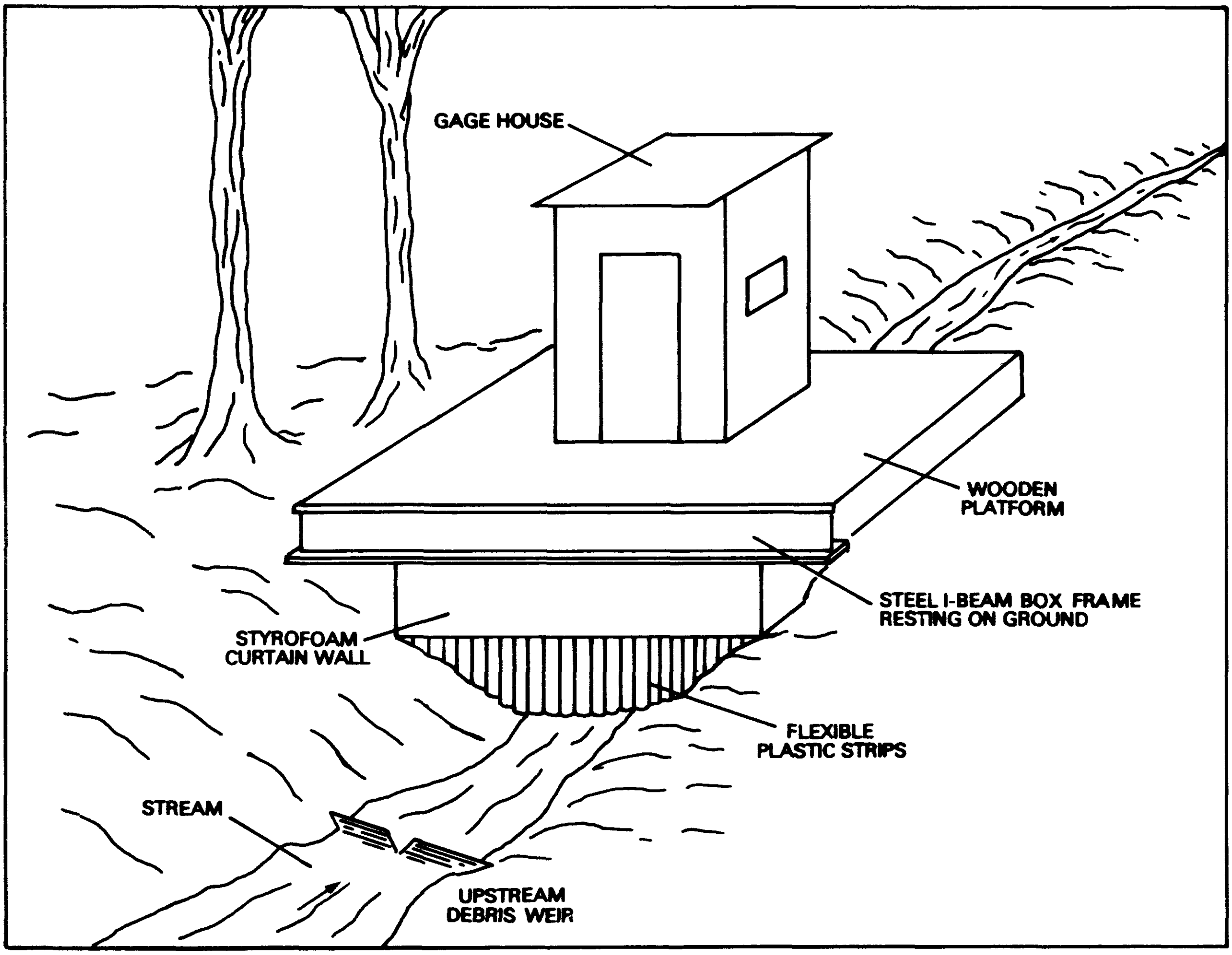


Figure 9.--Schematic diagram of streamflow-monitoring station enclosure used at north plateau stations 1 and 3.

Flow Characteristics

Lagoon Road

Flow measured at the Lagoon Road station responded quickly to most rainstorms and generally returned to near prestorm conditions within several hours after precipitation ended. During 1981-83, average flow at Lagoon Road was 0.675 x 10^{-3} m^3/s. The highest daily recorded flow was 28.3 x 10^{-3} m^3/s on March 17 and September 2, 1982, and the stream was dry for approximately 60 days during each summer.

North Plateau

In contrast to the Lagoon Road site, the north plateau streams were not highly responsive to rainfall, and base flow rarely ceased. At the NP1 site (fig. 8), average daily recorded flow was 1.30 x 10^{-3} m^3/s. Maximum recorded flow was 31.2 x 10^{-3} m^3/s on November 4, 1982, and the stream was dry for a few days during each summer (1981-83). The NP3 site had higher average daily flow of 2.48 x 10^{-3} m^3/s, with a maximum daily recorded flow of 28.3 x 10^{-3} m^3/s on March 13, 1982 and a minimum daily recorded flow of 0.113 x 10^{-3} m^3/s for several days during July and August 1981.

Streamflow data for the NP2 site were derived from stage readings from a staff and crest-stage gage. The average flow, based on correlation of 44 staff-gage readings to the records of stations NP1 and NP3, was 0.340 x 10^{-3} m^3/s. Maximum recorded flow was 1.98 x 10^{-3} m^3/s, during the spring of 1983; no flow was observed on July 9, 1982.

Flow monitoring at 18 seepage (ground-water-discharge) sites was added to the surface-water-monitoring network in 1983. Measurements were made during March, July, and October 1983 during base-flow periods (appendix A). Results of these measurements indicated that approximately 73 percent of the flow leaving the plateau during nonstorm periods flowed past the NP1 and NP3 gages; the remaining 27 percent was discharged from seepage faces and flowed directly to Quarry Creek, Erdman Brook, or Franks Creek, bypassing the gaging stations. The major seepage-discharge point was a french-drain system constructed to eliminate seepage of ground water into Lagoons 2 and 3 (fig. 8). The highest concentration of seeps is between the NP3 site and the french drain on the northeast side of the plateau.

GROUND-WATER HYDROLOGY

From 1980 to July 1983, the U.S. Geological Survey drilled 41 test holes to provide geologic and hydrologic information in the area of the fuel-reprocessing plant and the facility's disposal site. Locations of the test holes and previously drilled test holes are shown in plate 1. In all test holes except 80-10, wells or piezometers were installed to monitor water-level changes to define spatial head relationships and to determine patterns of ground-water flow from water-table and potentiometric-surface maps. Records of each test hole and piezometer are given in table 1. Water-level altitudes measured from January 19, 1981 through May 22, 1984 are given in appendix B.

Ground-Water on the North Plateau

Recharge

Some of the precipitation on the north plateau drains from the area through small drainage channels; the rest infiltrates downward to recharge the ground-water system. Ground water also enters the plateau as underflow along the upland boundary southwest of the plant. Preliminary results from a two-dimensional finite-difference model that simulates ground-water flow through the surficial gravel indicates the recharge rate to be 40 to 50 cm/yr. Although some water infiltrates downward into the underlying till, most of it moves laterally in the surficial gravel to points of discharge.

Ground-Water Movement in Surficial Sand and Gravel

Water levels in 10 U.S. Geological Survey wells and 15 other wells were measured periodically to monitor changes and to evaluate the direction of

Table 1.--Records of wells drilled by U.S. Geological Survey, 1980-83

Well number	Location Lat. ° ' "	Location Long. ° ' "	Land-surface elevation (m)	Measuring-point elevation (m)	Depth of well (m)	Screen interval (m)	Depth of casing (m) AW[1]	Depth of casing (m) BW[2]	Depth of casing (m) NW[3]	Hydrologic unit	Remarks
80-1	42 27 00	78 39 21	433.66	434.42	7.01	426.652-429.70	--	--	--	Sand & gravel	
80-2	42 27 03	78 39 23	435.01	435.29	4.26	430.749-432.27	--	--	--	do	
80-3	42 27 13	78 39 17	420.87	421.33	1.82	419.042-419.65	--	--	--	do	
80-4	42 27 11	78 39 11	421.02	421.45	3.04	417.947-419.47	--	--	--	do	
80-5	42 27 12	78 39 14	417.84	418.55	4.26	413.577-416.92	--	--	--	do	
80-6	42 27 09	78 39 03	420.13	421.04	4.26	416.167-416.77	--	--	--	do	
80-7	42 27 01	78 39 09	424.50	425.21	1.82	422.675-423.58	--	--	--	do	
80-8	42 26 56	78 39 19	431.83	432.67	6.40	425.433-428.48	--	--	--	do	
80-9	42 26 51	78 39 16	425.97	426.58	6.09	no screen	--	6.10	--	Till	
80-10	42 26 45	78 39 13	426.87	--	12.71	--	12.71	9.14	--	--	Hole plugged
82-1A	42 26 49	78 39 02	421.09	421.50	5.85	415.268-415.87	--	--	1.11	Till	
82-1B	42 26 49	78 39 02	420.99	421.59	10.66	410.358-410.96	--	--	.92	do	
82-1C	42 26 49	78 39 02	420.91	421.75	15.30	405.762-406.37	--	14.78	8.68	do	
82-1D	42 26 49	78 39 02	420.99	421.91	29.87	391.058-391.66	29.32	26.21	15.69	Sandy silt (lacustrine)	
82-2A	42 26 47	78 39 04	422.71	422.84	6.76	415.488-416.09	--	--	1.38	Till	
82-2B	42 26 47	78 39 04	422.70	423.17	11.88	410.568-411.17	--	--	1.05	do	
82-2C	42 26 47	78 39 04	422.68	423.26	15.30	407.441-408.05	--	14.93	7.46	do	
82-3A	42 26 49	78 39 08	423.45	423.88	5.82	417.634-418.24	--	1.09	--	do	No water in well
82-3B	42 26 49	78 39 08	423.45	424.11	11.12	412.483-413.09	--	--	--	do	do
82-3C	42 26 49	78 39 08	423.45	424.41	15.27	408.459-409.06	--	14.63	8.53	do	do
82-3D	42 26 49	78 39 08	423.45	420.67	30.78	392.604-393.21	30.17	24.38	15.24	Sandy silt (lacustrine)	
82-4A	42 26 52	78 39 08	421.92	422.56	4.57	417.448-418.05	--	--	.88	Till	
82-4A2	42 26 52	78 39 08	422.33	423.00	--	--	--	--	--	do	
82-4A3	42 26 52	78 39 08	422.63	423.33	--	--	--	--	--	do	
82-4B	42 26 52	78 39 08	421.92	422.66	10.97	410.956-411.56	--	--	.78	do	
82-4C	42 26 52	78 39 08	421.98	422.91	15.81	406.43-407.048	--	15.24	8.53	Till	
82-5A	42 26 53	78 39 04	420.10	420.47	6.21	413.94-414.555	--	--	1.15	do	
82-5B	42 26 53	78 39 04	420.10	420.56	13.56	406.60-407.209	--	--	1.05	do	
82-5C	42 26 53	78 39 04	420.10	420.66	15.42	404.95-405.564	--	14.84	8.53	Till	
83-1D	42 26 48	78 39 14	425.28	425.70	18.44	408.21-408.828	16.45	17.06	7.62	Sandy silt	
83-1E	42 26 48	78 39 14	425.28	425.74	20.42	--	--	18.47	1.06	Shale bedrock	Open hole below 18.47 m
83-2D	42 26 46	78 39 09	424.61	425.63	25.90	399.01-399.623	24.993	--	.51	Sandy silt	
83-2E	42 26 46	78 39 09	424.61	424.92	30.78	--	28.651	--	.91	Shale bedrock	Open hole below 28.651 m
83-3E	42 26 49	78 39 11	420.50	420.65	26.51	394.59-393.984	25.908	--	.91	Sandy silt	
83-A1	42 27 15	78 39 06	417.6*	420.42	4.99	412.6 -413.2*	--	--	--	Sand and gravel	
83-A2	42 27 15	78 39 12	419.5*	417.79	4.63	414.9 -415.6*	--	--	--	Sand and gravel	
83-4D	42 27 22	78 39 11	421.02	421.81	--	-- --	--	--	--	Shale bedrock	Open hole below 74.6 m; 12-in casing to 7 m; 10-in casing to 40 m; 6-in casing to 74.6 m
83-4E	42 27 11	78 39 11	421.02	421.38	75.28	-- --	--	--	--	--	

1 AW = Flush joint steel casing ID 4.842 cm, OD=5.715 cm
2 BW = Flush joint steel casing ID 6.032 cm, OD=7.302 cm
3 NW = Flush joint steel casing ID 7.620 cm, OD 8.890 cm

* Estimated from topographic map.

ground-water flow. Water-table contours and ground-water altitudes measured on May 10, 1983 are depicted in figure 10; the contours indicate that ground water flows from an area southwest of the fuel-reprocessing facilities to lower areas northeast, east, and southeast of the plant. The saturated thickness of the surficial sand and gravel deposit, shown in figure 11, ranges from less than 1 m to 5.5 m.

Some ground water discharges to wetland areas and ponds northeast of the plant, where it is lost by evapotranspiration; the remainder appears as base flow in small channels or as seepage at gravel and till contacts on steep streambanks adjoining the north plateau. This generalized flow pattern is illustrated in the cross-sectional view in figure 12.

Depth to water fluctuates throughout the year in response to seasonal variations in recharge and discharge. Annual hydrographs of observation wells 80-4 and 80-8 (fig. 13) indicate that water-table fluctuations range from 1 to 2 m/yr. Water levels are normally lowest in the mid- to late winter and are highest in mid- to late spring in response to recharge from snowmelt.

Influence of Plant Facilities on Ground-Water Flow

Plant facilities influence the pattern of ground-water flow locally by creating barriers to flow in some areas and providing preferential discharge areas in others. Part of the reprocessing-plant facilities and the high-level-waste-tank complex completely penetrate the surficial gravel and divert ground water around these areas.

Five lagoons have been constructed on the site as part of a low-level-radioactive-wastewater-treatment facility, but only lagoon 1 penetrates the surficial gravel. The lagoon is hydraulically connected to the ground-water system, so that water flows both into and out of the lagoon. However, the lagoon causes a net loss of ground water through evaporation and overflow into lagoon 2 and thus represents a ground-water discharge point. Lagoon 1 was removed from the wastewater-treatment system in 1985.

Lagoons 2 and 3 are both excavated into the till beneath the surficial gravel, and water levels within these lagoons are normally below the contact between gravel and till. Lagoons 4 and 5 are finished in the surficial gravel, but both are lined to prevent leakage.

Most ground water from the north plateau discharges to a large wetland area that drains into the channel above station NP3 (fig. 8 .) A significant volume of ground water also discharges to a subsurface french drain (shown in fig. 8) that was designed to reduce ground-water leakage into Lagoons 2 and 3. The french drain discharges to Erdman Brook.

An outfall channel from the plant crosses the surficial gravel adjacent to Lagoon 1; it carries condensation from the steam plant and backwash from water filters to an unnamed tributary of Erdman Brook (fig. 8). Preliminary results from the simulation model indicate that water from the outfall channel probably recharges the surficial gravel during periods when the water table is low and that the channel receives ground water when the water table is seasonally high. Thus, flow within the channel maintains a fairly constant water level in the surrounding area.

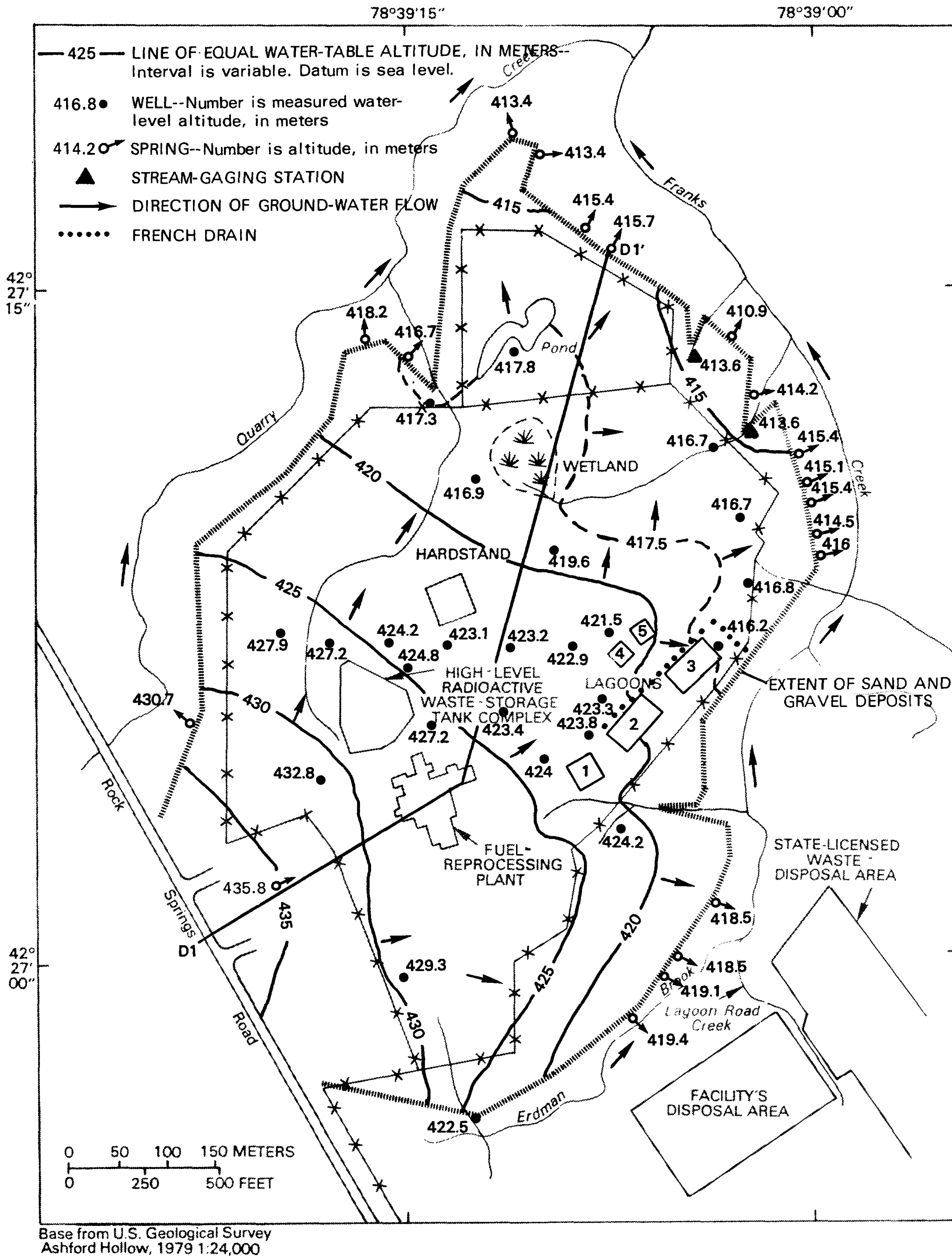
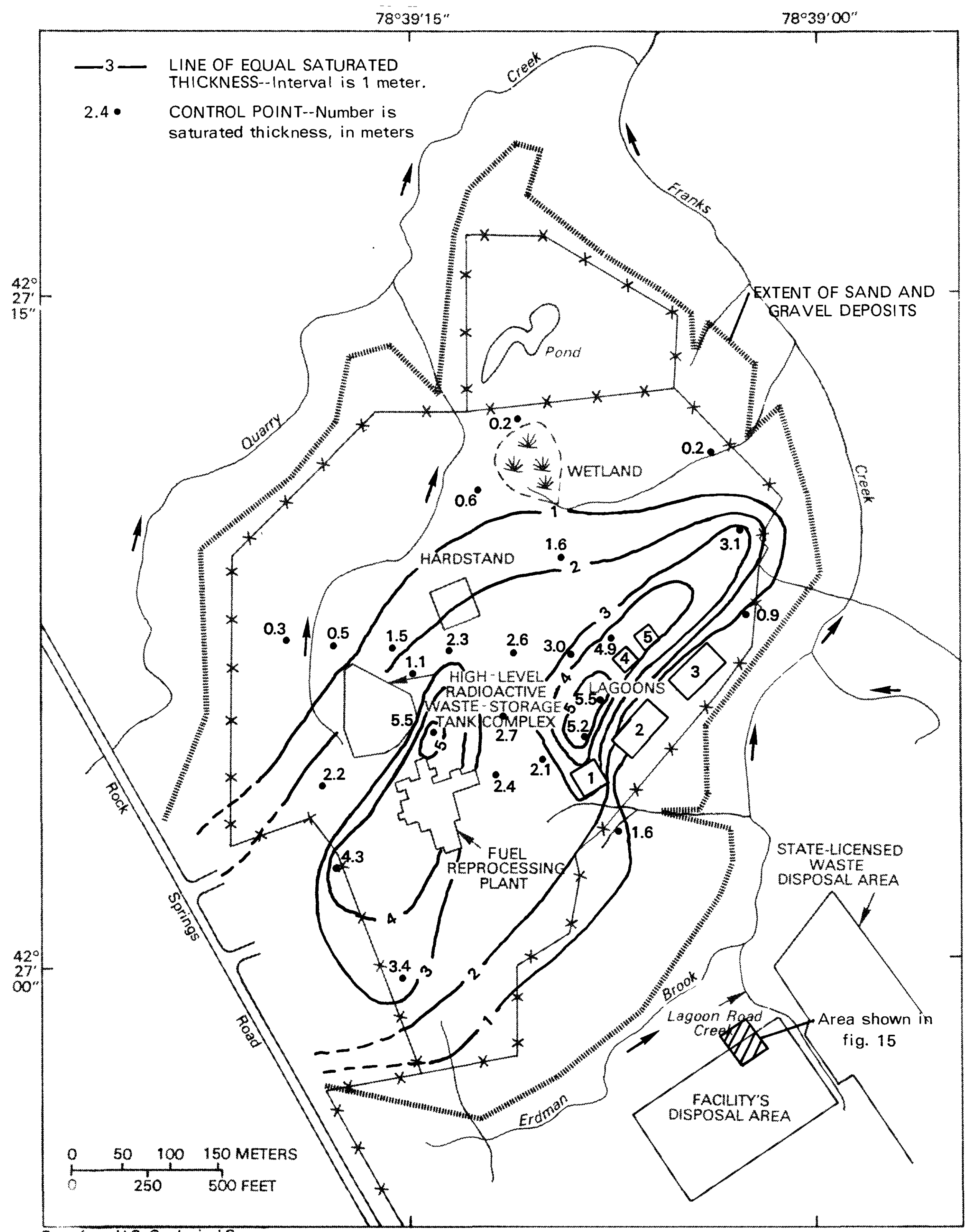


Figure 10.--Water-table altitude and direction of ground-water flow in the north plateau area on May 10, 1983.



Base from U.S. Geological Survey
Ashford Hollow, 1979 1:24,000

Figure 11.--Saturated thickness of surficial sand and gravel in the north plateau area on May 10, 1983.

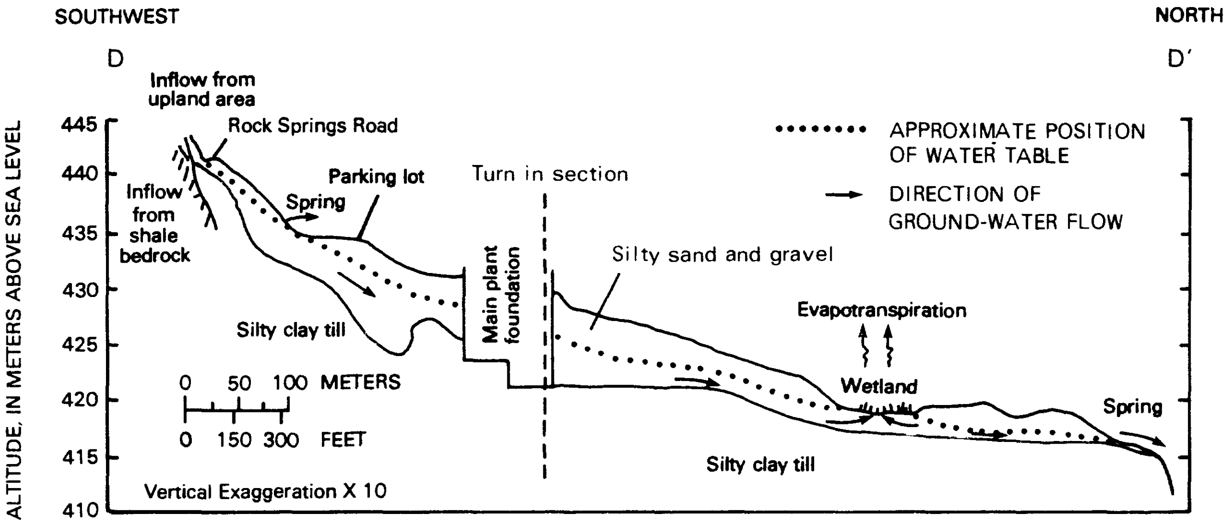


Figure 12.--Generalized geologic section of the surficial gravel deposit on the north plateau. (Location of section is shown in fig. 10.)

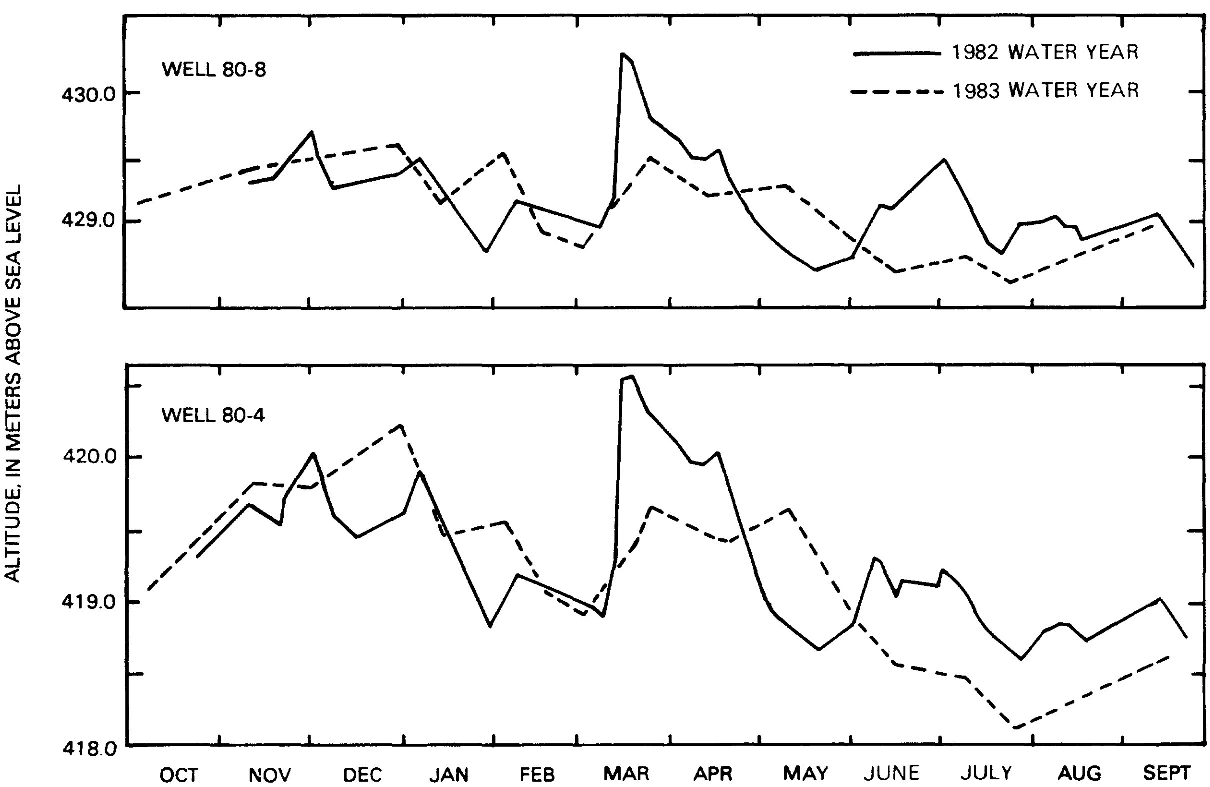


Figure 13.--Hydrographs of wells 80-8 and 80-4 on the north plateau, 1982-83. (Well locations are shown in pl. 1.)

Ground-Water Discharge

Total measured ground-water discharge from the north plateau on three separate days in 1983 are presented in table 2. These flows were measured at gaging stations NP1 and NP3 and at 19 seepage faces. The measurements of March 3 and July 5 were made during base-flow conditions with negligible surface runoff. The measurements of October 6 reflect 2.4 cm of rain that fell during the preceding hours and produced significant runoff at station NP1.

Seasonal variation in discharge (table 2) parallels the water-table trends shown in figure 11. The highest annual water levels generally occur in the spring after snowmelt and seasonal precipitation and produce the largest ground-water discharges. Water levels decline during late spring and are lowest in July, when evapotranspiration is greatest. Ground-water discharges decrease nearly 70 percent during summer. Flow from the buried french drain near lagoons 2 and 3 remains fairly constant, however, because the saturated thickness in that part of the north plateau is sufficient to maintain discharge throughout the year. Increased recharge in the fall causes the water table to rise, and ground-water discharge increases through December. Then, as low temperatures and freezing of the ground begin to limit recharge, discharge decreases until spring.

Table 2.--Ground-water discharge from the north plateau, 1983

[Values are in liters per second. Locations are shown in figure 8.]

Discharge point	3-3-83	7-5-83	10-6-83
NP 3	1.76	0.60	1.56
NP 1	.37	.03	.62
French drain	.29	.22	.31
Seepage flow	.38	.09	.40
Total	2.80	.94	2.89

Hydraulic Conductivity of Surficial Gravel

The horizontal hydraulic conductivity of the surficial gravel was estimated from slug tests on eight wells screened throughout the saturated thickness of the gravels. Slug-test data were analyzed through a type-curve method described by Cooper and others (1967) that assumes horizontal flow to the perimeter screen. Although the method was developed for wells tapping confined aquifers, it applies also to the unconfined surficial gravel because the variation in saturated thickness during the tests was small.

The Cooper method requires semilogarithmic plots of H/H_0 against time (t), where H_0 is the decline of the water level immediately after injection, and H is the water level at some time, t, after injection. The plots were compared to a family of type curves presented in Cooper and others (1967) to estimate transmissivity. The horizontal hydraulic conductivity was then calculated by dividing the transmissivity by the saturated thickness. A sample plot and calculation for well 80-8 is given in figure 14. Values of horizontal hydraulic conductivity estimated from the slug-test data (table 3) range from 0.11 to 7.9 m/d. These values are comparable to the soil permeability of 1 to 4 m/d on the north plateau derived by Pearson and others (1940).

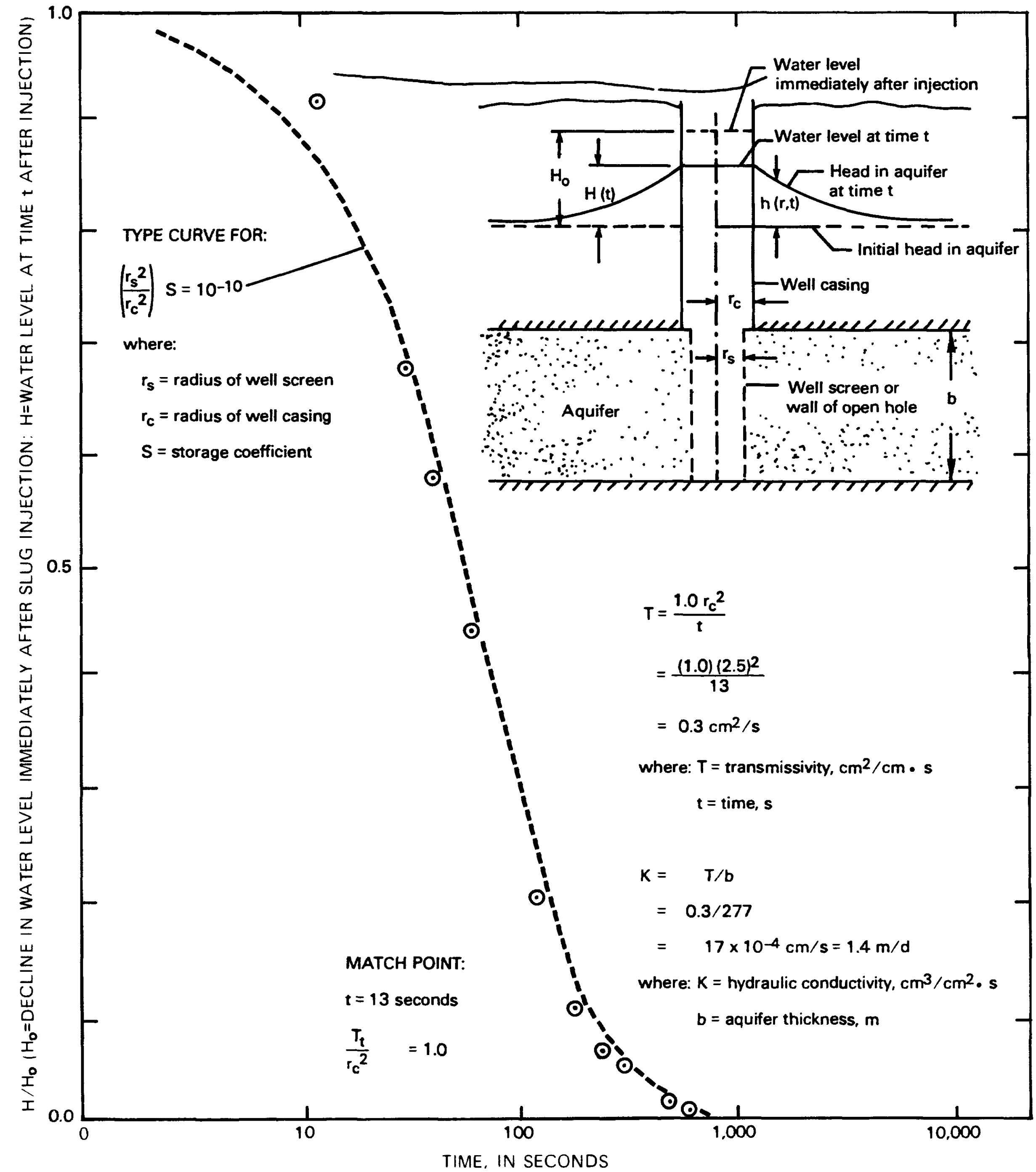


Figure 14.--Calculation of hydraulic conductivity from slug-test data from well 80-8, by method of Cooper (1967).

Table 3.--Hydraulic conductivity of surficial gravel on the north plateau calculated from slug-test data by method of Cooper and others (1967).

[Well locations are shown on pl. 1.]

Well number	Hydraulic conductivity (in m/d)	Saturated thickness (m)
80-1	2.5	4.5
80-2	0.22	2.5
80-3	7.9	1.0
80-4	0.19	1.6
80-5	0.22	3.3
80-6	0.11	0.8
80-7	0.38	0.6
80-8	1.5	2.8
Geometric mean	0.57	

Ground-Water in the Burial-Ground Areas

Most precipitation falling near the burial areas runs off into nearby streams or is lost through evapotranspiration. The remainder percolates downward to the silt-clay till, the host material of the buried wastes. The till contains a shallow system where flow is predominantly lateral, and a deeper system in which flow is mainly vertical.

Ground-Water Movement

Shallow Till.--Recent evidence from areas near the facility's waste-burial site suggests a strong potential for lateral migration in the shallow (3 m to 4 m thick), highly fractured, weathered, and oxidized till zone. In December 1983, kerosene containing an organic solvent, tributylphosphate, was detected in a shallow observation well (82-5A) on the north side of the disposal area (fig. 15). During the ensuing months, the site operator (West Valley Nuclear Services, Inc.), under contract to the U.S. Department of Energy, did several studies to identify the substance and its source and to delineate the extent of migration. Radiochemical analysis confirmed the presence of radioisotopes in the solvent. Results of these investigations indicate that the organic liquid originated from one or more burial pits (SH-10 and SH-11) nearly 18 m away that contained fluid of similar composition. The kerosene was detected mostly at depths of 3 to 4 m within the fractured, weathered, oxidized till. The pits containing the solvent are about 10 m deep and were filled about 1970. The extent of solvent migration in 1983 is depicted in figure 15.

Deeper Till.--A total of 14 piezometers were installed in test holes at various depths adjacent to the facility's waste-disposal area (fig. 16) to monitor water-level changes and to delineate the pattern of ground-water flow within the deeper, unweathered till and in underlying materials. An east-west cross section through the facility's disposal area and the north trenches of the State-licensed disposal area (fig. 17) shows the distribution of head and patterns of ground-water flow as indicated by water-level measurements made on

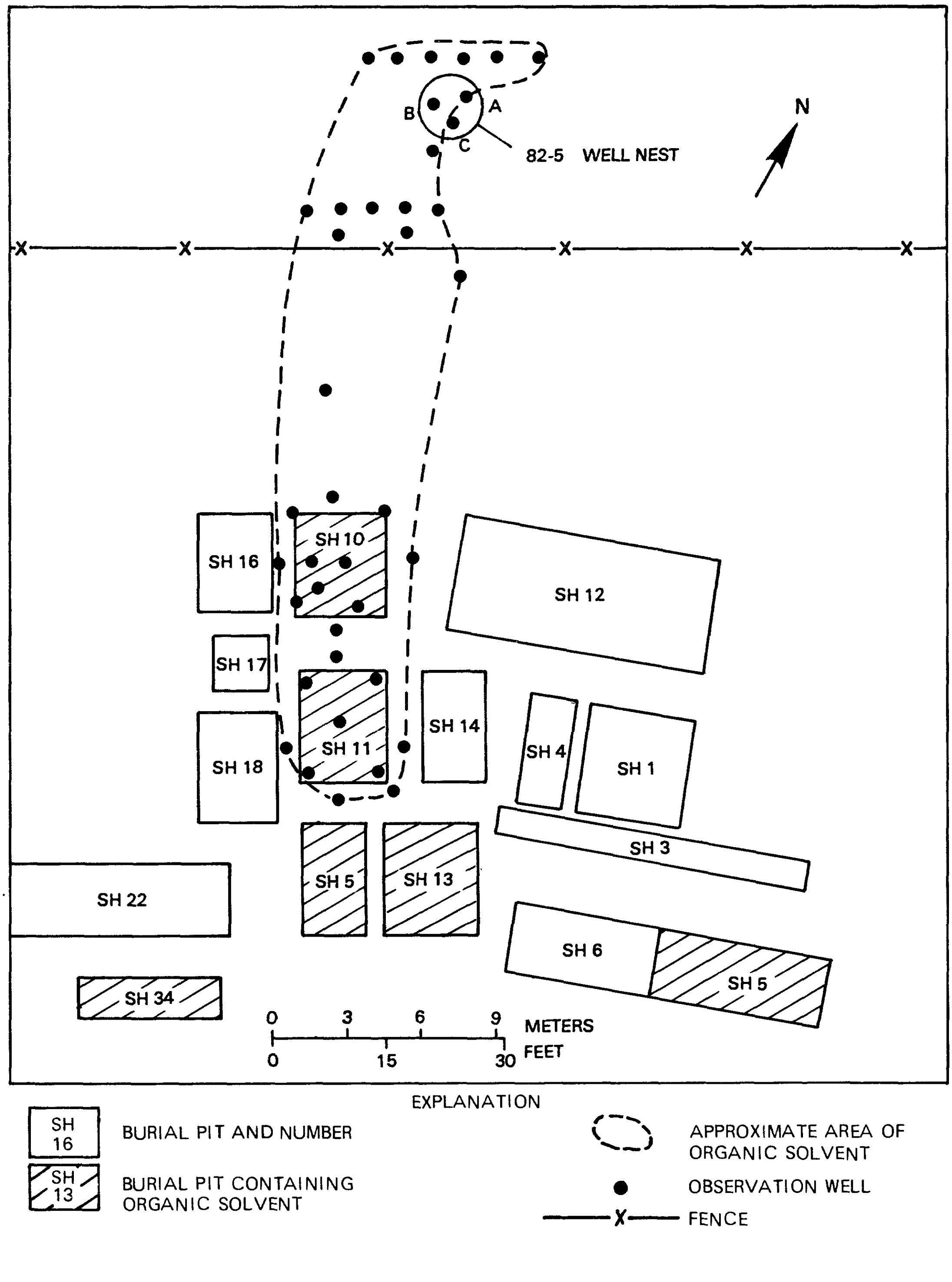


Figure 15.--Approximate extent of solvent migration in 1984 from the facility's waste-disposal area. (Location is shown in fig. 11.)

May 10, 1983. In general, ground water moves vertically downward through the 22- to 28-m-thick sequence of till, even beneath small stream valleys along the cross section (fig. 17), where a small amount of discharge was expected. The head distribution at the facility's disposal area reflects water levels measured in piezometers along the sides of the burial ground and presumably shows a natural pattern of flow unaffected by burial pits. No information is available on the hydraulic connection between the flow system and the burial pits.

Data from some piezometers installed adjacent to the facility's disposal area support Prudic and Randall's conclusions (1979, p. 859) that unsaturated conditions within the Lavery Till are found not only in the thin, narrow zone of unsaturated sediment between land surface and the water table. West of the facility's burial ground, piezometers between depths of 6.1 and 16.2 m in holes 82-3A, 82-3B, and 83-3C (fig. 16) have never contained water since their installation. Prudic and Randall (1979) cited similar conditions in piezometers between 5.5- and 14-m depths in holes L and Q west of trench 14 at the State-licensed waste-burial ground. The area near the 82-3 nest of piezometers (fig. 16) is routinely traveled over and scraped by heavy equipment that has formed a compacted surface with little vegetation. This type of surface would encourage rapid runoff of rainfall and would reduce infiltration and could thus explain the absence of saturation at depth.

Neutron-moisture profiles from till near the 82-3 nest of piezometers and in saturated till near the 82-1 nest of piezometers south of the facility's disposal area (appendix C) show a 0- to 10-percent moisture content in the nonwater-yielding till, compared to a 20- to 35-percent moisture content of the saturated till. The presence of moisture in the nonwater-yielding till indicates, as Prudic and Randall (1979, p. 859) suggested, that pressure head in this area is negative but may approach zero. This interpretation is reflected by the dashed equipotential lines in figure 17.

Below the Till.--Water moving downward through the till from the burial grounds eventually reaches the underlying lacustrine fine sand and silt. Data from eight test holes near the higher level and the low-level-waste disposal areas indicate that the upper sandy part of the lacustrine sequence is not water yielding. Neutron-moisture profiles (appendix C) of four boreholes (83-1E, 83-2E, 82-3D, and 82-1D) suggest minor levels of saturation, which indicates that pressure heads are less than or close to zero through this sequence. Water levels in piezometers completed in saturated silt and clay at the base of the unit (fig. 18) suggest a small lateral gradient (0.023 m/m) northeastward toward Buttermilk Creek. Although no major springs are evident in outcrop areas along Buttermilk Creek, Prudic and Randall (1979, p. 861) suggested that either ground-water discharge may be large enough to cause soil creep but too small to carry away slumped and landslide material that mantles the outcrop slope, or that the discharge occurs chiefly where the unit dips to creek grade some distance to the north.

Head data collected during drilling of bedrock test hole 83-4E, 200 m northeast of the main plant (fig. 19), suggest that part of the water entering the saturated silt and fine sand may continue downward to recharge lower glacial deposits and the bedrock in an area northeast of the main plant building. However, this flow pattern has not been verified in other areas of the plant facilities because no information is available on heads within the lower sequences of glacial deposits.

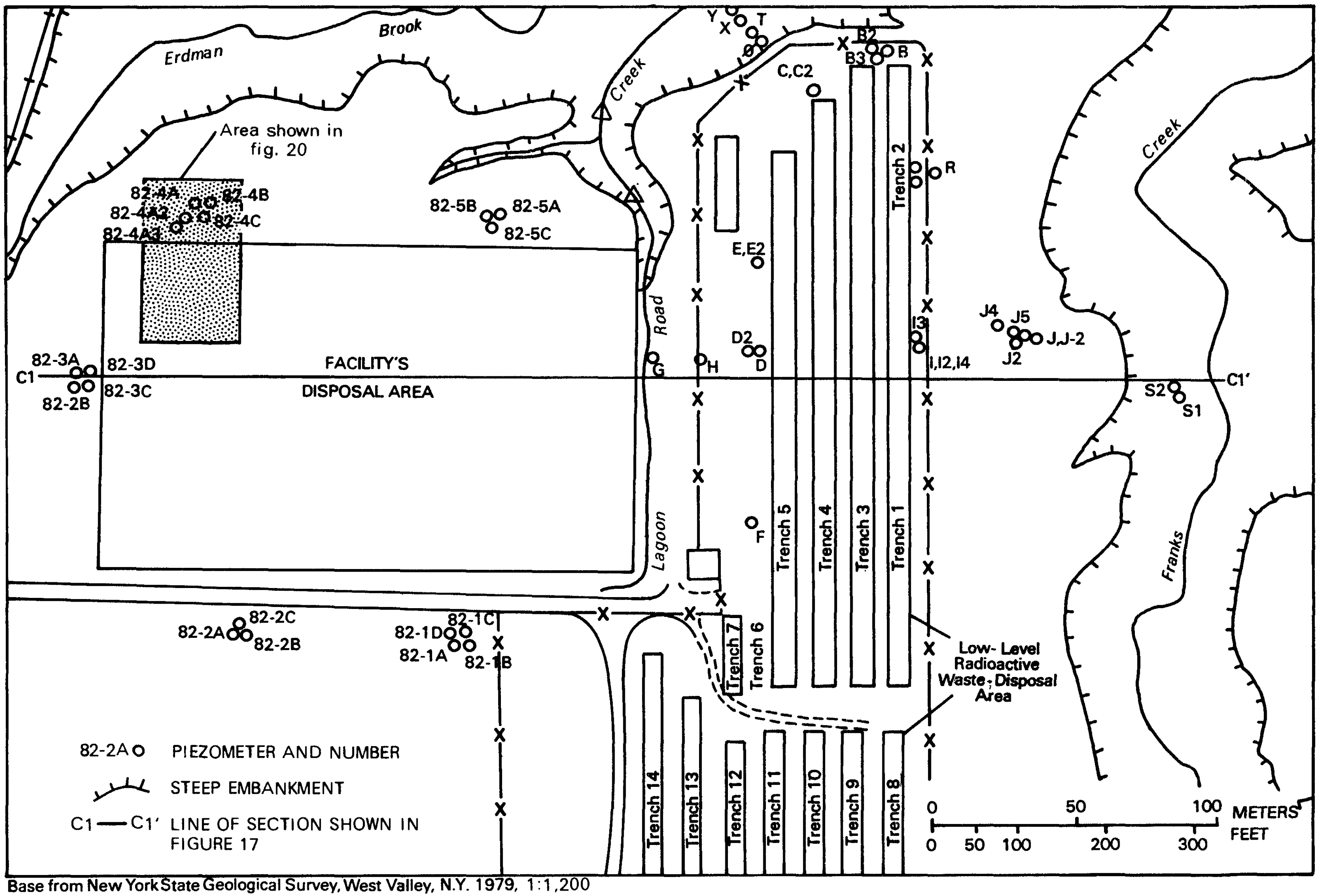


Figure 16.--Location of piezometers installed adjacent to the facility's disposal area.

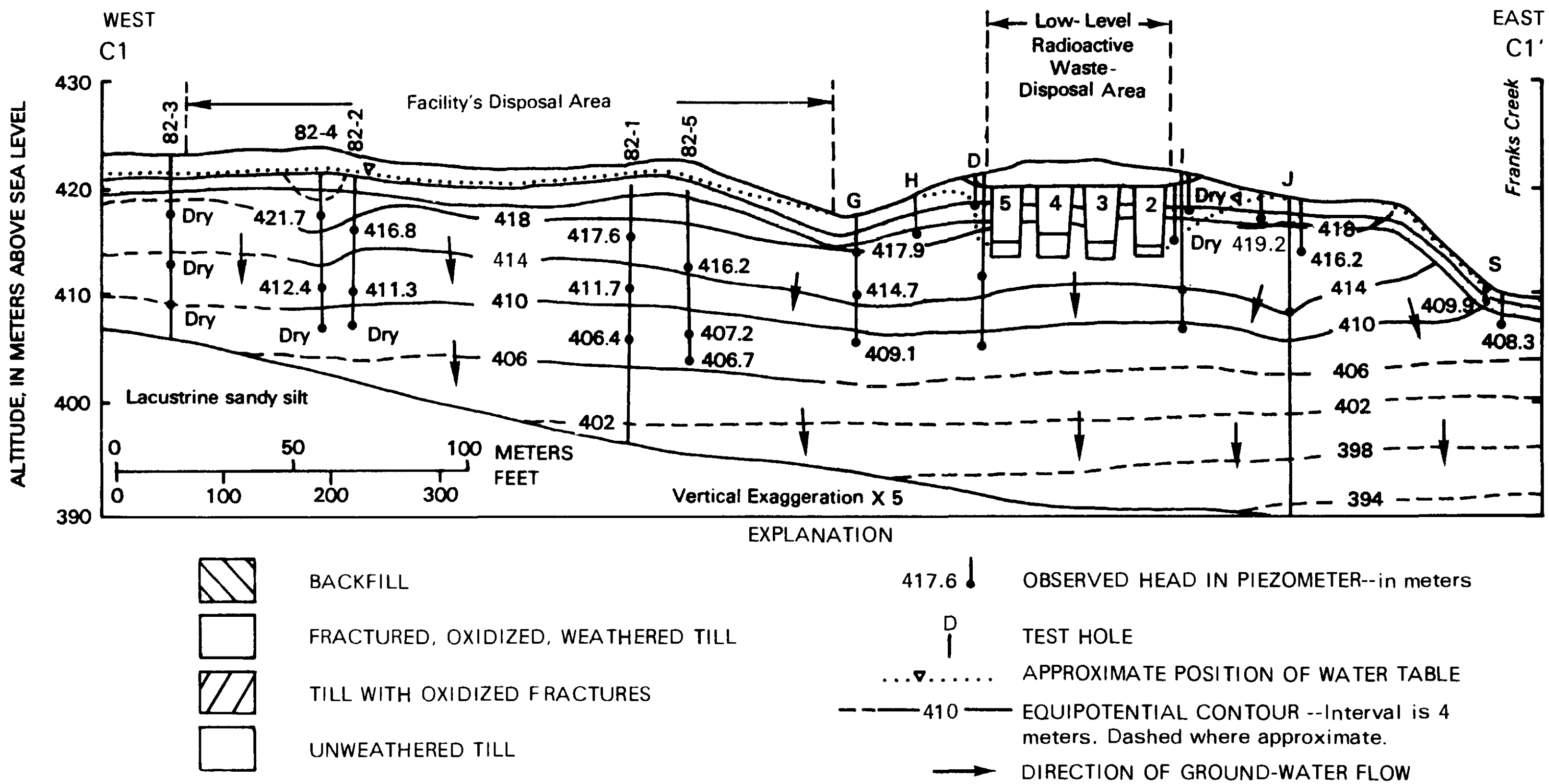


Figure 17.--Distribution of head and directions of ground-water flow in cross section through facility's disposal area and north trenches of the State-licensed waste-disposal areas on May 10, 1983. (Location of section is shown in fig.

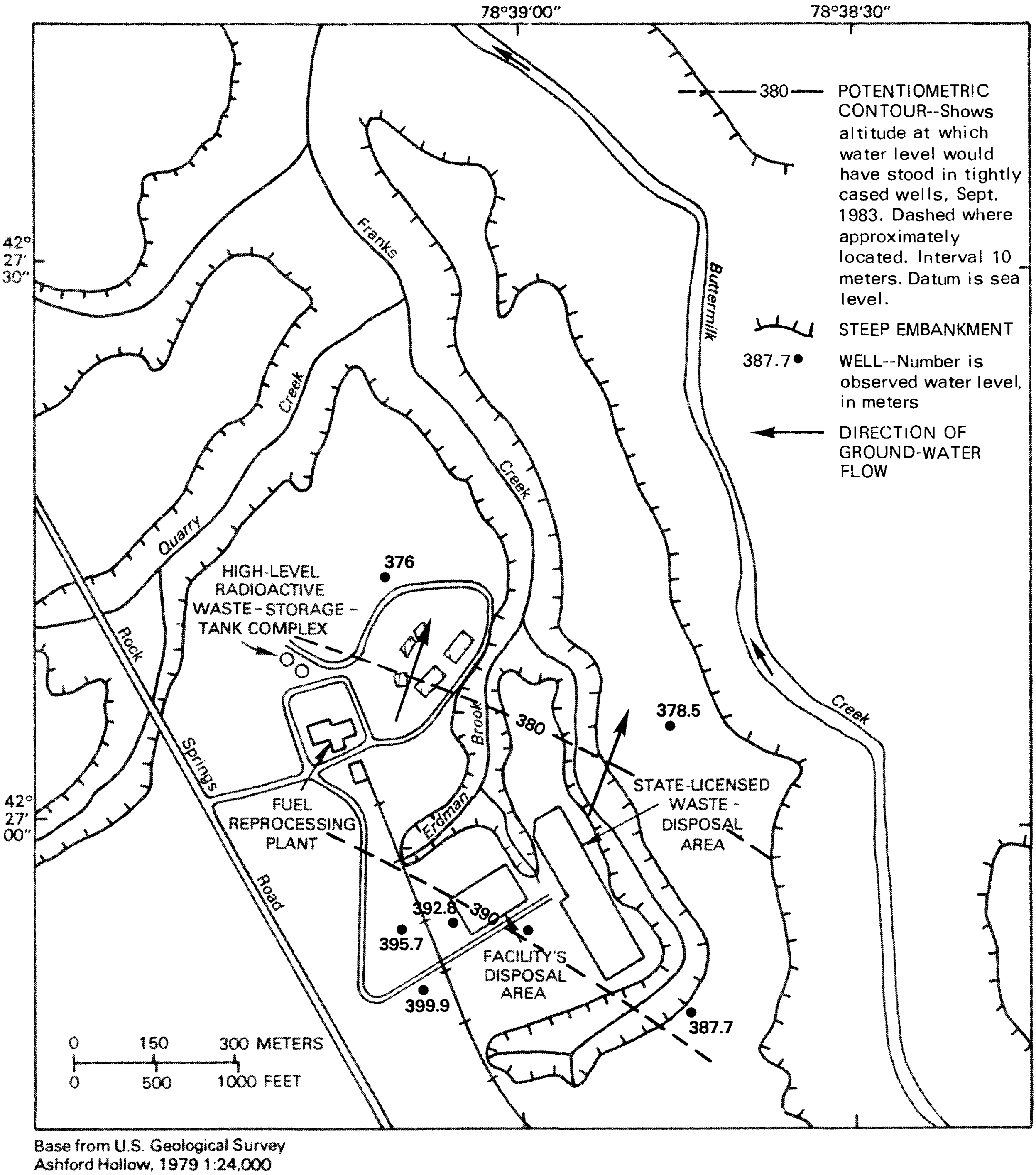


Figure 18.--Distribution of head within the lacustrine unit in September 1983.

Infiltration of Rainwater into Burial Pits

Rapid water-level rises were recorded in sumps in the north trenches and trench 14 of the low-level waste-burial ground during 1974 and 1975, which suggested that rainfall was infiltrating directly through cracks and fractures in trench covers. Cap failure was attributed to wetting and desiccation of cap

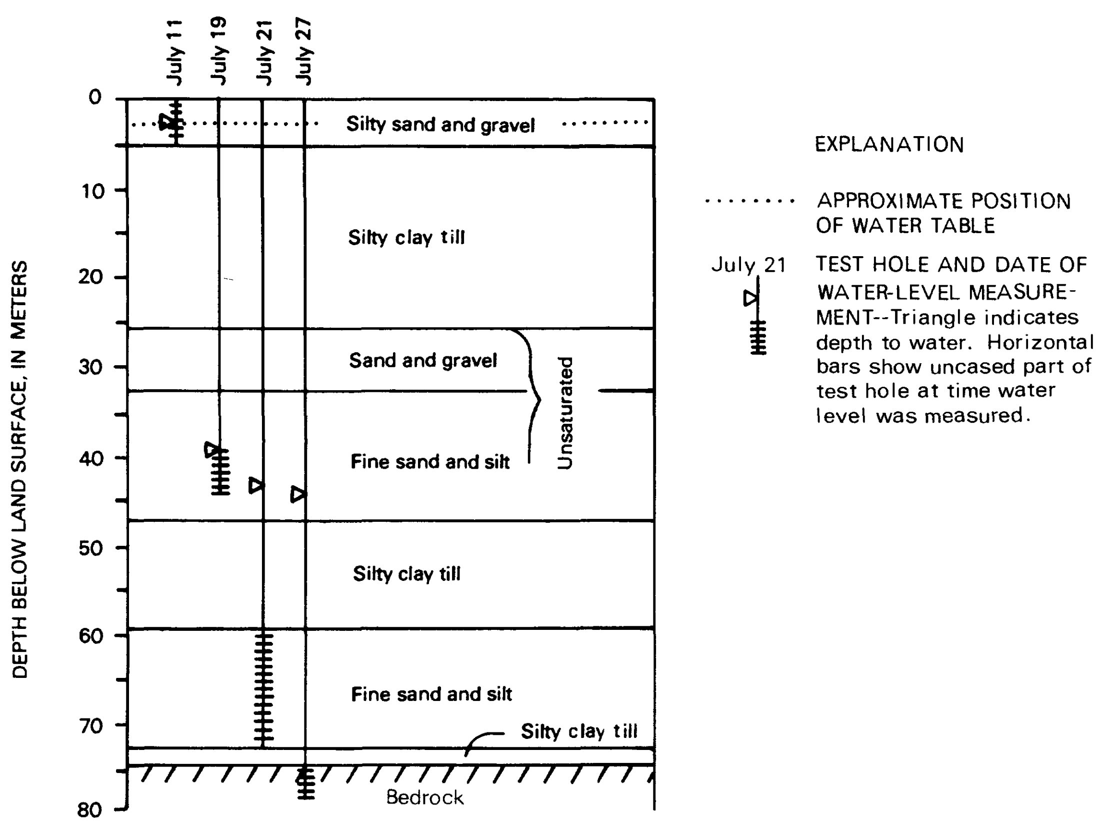


Figure 19.--Schematic diagram of head relationships in bedrock test hole 83-4E, July 1983. (Location is shown on pl. 1.)

material, coupled with collapse and compaction of decaying refuse and waste containers below. Overflow of trench water at the north ends of trenches 4 and 5 subsequently led the site operator to voluntarily close the burial operations in February 1976. Although burial pits within the facility's waste-disposal area are smaller than trenches in the State-licensed waste-burial ground, the capping material and procedure used were similar to those used in the north trenches of the latter, which suggests a potential for infiltration.

The most significant evidence of burial-pit cap failure and rainwater infiltration in the facility's disposal area is the migration of organic solvent in the shallow till flow system, described earlier. The solvent contained in burial pits SH-10 and SH-11, the probable sources of the solvent, was mixed with absorbant material and stored in steel tanks. Burial records indicated that the tanks were buried at depths between 5 and 10 m. The solvent migration from the pits was found at depths 1 to 2 m above the minimum (5 m) burial depth, or 3 to 4 m below land surface. This suggests that solvent leaked out the steel tanks, and the heavier rainwater, infiltrating through pit-cap material, partly filled the burial pits and displaced the solvent upward to less than 4 m below land surface. Once raised to this depth, the solvent migrated laterally through the fractured, weathered, oxidized till zone.

Other evidence of preferential infiltration of rainwater was found at a series of boreholes (82-4 series, fig. 16) drilled adjacent to the facility's waste-disposal area along its northwest border. A 15-m borehole (82-4C) in this area, drilled with continuous coring, indicated a general lack of permeable or water-bearing materials in the sequence of till penetrated. During the drilling of a hole approximately 1.5 m northwest of the original 15-m hole (borehole 82-4A) to install a piezometer at a shallower depth, a water-bearing zone was encountered at a depth of about 3.6 m that produced an anomalous pressure head of about 3 m. Borehole 82-4A was evacuated on several occasions and, in each instance, water levels in the piezometers recovered rapidly, which suggests that the piezometer was tapping a significant water-bearing zone.

Investigation of burial records indicated that an access ramp was excavated in the vicinity of hole 82-4A to lower a large dissolver tank into burial pit SH-9 (fig. 20). The ramp was subsequently covered with reworked fill. The approximate location of the ramp and of borehole 82-4A, also shown in figure 20, suggest that the borehole penetrated the ramp. Borehole and water-level data indicate that the material at the base of the buried ramp has become saturated. Lack of saturation in boreholes adjacent to the ramp suggest that the fill material, owing to its relatively high permeability, has preferentially allowed rainfall into the buried ramp. Water in borehole 82-4A at a depth of about 3.5 m originated at the contact between the disturbed material that fills the ramp area and the undisturbed till at a depth of about 3.5 m. Evidence from two additional holes, 82-4A2 and 82-4A3, hand augered to 3- and 5-m depths, respectively, south of hole 82-4A in the ramp area, indicate that the depth of the contact between reworked fill and undisturbed till increased near the burial ground. This is consistent with the assumed presence of the ramp. Water levels in piezometers installed at the contact produce heads similar to those measured in hole 82-4A and indicate a small hydraulic gradient toward hole 82-4A. A cross section (fig. 21) from burial pit SH-9, which contains the dissolver tank, to the 82-4 nest of bore holes, shows measured water levels in piezometers 82-4A, 4A2, and 4A3 and the inferred location of the contact between the reworked fill and the till contact.

Hydraulic Conductivity of the Till

The vertical hydraulic conductivity of the till in which wastes are buried at the facility's disposal area was estimated from laboratory analyses of several undisturbed samples. A total of nine till samples collected in thin-wall Shelby tubes were analyzed with a constant-head permeability with back-pressure saturation test. Results of these analysis, given in table 4, indicated that the vertical hydraulic conductivity of four samples of weathered, oxidized till ranges from 2.1×10^{-5} m/d to 1.0×10^{-4} m/d and averaged 4.27×10^{-5} m/d. Analyses of five samples of unweathered, unoxidized till, also shown in table 4, resulted in vertical hydraulic conductivities ranging from 1.8×10^{-5} to 3.7×10^{-5} m/d and averaging 2.4×10^{-5} m/d. A summary of these permeability results and other laboratory analyses is presented in table 4.

Six additional constant-head permeability tests were performed on three samples of unweathered unoxidized till to examine the effect of overburden pressure on hydraulic conductivity. Each sample was tested in two stages. In the first stage, a net cell confining pressure was used that corresponded to the estimated overburden pressure at the depth from which the sample was obtained. All three samples were collected from depths of 9.8 to 10.9 m. In the second stage, the samples were consolidated to simulate overburden pressures at greater

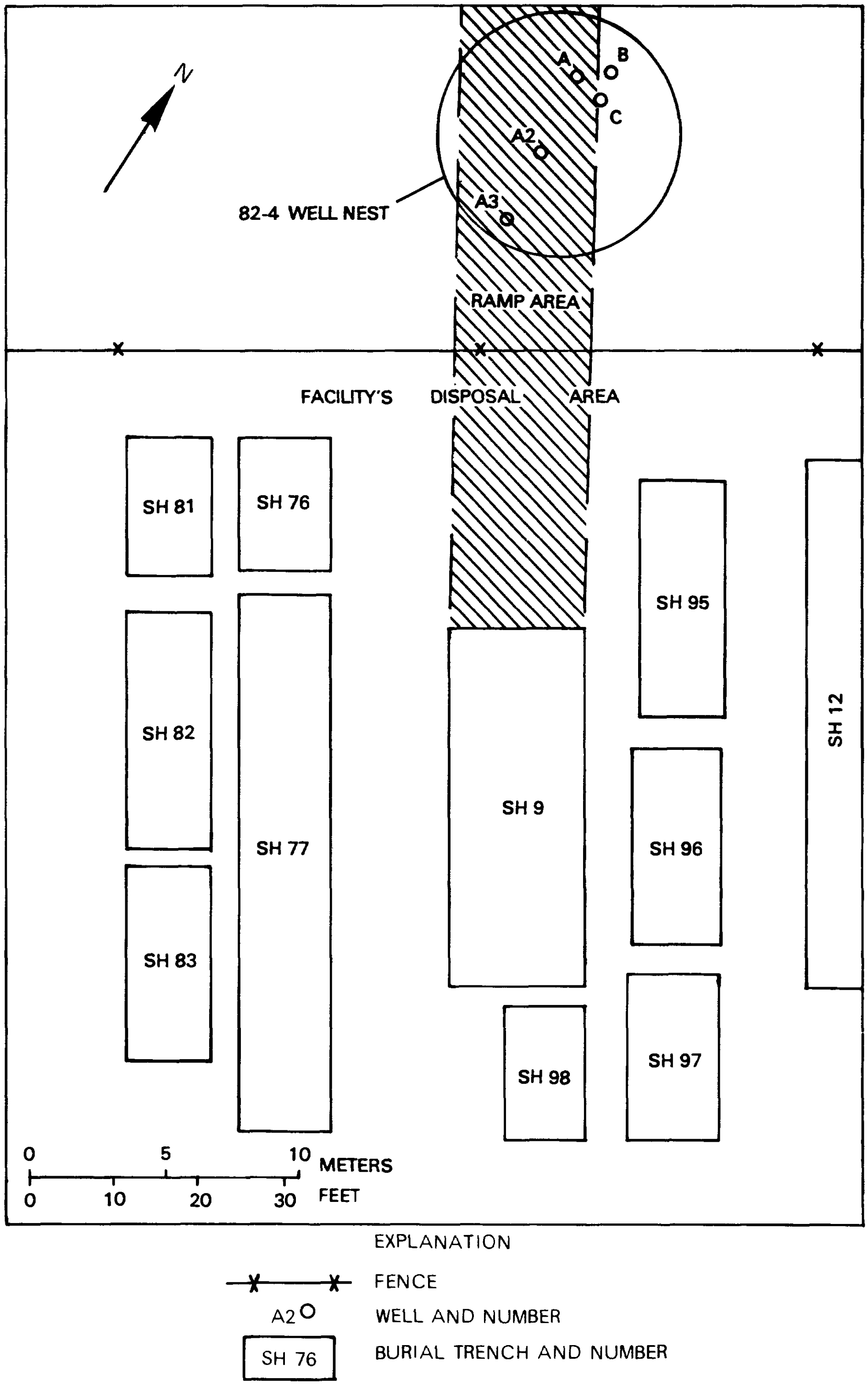


Figure 20.--Location of 82-4 series piezometers and approximate location of buried access ramp. (Location is shown in fig. 16.)

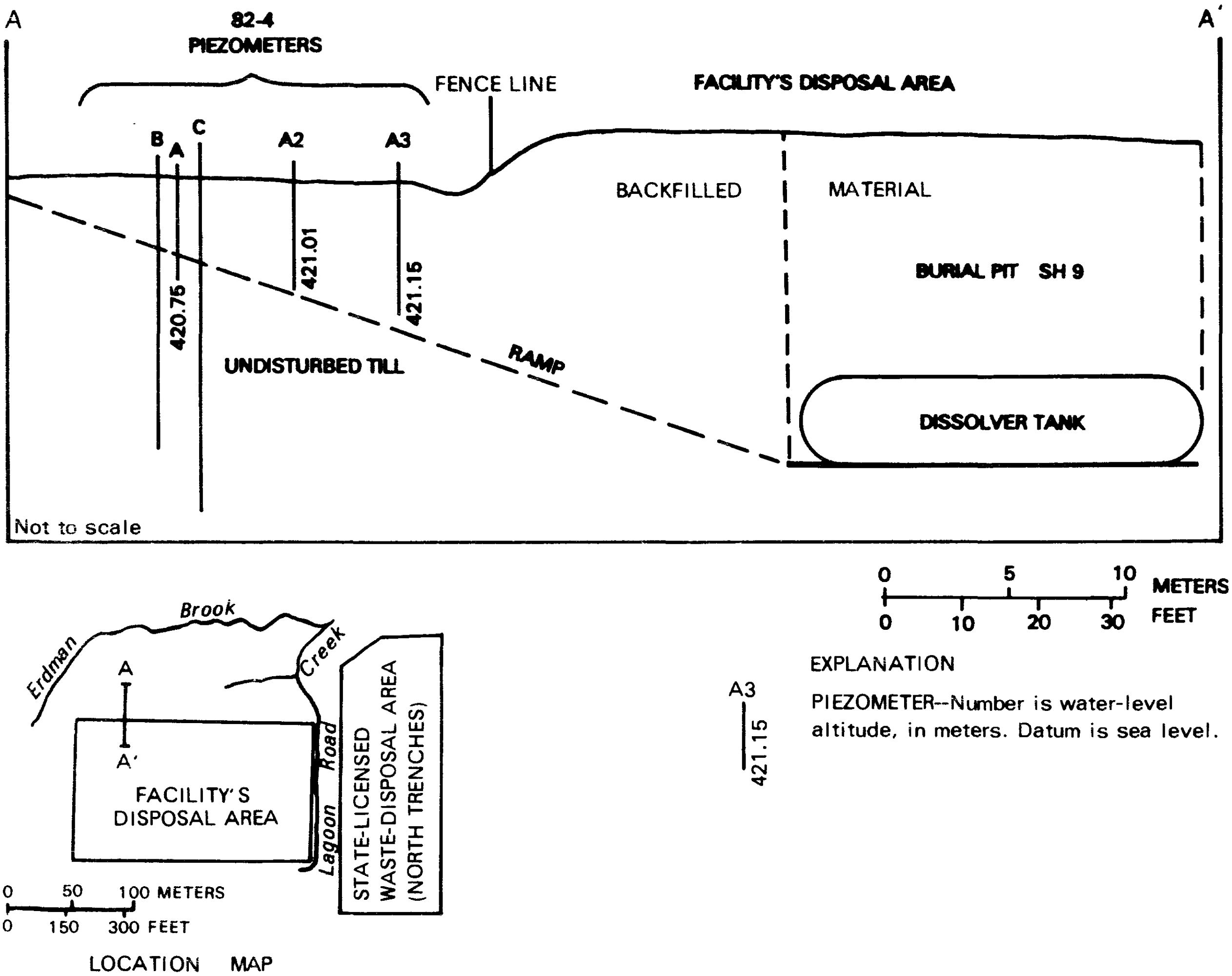


Figure 21.--Geologic section from 82-4 series of piezometers to burial pit SH 9 showing inferred position of buried access ramp.

depths (21.0 to 23.2 m). Permeability values resulting from the first stage ranged from 1.17 x 10^{-5} to 1.5 x 10^{-5} m/d and averaged 1.3 x 10^{-5} m/d (table 5). The increased overburden pressures simulated in the second stage gave slightly lower values ranging from 0.1 x 10^{-5} to 1.27 x 10^{-5} m/d. This apparent reduction in permeability ranged from 3.5 to 18.4 percent and averaged 13.1 percent, which indicates that the increase in overburden pressure below trench-bottom levels reduces the hydraulic conductivity of the till only slightly.

The horizontal hydraulic conductivity of the clay-rich till was also evaluated in the field. Horizontal hydraulic conductivity values were estimated from recovery-test data from five piezometers. Recovery tests were analyzed by two methods--a type-curve-matching method described by Cooper and others (1967), which assumes horizontal flow to the piezometer screen, and a graphical method described by Hvorslev (1951), which assumes spherical, isotropic flow. The calculated values obtained by both methods ranged from 8.6 x 10^{-5} to 6.9 x 10^{-6} m/d and averaged 1.7 x 10^{-5} m/d.

Table 4.--Laboratory analysis of vertical hydraulic conductivity of selected till samples by constant-head permeability with back-pressure saturation tests
[Boring locations shown on pl. 1.]

Boring no.	Sample depth below land surface (m)	Moisture content (percent)	Grain size in sample (percent) >2mm	2-0.074	<0.074mm	Dry unit weight (kg/m^3)	Vertical permeability (m/d)
82-1B	0.9 - 1.45	17.6 17.5*	1.9	13.8	84.3	1825.9	2.5 x 10^{-5}
	6.1 - 6.6	19.6 20.5*	1.3	13.9	85.3	1760.2	2.4 x 10^{-5}
82-2A	1.5 - 1.9	12.8 12.4*	5.3	27.5	67.2	1933.2	1.0 x 10^{-4}
82-2B	6.2 - 6.7	19.7 18.5*	7.3	19.6	73.1	1819.4	2.4 x 10^{-5}
82-3A	1.2 - 1.7	16.7 17.0*	2.7	16.1	81.2	1859.5	2.1 x 10^{-5}
	5.0 - 5.5	16.0 11.2*	9.6	20.5	69.9	2091.8	1.9 x 10^{-5}
82-4B	6.1 - 6.6	18.9 20.5*	1.8	4.2	94.0	1758.6	3.7 x 10^{-5}
82-5A	1.8 - 2.3	17.6 17.3*	3.0	16.8	80.2	1846.7	2.16 x 10^{-5}
82-5B	3.0 - 3.6	18.4 18.4*	2.3	14.0	83.7	1816.3	1.8 x 10^{-5}

* Permeability sample

SUMMARY AND CONCLUSIONS

The Western New York Nuclear Service Center in northern Cattaraugus County contains a fuel-reprocessing plant, a high-level-radioactive liquid-waste tank complex, and other related waste facilities that include two separate burial grounds for shallow burial of solid radioactive wastes. The burial grounds consist of a 4-hectare area licensed by the State of New York for burial of commercial low-level radioactive wastes and a 2.2-ha area previously licensed by the U.S. Nuclear Regulatory Commission and now operated by the U.S. Department of Energy for burial of wastes with higher levels of radioactivity. The former is not operating at present (1987).

The plant and waste facilities are on a sequence of glacial and postglacial deposits at an altitude of 420 m on the west flank of the Buttermilk Creek valley. These deposits partly fill an ancestral bedrock valley that is as much as 150 m deep.

The facilities and burial grounds are on an elevated plateau, referred to as the north plateau, that is underlain by an alluvial fan and fluvial deposits composed of silty sand and gravel. Thickness of these surficial deposits ranges from slightly more than 9 m southwest of the plant area to less than 3.0 m along deeply incised stream channels of Quarry Creek and Franks Creek, tributary streams bordering the plateau.

The burial grounds are excavated into the Lavery Till (LaFleur, 1979), which is predominantly silt and clay and ranges from 22 to 28 m thick. Beneath the Lavery Till are recessional lacustrine and kame delta deposits of post-Kent Till age. The units consist of basal laminated silt and clay grading upward to fine to coarse sand and silt. In some boreholes, the upper sandy parts of the kame delta and lacustrine deposits are capped by coarse gravel. Evidence from regional stratigraphic studies and a bedrock test hole on the site indicates that post-Kent recessional deposits are underlain by at least two older clayey silt tills, the Kent Till and Olean(?) Till (LaFleur, 1979). These till units are separated by a sequence of fine sand and silt presumed to be post-Olean recessional lacustrine deposits.

Bedrock underlying the unconsolidated sediments consists of shale and sandstone of the Upper Devonian Canadaway and Conneaut Groups (Rickard and Fisher, 1970). Depth to bedrock ranges from about 150 m in the deepest parts of the ancestral bedrock valley to less than 1 m along hillsides west of the plant.

Surface runoff from the center drains to Franks Creek east and south of the main plant area and to Quarry Creek north of the center. Franks Creek drains into Buttermilk Creek north of the center. Buttermilk Creek flows into Cattaraugus Creek at Springville, and Cattaraugus Creek in turn flows into Lake Erie near Silver Creek.

Surface water leaving the site was monitored at three gaging stations. Flow measured at Lagoon Road Creek on a small tributary of Franks Creek that drains parts of the disposal areas, averaged 0.675×10^{-3} m^3/s during 1981-83. The highest daily flow was 28.3×10^{-3} m^3/s, and the stream was dry for about 60 days during the summer. During most rainstorms, streamflow increased quickly with runoff from the surficial silty-clay till of the area but returned to base-flow conditions within several hours after rainfall ended.

Streamflow from the north plateau was less responsive to rainfall. Base flow was normally sustained during summer, presumably by storage release from the surficial sand and gravel. Flow at the NP1 station ranged from zero during a few days in the summer to 31.2×10^{-3} m^3/s and averaged 1.30×10^{-3} m^3/s. Flow at the NP3 station ranged from 0.113×10^{-3} m^3/s to 28.3×10^{-3} m^3/s and averaged 2.48×10^{-3} m^3/s.

Periodic water-level measurements in observation wells indicate that ground water in the north plateau area flows from southwest of the fuel-reprocessing plant toward the perimeter of the plateau. Structures such as the main plant and the high-level radioactive liquid waste tanks create local barriers to flow, while other structures, such as lagoons associated with the low-level radioactive-wastewater-treatment plant, provide areas of preferential discharge.

Saturated thickness of the surficial sand and gravel ranges from 1 to 5.5 m. Hydraulic conductivity of the surficial sand and gravel, calculated from slug-test data, ranges from 0.1 to 7.9 m/d.

Evidence from a series of boreholes suggests that mechanisms similar to those causing preferential infiltration through materials capping the commercial burial area may be operating in the facility's disposal area. Water-level and borehole data suggest that the base of a buried access ramp used to dispose of a dissolver tank on the northwest side of the burial area has become saturated.

Vertical hydraulic conductivity of the clay-rich Lavery till was evaluated from laboratory permeability tests. Values for four samples of weathered, oxidized till samples ranged from 2.1×10^{-5} to 1.0×10^{-4} m/d and averaged 4.27×10^{-5} m/d. Values for five unweathered till samples ranged from 1.8×10^{-5} to 3.7×10^{-5} m/d and averaged 2.45×10^{-5} m/d.

Horizontal hydraulic conductivity of the till was evaluated through analysis of recovery-test data. Calculated values from five piezometers ranged from 8.6×10^{-5} to 6.9×10^{-6} m/d and averaged 1.0×10^{-5} m/d.

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APPENDIXES

APPENDIX A

DESCRIPTION AND DISCHARGES OF NOTABLE SEEPS AND SPRINGS IN THE NORTH PLATEAU AREA AT THE WESTERN NEW YORK NUCLEAR SERVICE CENTER

The area that contains the reprocessing plant, high-level waste tanks, and associated treatment and storage facilities is known as the north plateau. Most of the water draining the north plateau is measured at the NP1 and NP3 streamflow stations (fig. 8), but some is discharged from a series of seeps and springs along the edge of the plateau. To define the location and magnitude of these seeps and springs, the U.S. Geological Survey made several suveys during 1983. (Locations are shown on pl. 1.)

Description

Seeps and springs consist of zones generally 1.5 to 18 m long, downslope of the interface between surficial sand and gravel and the till, where sustained flow can be seen. Physical signs of such areas are an accumulation of organic matter and ground slumping. The organic matter is generally black, the soil surface is moist, and some locations have wetland vegetation. The predominant wetland vegetation at the Western New York Nuclear Service Center site is Typha spp. (cattail). Within a given seepage area, water may appear at several distinct points or as general seepage from the entire face.

Following are descriptions of seeps and springs around the north plateau; the location of each seep and spring is shown on plate 1. The numbering system proceeds clockwise around the plateau, starting at the new parking lot for the administration complex, which covers the first seepage area listed, and ending at the railroad grade south of the plant (pl. 1).

Seepage Area

SF-1 Two seepage areas under what is now the upper parking lot for the administration building. Drainage pipes were placed near the areas for drainage. Flow from these seeps generally infiltrates back into the alluvial material during dry periods.

SF-2 Several distinct wet zones. The northwesternmost seep at the base of a maple tree (6 to 8 cm in diameter) was measurable. The other seeps have similar discharge rates.

SF-3 Several small seeps. Small decomposition zones and little discernible discharge.

SF-4 A 18-m seepage face with several distinct wet zones along the left bank of the NP1 discharge station (pl.1); none were observed on the right bank. Seepage on left bank was observed year-round but was too diffuse to measure. Slumping has occurred 5 to 10 m downstream.

SF-5 Two distinct seepage zones on either side of ridge, with minimal flow; no measurements were made. Standing water in "old stream channel" that traverses this ridge may feed these seeps.

SF-6 Several seeps are combined in this unit. All are small and generally appear as broad mud flats on gentle slopes but disappear or become channelized on steeper slopes. No measurements have been made.

SF-7 Seepage beginning inside the old security fence northeast of the gravel pits. The seepage area broadens downslope (as found at SA-6) and narrows to several distinct channels as slope steepens. Measureable flow was found in one channel.

SF-8 NP2 drainage. Seepage zone begins inside security fence in swamp. Flow increases considerably between drainpipe under fence and NP2 gage pool. Measurements were made (see table A-1) at lower weir pool in NP2 channel.

SF-9 Two seepage zones in this face. Southern zone was measurable; the other was too diffuse. Alluvial material 1.5 to 2.4 m thick covers surface.

SF-10 Active seepage area on left bank of channel 45 m downstream of the NP3 station. An active slump 9 m long had diffuse flow. A new mudflow appeared in spring 1983. A yellow-brown mud emanates from a 0.3-m-deep hole on the steeper slope. A 1-m-wide sluiceway channels the mud to the NP3 streamcourse. No measurements were possible.

SF-11 Active seepage area along right bank of NP3 channel. Seepage along entire bank, 9 m upstream of station through the weir pond area (approximately 15 m). The major seepage point was measured; several others were seen. This area flows year-round.

SF-12 Seepage area is 7.5 m wide with flow dispersed along entire face. Flow into two broad channels, neither of which are measurable. Magnitude of seepage is similar to that of SF-13.

SF-13 Active seepage from 4.5-m-wide area. Flow becomes channelized one-third of the way down the slope.

SF-14 Seepage from 6-m-wide area. Flow becomes channelized two-thirds way downslope; most of seepage is probably in this channel.

SF-15 Seepage from 6-m-wide area. Flow becomes channelized halfway downslope; most seepage is measured in this channel.

SF-16 Seepage from 20.5-m-wide area. Flow becomes channelized halfway downslope; most of the flow is probably here.

SF-17 Outlet of french-drain system east of the large storage lagoons. Appreciable flow with black (manganese?) stain in channel.

SF-18 Seepage from field east of plant complex. Forms several small connected wetlands opposite low-level waste-burial trenches. Most drainage flows along south side of road.

SF-19 Long seepage area halfway between railroad and SF-18. Small seeps near crest of slope; one of four had measurable flow.

Table A-1.--Altitudes and discharge measurements of seepage faces around the north plateau

[Altitudes are in meters above land surface. Dashes (-) indicate no measurable flow. Locations are shown on pl. 1)

Seepage area		Altitude (m)	Discharge measurements (L/s) 3/3/83	7/5/83	10/6/83
SF-1	approx	436.00	-	-	0.018
2		430.77	0.0018	dry	dry
3	approx	418.00	-	-	-
4		416.75	-	-	-
5		410.66	-	dry	-
6		415.50	-	-	-
7		415.84	0.025	-	0.016
8	(NP2)	413.67	0.092	0.035	0.101
9		410.96	0.007	dry	0.002
10		414.25	-	0.003	0.005
11		414.07	0.039	0.032	0.040
12		415.44	-	dry	dry
13		415.20	0.027	-	-
14		415.41	0.003	-	-
15		414.53	0.007	0.0205	0.023
16		416.14	0.005	-	-
17		416.21	0.287	0.215	0.312
18		418.48	0.138	-	0.200
19		419.27	0.008	dry	dry
			0.669	0.035	0.717
Rainfall (cm) within 24 hours			00.0	00.0	2.41

Total Flow Computations

Date	3/3/83 Discharge (L/s)	Percentage of total discharge	7/5/83 Discharge (L/s)	Percentage of total discharge	10/6/83 Discharge (L/s)	Percentage of total discharge
Streamflow						
NP 1	0.368	13	0.028	3	0.623	22
NP 3	1.755	63	0.595	64	1.558	53
French drain	0.287	10	0.215	24	0.312	10
Seepage flow	0.382	14	0.090	9	0.405	15
TOTAL	2.792	100	0.928	100	2.898	100

APPENDIX B

WATER-LEVEL ALTITUDES IN WELLS AT THE WESTERN NEW YORK NUCLEAR SERVICE CENTER, 1981-84.

[Well locations are shown in plate 1. Altitudes are in meters. Dashes indicate no measurement.]

Date	Well numbers								
	80-1	80-2	80-3	80-4	80-5	80-6	80-7	80-8	80-9
810119	---	432.8	---	419.0	416.2	---	---	---	---
810520	---	432.8	---	419.4	416.6	---	---	---	---
810623	---	433.1	---	419.5	416.9	---	---	---	---
810723	---	432.4	---	418.6	416.1	---	---	---	---
810821	---	432.8	---	419.0	416.4	---	---	---	---
810929	---	432.9	---	419.2	416.5	---	---	---	---
811022	---	432.9	---	419.3	416.6	---	---	---	---
811119	431.2	433.1	420.0	419.6	416.9	416.7	424.4	429.6	---
811230	430.8	432.8	419.8	419.5	416.7	416.7	424.3	429.4	---
820105	431.3	433.0	420.0	419.8	417.0	416.9	424.5	429.5	---
820129	429.9	432.5	419.4	418.8	416.2	416.2	424.1	428.9	---
820209	430.7	432.9	419.7	419.1	416.5	416.4	424.2	429.2	---
820304	430.6	432.8	419.5	418.9	416.4	416.3	424.2	429.1	---
820308	430.4	432.6	419.4	418.9	416.3	416.2	424.2	429.1	---
820312	431.3	433.0	420.3	419.2	416.8	416.5	424.5	429.3	---
820315	431.7	433.1	420.2	420.5	417.3	417.3	424.6	430.3	---
820318	431.6	433.1	420.2	420.5	417.3	417.4	424.6	430.2	---
820322	431.3	433.0	420.2	420.3	417.1	417.3	424.4	429.9	---
820324	431.2	433.0	420.2	420.2	417.1	417.3	424.3	429.8	---
820402	431.2	433.0	420.1	420.0	417.0	417.0	424.3	429.7	---
820407	431.1	433.0	420.1	419.9	416.9	417.1	424.3	429.5	---
820412	431.1	433.0	420.1	419.9	416.9	416.9	424.3	429.5	---
820416	431.0	432.9	419.9	419.9	416.9	417.0	424.3	429.6	---
820420	430.9	432.9	419.6	419.7	416.7	416.8	424.3	429.4	---
820427	430.5	432.7	419.3	419.2	416.5	416.6	424.2	429.2	---
820503	430.2	432.6	419.1	419.0	416.3	416.3	424.2	429.0	---
820506	430.1	432.5	419.1	418.8	416.2	416.3	424.2	429.0	---
820511	430.0	432.7	419.4	418.8	416.2	416.2	424.2	428.9	---
820517	430.5	432.4	419.1	418.7	416.1	416.1	424.1	428.8	---
820520	430.0	432.5	419.1	418.6	416.0	416.0	424.1	428.8	423.5
820601	430.8	432.5	419.4	418.8	416.3	416.2	424.2	428.9	423.4
820608	431.1	433.0	419.6	419.2	416.6	416.5	424.3	429.1	423.4
820610	430.9	432.9	419.3	419.2	416.5	416.5	424.2	429.2	423.4
820615	430.9	432.8	419.2	419.0	416.5	416.4	424.2	429.2	423.4
820616	---	---	---	---	---	416.1	---	---	---
820617	431.2	432.8	420.0	419.1	416.5	416.4	424.4	429.3	423.4
820629	431.2	432.4	420.0	419.1	416.5	416.5	424.5	429.5	423.4
820701	431.1	433.0	419.6	419.2	416.5	416.4	424.3	429.5	423.4
820706	430.7	432.8	419.2	419.1	416.3	416.3	424.2	429.4	423.3
820708	430.6	432.7	419.1	419.0	416.3	416.3	424.2	429.3	423.3
820712	430.5	432.6	419.1	418.9	416.2	416.2	424.1	429.1	423.3
820715	430.5	432.5	419.1	418.8	416.1	416.1	424.1	429.0	423.3

Date	80-1	80-2	80-3	80-4	80-5	80-6	80-7	80-8	80-9
	Well numbers								
820721	430.5	432.5	419.0	418.7	416.0	416.0	424.2	428.9	423.3
820727	430.2	432.4	419.0	418.6	416.0	416.1	424.1	429.1	423.3
820805	431.0	432.5	419.5	418.8	416.1	416.0	424.2	429.1	423.3
820809	431.2	432.6	419.7	418.8	416.2	416.0	424.3	429.2	423.5
820812	431.1	432.6	419.3	418.8	416.1	416.0	424.2	429.1	423.6
820816	431.1	432.6	419.0	418.8	416.0	---	424.1	429.1	423.6
820818	430.9	432.5	419.1	418.7	416.0	416.0	424.1	429.0	423.6
820913	430.5	432.8	419.2	419.0	416.4	416.7	424.2	429.2	423.6
820922	430.7	432.6	419.5	418.7	416.1	416.1	424.2	428.8	421.1
821001	430.9	433.0	---	---	---	---	---	---	---
821004	430.6	432.8	419.4	419.0	416.3	416.3	424.2	429.2	421.5
821015	431.1	432.7	419.9	418.9	416.2	416.1	424.2	429.1	---
821110	430.9	433.0	419.8	419.7	416.8	416.9	424.3	429.5	421.5
821130	431.2	433.1	420.0	419.7	416.9	416.9	424.4	429.5	421.8
821229	431.0	433.1	420.0	420.1	417.0	417.1	424.4	429.6	422.0
830113	431.0	433.0	419.8	419.4	416.7	416.7	424.3	429.2	422.1
830204	431.1	433.1	419.4	419.5	416.9	416.7	424.5	429.5	422.2
830217	429.6	432.8	419.6	419.0	416.5	416.5	424.2	429.0	422.2
830303	430.4	432.7	419.5	418.9	416.4	416.4	424.2	429.0	422.2
830325	431.0	433.0	420.1	419.6	416.8	416.8	424.3	429.5	422.2
830414	431.0	433.0	419.7	419.4	416.7	416.7	424.4	429.3	422.3
830421	---	---	420.2	419.4	416.7	416.7	424.3	---	---
830510	430.9	432.8	419.6	419.6	416.7	416.8	424.3	429.3	422.3
830531	---	432.6	419.4	418.9	416.3	416.3	424.1	429.0	422.3
830601	430.7	---	---	---	---	---	---	---	---
830615	430.1	432.5	419.1	418.6	416.0	416.1	424.0	428.7	422.3
830706	430.2	432.5	419.1	418.5	415.9	416.0	423.9	428.8	422.3
830726	430.0	432.3	419.0	418.1	415.8	415.9	423.9	428.6	422.3
830909	430.8	433.0	419.1	418.9	416.0	416.0	423.9	429.0	422.4
831013	430.8	432.9	419.2	419.1	416.1	416.1	424.3	429.1	422.5
831213	---	---	---	---	---	---	424.5	---	---
831219	---	---	---	---	---	---	---	---	422.5
831220	---	---	419.5	---	---	416.8	---	---	---
831221	---	---	---	419.8	---	---	---	---	---
840216	431.3	---	419.8	420.4	417.0	417.4	424.6	430.1	422.5
840412	430.9	---	419.5	419.9	---	417.8	424.3	429.4	422.4
840522	432.8	433.1	420.0	420.4	416.9	417.1	424.3	429.9	422.6

Date	82-1A	82-1B	82-1C	82-1D	82-2A	82-2B	82-2C	82-3A	82-3B
	Well numbers								
821015	---	---	406.5	---	---	---	---	---	---
821110	415.6	410.8	406.5	---	---	---	---	---	---
821130	415.8	410.8	406.4	---	416.3	---	---	---	---
821229	416.2	411.3	406.5	---	416.6	410.7	407.4	---	---

Date	82-1A	82-1B	82-1C	82-1D	82-2A	82-2B	82-2C	82-3A	82-3B
	Well numbers								
830113	416.3	411.3	406.3	---	416.5	410.8	---	---	---
830204	416.4	411.5	406.3	---	416.2	410.9	---	---	---
830217	416.6	411.4	406.3	---	416.5	410.9	---	---	---
830303	416.8	411.4	416.3	---	416.5	411.1	---	---	---
830325	417.0	411.5	406.3	---	416.5	411.1	---	---	---
830414	417.2	411.9	406.4	391.3	416.6	411.2	---	---	---
830601	417.6	411.7	406.4	---	416.8	411.3	---	---	---
830615	417.5	411.7	406.4	---	417.8	411.3	---	---	---
830706	417.5	411.7	406.5	---	416.9	411.2	---	---	---
830726	417.3	411.8	406.5	---	417.0	411.2	---	420.6	---
830912	416.7	411.6	406.6	---	417.4	411.4	---	420.0	---
831014	416.3	411.5	406.6	---	417.0	411.5	---	422.5	---
831201	416.1	411.2	406.4	---	420.9	411.5	---	---	---
831208	416.0	411.0	406.3	---	416.6	411.2	---	422.7	412.9
831215	416.2	411.1	406.4	---	416.6	411.4	---	422.7	412.9
831221	---	---	---	---	---	---	---	422.7	412.8
840216	417.1	411.5	406.2	---	416.4	411.4	---	421.8	412.4
840412	417.7	411.7	406.3	---	416.6	411.5	---	423.0	---
840522	418.5	412.3	406.6	---	416.9	411.5	---	422.3	---

Date	82-3C	82-3D	82-4A	82-4A2	82-4A3	82-4B	82-4C	82-5A	82-5B
	Well numbers								
821015	---	---	421.2	---	---	410.9	---	---	---
821110	---	---	421.6	---	---	412.0	406.7	414.1	406.7
821130	---	---	421.8	---	---	412.2	406.7	414.9	406.8
821229	---	---	421.8	420.2	421.6	412.4	407.7	415.9	406.8
830113	---	---	421.7	421.3	421.6	413.4	---	416.0	406.9
830204	---	---	421.6	421.5	421.7	412.6	406.8	416.1	407.1
830217	---	---	421.6	421.5	421.6	---	---	416.1	407.1
830303	---	---	421.7	421.5	421.7	412.5	---	416.1	407.1
830325	---	---	421.7	421.5	422.1	412.4	---	416.1	407.1
830414	---	---	421.8	421.6	421.8	412.4	---	416.2	407.1
830601	---	392.8	421.7	421.6	422.1	412.4	---	416.2	407.2
830615	---	---	421.8	421.5	422.0	412.4	---	416.1	407.2
830706	---	---	421.6	421.6	421.8	412.4	---	416.0	407.2
830726	---	392.9	421.3	421.3	421.4	412.3	---	415.9	407.2
830912	---	392.9	421.2	421.0	421.2	412.2	---	415.8	407.2
831014	---	---	421.7	421.1	421.1	412.2	---	415.6	407.2
831201	---	393.3	---	---	---	412.3	---	---	407.5
831208	411.3	393.1	422.1	---	---	412.5	---	414.1	407.2
831209	---	---	---	---	---	---	---	414.1	---
831211	---	---	---	---	---	---	---	414.0	---
831213	---	---	---	---	---	---	---	414.0	---
831215	411.0	---	422.1	421.2	421.5	412.4	---	414.0	407.2
831219	---	---	---	---	---	---	---	414.1	---

APPENDIX B (continued)

Date	82-3C	82-3D	82-4A	82-4A	82-4A3	82-4B	82-4C	82-5A	82-5B
	Well numbers								
831221	411.7	393.2	421.5	---	---	412.2	---	---	---
831222	---	---	---	---	---	---	---	414.1	---
831229	---	---	---	---	---	---	---	414.1	---
840216	---	---	422.3	421.3	421.5	412.5	---	414.3	407.7
840412	---	393.2	422.0	421.4	421.2	412.3	---	414.3	407.5
840522	---	---	422.1	421.8	421.8	412.5	---	---	---

Date	82-5C	83-A-1	83-A-2	83-A-3	83-A-4	83-A-5	83-1D	83-1E	83-2D
	Well numbers								
821015	405.2	---	---	---	---	---	---	---	---
821110	405.4	---	---	---	---	---	---	---	---
821130	405.9	---	---	---	---	---	---	---	---
821229	406.2	---	---	---	---	---	---	---	---
830113	406.2	---	---	---	---	---	---	---	---
830204	406.8	---	---	---	---	---	---	---	---
830217	406.7	---	---	---	---	---	---	---	---
830303	406.4	---	---	---	---	---	---	---	---
830325	406.3	---	---	---	---	---	---	---	---
830414	406.5	---	---	---	---	---	---	---	---
830421	---	417.7	416.3	---	---	---	---	---	---
830510	---	417.8	416.3	---	---	---	---	---	---
830531	---	418.3	416.1	---	---	---	410.4	410.8	400.0
830601	406.7	---	---	---	---	---	---	---	---
830615	406.7	418.1	415.8	419.5	---	430.7	410.4	414.6	399.6
830616	---	---	---	---	---	---	---	---	---
830706	406.7	417.9	415.7	419.9	---	430.7	---	410.2	399.8
830707	---	---	---	---	---	---	---	---	---
830726	406.8	417.7	415.7	420.1	---	430.5	410.0	410.3	399.9
830909	---	418.0	415.8	420.4	---	430.8	409.8	410.3	399.8
830912	406.8	---	---	---	---	---	---	---	---
831013	---	418.4	415.5	---	---	---	---	---	---
831014	406.8	---	---	420.5	---	431.0	410.0	410.2	399.9
831201	---	---	---	---	---	---	---	---	---
831202	---	---	---	---	---	---	---	410.8	399.9
831208	406.2	---	---	---	---	---	409.9	411.5	400.0
831215	406.3	---	---	---	---	---	410.0	411.5	400.0
831219	---	---	---	---	---	431.1	---	---	---
831220	---	418.3	416.2	---	---	---	---	---	---
840216	406.4	418.4	416.6	421.2	---	430.9	409.7	---	399.8
840412	406.8	418.2	416.2	421.4	---	430.9	409.5	---	399.8
840522	---	418.3	416.4	421.0	---	430.9	409.6	---	400.0

APPENDIX B (continued)

Date	Well numbers 83-2E	83-3D	G1	G2	G3	J-1	J-2	J2	J5
821229	---	---	417.5	414.3	409.3	414.7	391.3	416.5	419.2
830113	---	---	417.5	414.3	---	414.8	---	416.4	419.2
830204	---	---	417.6	414.3	409.3	414.8	---	416.4	419.2
830217	---	---	417.5	414.2	---	---	---	---	---
830218	---	---	---	---	408.9	415.8	382.0	416.3	419.3
830303	---	---	417.5	414.1	409.8	414.8	382.1	416.3	419.2
830325	---	---	417.6	414.1	409.3	414.7	382.0	416.2	419.2
830414	---	---	418.6	417.5	416.0	---	---	---	---
830510	---	---	---	---	---	414.7	382.0	416.3	419.1
830531	---	395.5	417.9	414.0	---	414.7	---	416.2	419.2
830601	---	---	---	---	---	---	382.1	---	---
830615	400.3	395.6	417.7	414.0	409.1	414.9	382.0	416.2	418.7
830706	400.3	395.7	417.7	413.9	409.0	414.5	381.3	416.1	418.6
830726	400.3	395.7	417.6	413.8	408.9	414.4	381.9	416.1	418.5
830909	400.2	395.7	---	---	---	---	---	---	---
830912	---	---	417.3	413.9	408.9	414.4	382.1	415.9	418.6
831014	400.2	395.7	417.3	414.0	409.0	414.5	419.8	418.7	415.0
831202	400.5	395.8	---	---	---	---	---	---	---
831208	400.4	396.1	---	---	---	---	---	---	---
831213	---	---	---	---	---	414.6	381.8	416.0	419.2
831215	400.4	395.7	---	---	---	---	---	---	---
840216	400.2	395.8	417.5	417.5	412.6	414.9	382.3	416.0	419.3
840412	400.2	395.2	417.6	414.0	409.2	419.4	382.1	416.0	419.1
840522	401.0	395.6	417.9	414.0	409.1	414.6	382.2	416.2	419.0

Date	Well numbers S1	S2	V	W1	W2	CT-272	B	E	F
821229	408.4	410.0	---	---	---	---	---	---	---
830113	---	410.0	379.3	---	---	---	---	---	---
830204	408.3	410.0	379.2	---	---	---	---	---	---
830217	---	---	---	390.1	387.5	---	---	---	---
830218	408.2	410.0	379.0	---	---	---	---	---	---
830303	408.2	410.0	379.2	390.0	387.7	---	---	---	---
830325	408.2	410.0	379.2	390.0	387.7	---	424.0	423.9	422.5
830414	---	---	---	390.0	387.7	---	424.0	424.0	423.4
830510	408.2	409.9	---	---	---	---	424.0	422.7	422.9
830531	408.3	---	---	---	---	---	---	---	---
830601	---	---	379.1	---	387.7	398.0	423.7	422.4	422.5
830615	408.2	409.5	---	---	---	398.0	423.6	422.1	422.2
830616	---	---	378.7	387.5	388.4	---	---	---	---
830706	408.1	409.3	---	---	---	398.0	423.6	422.1	422.2
830707	---	---	378.7	389.4	387.5	---	---	---	---
830726	408.9	407.9	378.5	389.7	387.5	397.9	423.5	422.3	422.1

APPENDIX B (continued)

Date	Well numbers								
	S1	S2	V	W1	W2	CT-272	B	E	F
830909	---	---	378.6	389.8	387.7	397.9	423.7	422.8	422.5
830912	408.1	409.3	---	---	---	---	---	---	---
831013	---	---	---	---	---	---	423.8	423.4	422.4
831014	408.2	409.9	---	---	---	398.0	---	---	---
831213	408.3	410.0	---	---	---	---	---	---	---
831219	---	---	---	---	---	397.8	---	---	---
840216	408.1	410.0	379.0	---	---	397.9	---	---	423.4
840412	408.1	410.0	379.2	---	---	397.7	---	---	423.3
840522	408.2	410.0	---	---	---	398.7	424.5	---	423.4

Date	Well numbers								
	L-2	L-5	M-5	N-1	N-2	N-3	NJ-1	NJ-2	NJ-4
830325	423.6	423.5	423.9	427.3	---	---	---	427.5	424.4
830414	424.4	423.3	423.7	427.5	---	424.7	428.0	427.8	424.4
830510	423.3	426.5	423.8	427.2	427.2	424.5	427.9	427.2	424.2
830601	422.7	423.2	423.5	427.0	427.5	424.4	428.0	427.2	424.1
830615	422.6	423.3	423.4	426.7	427.2	424.3	427.8	427.0	424.0
830706	422.6	423.0	423.4	426.7	427.1	424.2	427.8	427.0	424.0
830726	422.5	422.9	423.2	426.3	426.6	424.2	427.7	426.7	424.0
830909	422.8	423.2	423.6	426.1	426.9	424.3	427.8	426.7	424.0
831013	422.8	423.3	423.7	425.8	427.0	424.5	427.9	426.8	424.0
840216	424.1	423.3	424.2	426.7	427.7	424.8	428.2	427.6	424.6
840412	423.0	423.4	424.0	426.1	427.3	424.6	427.9	427.2	424.3
840522	423.2	424.0	424.6	427.5	427.5	424.6	428.3	427.5	424.5

Date	Well numbers					
	NJ-6	NJ-8	NJ-10	P	Q	R
830325	423.4	423.3	---	424.9	---	---
830414	424.4	423.3	424.9	424.7	416.4	---
830510	423.1	423.2	424.2	424.7	416.3	---
830601	423.0	423.0	424.0	---	416.2	---
830615	423.1	422.9	423.9	424.0	416.1	---
830706	422.7	422.9	423.9	424.1	416.1	418.5
830726	422.5	422.9	423.8	423.9	416.1	418.6
830909	422.7	423.1	424.0	424.3	416.1	419.0
831013	422.9	423.2	424.0	424.3	416.2	419.0
831220	---	---	---	---	416.4	---
840216	423.5	423.5	425.2	425.3	416.7	---
840412	423.2	423.2	424.6	425.1	416.4	419.0
840522	424.2	423.5	425.0	425.4	416.7	---

APPENDIX C

NATURAL GAMMA AND NEUTRON-MOISTURE INFORMATION FROM SELECTED WELLS

Following are natural gamma and neutron moisture logs of selected wells logged by the U.S. Geological Survey May 11, 1983. Pertinent logging information of each well is presented in tables 1 and 2.

A. Natural gamma logging

	Well Number				
	82-1D	82-3D	83-1E	83-2E	83-3E
Land surface datum (m)	420.99	423.46	425.68	424.64	420.50
Depth of casing (m)	29.26	26.21	18.60	28.95	24.99
Type of Casing	AW[1]	AW[1]	BW[2]	BW[2]	AW[1]
Count rate (counts/s)	20	20	20	20	20
Variable span	1.0	1.0	1.0	1.0	1.0
Logging speeds (m/min)	3.05	3.05	3.05	3.05	3.05
Time constant	0.5	0.5	0.5	0.5	0.5

B. Neutron moisture logging

	Well Number				
	82-1D	82-3D	83-1E	83-2E	83-3E
Land surface datum (m)	420.99	423.46	425.68	424.62	420.50
Depth of casing (m)	29.26	26.21	18.60	28.95	24.99
Type of casing	AW[1]	AW[1]	BW[2]	BW[2]	AW[1]
Count rate (counts/s)	500	500	500	500	500
Variable span	2.65	2.65	2.65	2.65	2.65
Logging speeds (m/min)	1.22	1.22	1.22	1.22	1.22
Time constant	4	4	4	4	4

1 Steel flush-joint casing with inside diameter of 4.84 cm
2 Steel flush-joint casing with inside diameter of 6.03 cm

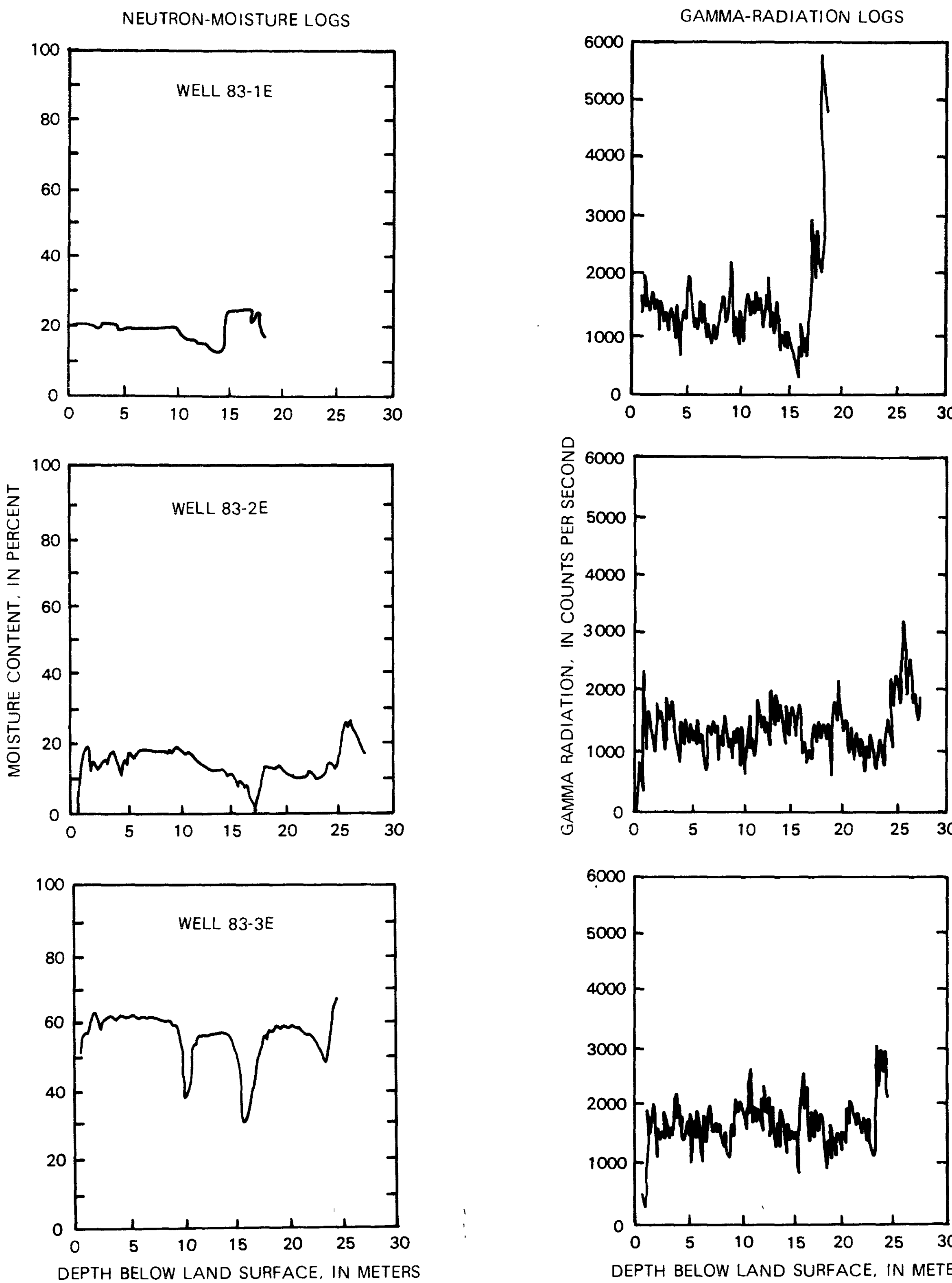

Figure C1.--Geophysical borehole logs from selected wells near the facility's waste-disposal area showing gamma radiation and neutron-moisture readings within the Lavery Till and in lower units.

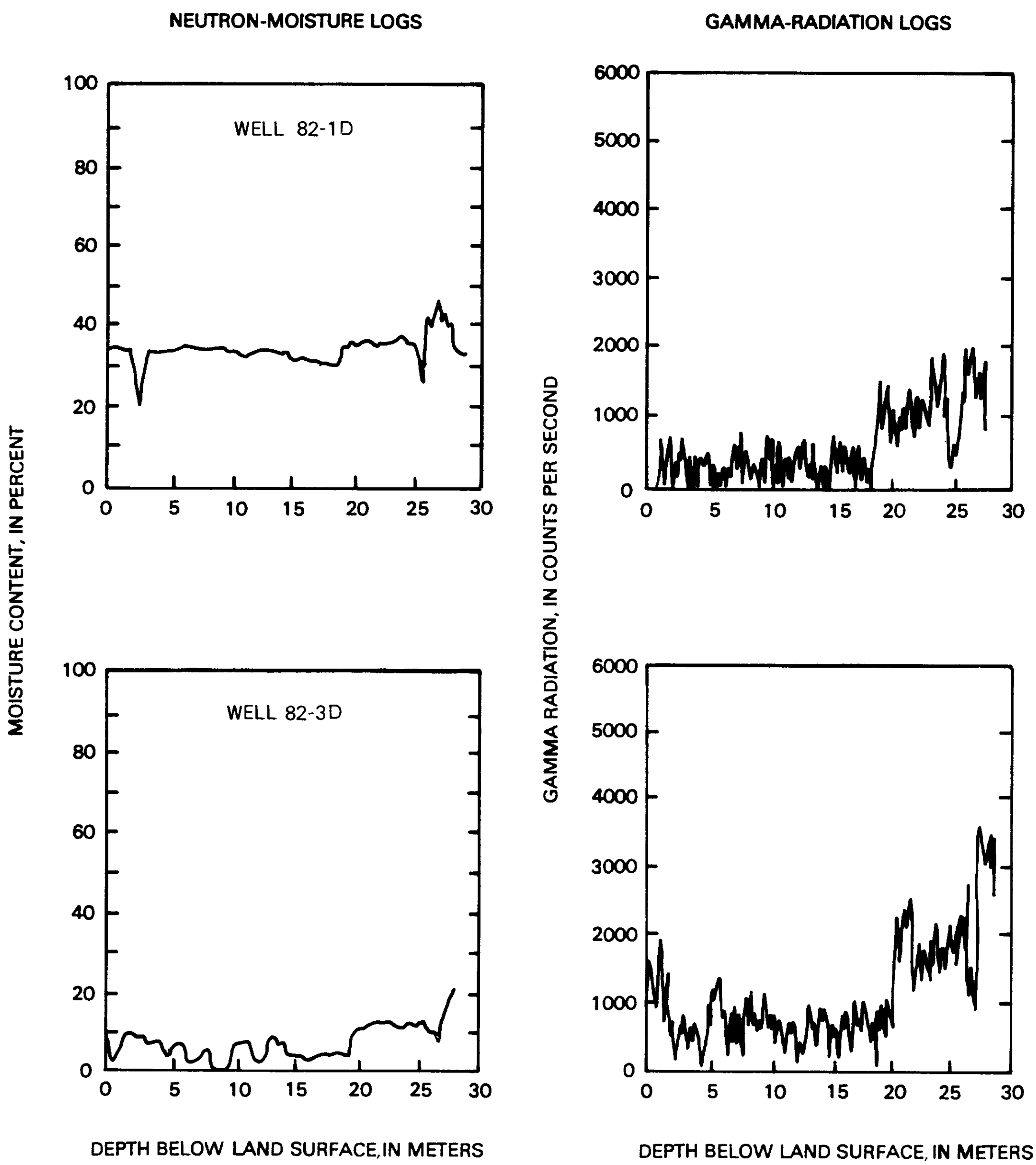

Figure C1.--Geophysical borehole logs from selected wells near the facility's waste-disposal area showing gamma radiation and neutron-moisture readings within the Lavery Till and in lower units.