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NIAGARA FALLS STORAGE SITE

ANNUAL SITE ENVIRONMENTAL REPORT

CALENDAR YEAR 1988

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By

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DISCLAIMER

ABSTRACT

The environmental monitoring program, begun in 1981, was continued during 1988 at the Niagara Falls Storage Site (NFSS), a United States Department of Energy (DOE) surplus facility located in Niagara County, New York, that is currently used for interim storage of radioactive residues, contaminated soils, and rubble. The monitoring program is being conducted by Bechtel National, Inc.

The monitoring program at the NFSS measures radon concentrations in air; external gamma radiation levels; and uranium and radium concentrations in surface water, groundwater, and sediment. To verify that the site is in compliance with the DOE radiation protection standard and to assess its potential effect on public health, the radiation dose was calculated for a hypothetical maximally exposed individual. Based on the conservative scenario described in this report, this hypothetical individual receives an annual external exposure approximately equivalent to 6 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than a person receives during two round-trip flights from New York to Los Angeles (because of the greater amounts of cosmic radiation at higher altitudes).

The cumulative dose to the population within an 80-km (50-mi) radius of the NFSS that results from radioactive materials present at the site is indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

Results of the 1988 monitoring show that the NFSS is in compliance with applicable DOE radiation protection standards.

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1.0 INTRODUCTION

Environmental monitoring has been conducted at the Niagara Falls Storage Site (NFSS) since 1981. This report presents the findings of the environmental monitoring program conducted at the NFSS during calendar year 1988. The NFSS is part of the United States Department of Energy (DOE) Surplus Facilities Management Program.

1.1 LOCATION AND DESCRIPTION

The NFSS occupies approximately 77.4 ha (191 acres) located in northwestern New York within the Township of Lewiston (Niagara County). The site is approximately 6.4 km (4 mi) south of Lake Ontario, 16 km (10 mi) north of the City of Niagara Falls, and is in a generally rural setting. The NFSS and its regional setting are shown in Figure 1-1; Figure 1-2 is an aerial photograph of the site that highlights the interim waste containment facility (IWCF).

The NFSS was developed as an interim waste storage area for radioactive residues from pitchblende processing and radium-contaminated sand, soil, and building rubble. Work on the IWCF was completed in late 1986.

The dominant feature of NFSS as presented in Figure 1-3 is the 4-ha (10-acre) IWCF, which is enclosed within a dike and cutoff wall, each constructed of compacted clay. The cutoff wall extends a minimum of 45 cm (18 in.) into an underlying gray clay unit. The dike and cutoff wall, in conjunction with the engineered earthen drainage cover or cap, enclose the wastes in a clay envelope that provides a barrier to migration of waste constituents. More detailed information on the design of the IWCF is provided in Ref. 1.

Pollution control measures implemented during construction included the use of prudent engineering controls, e.g., use of sedimentation

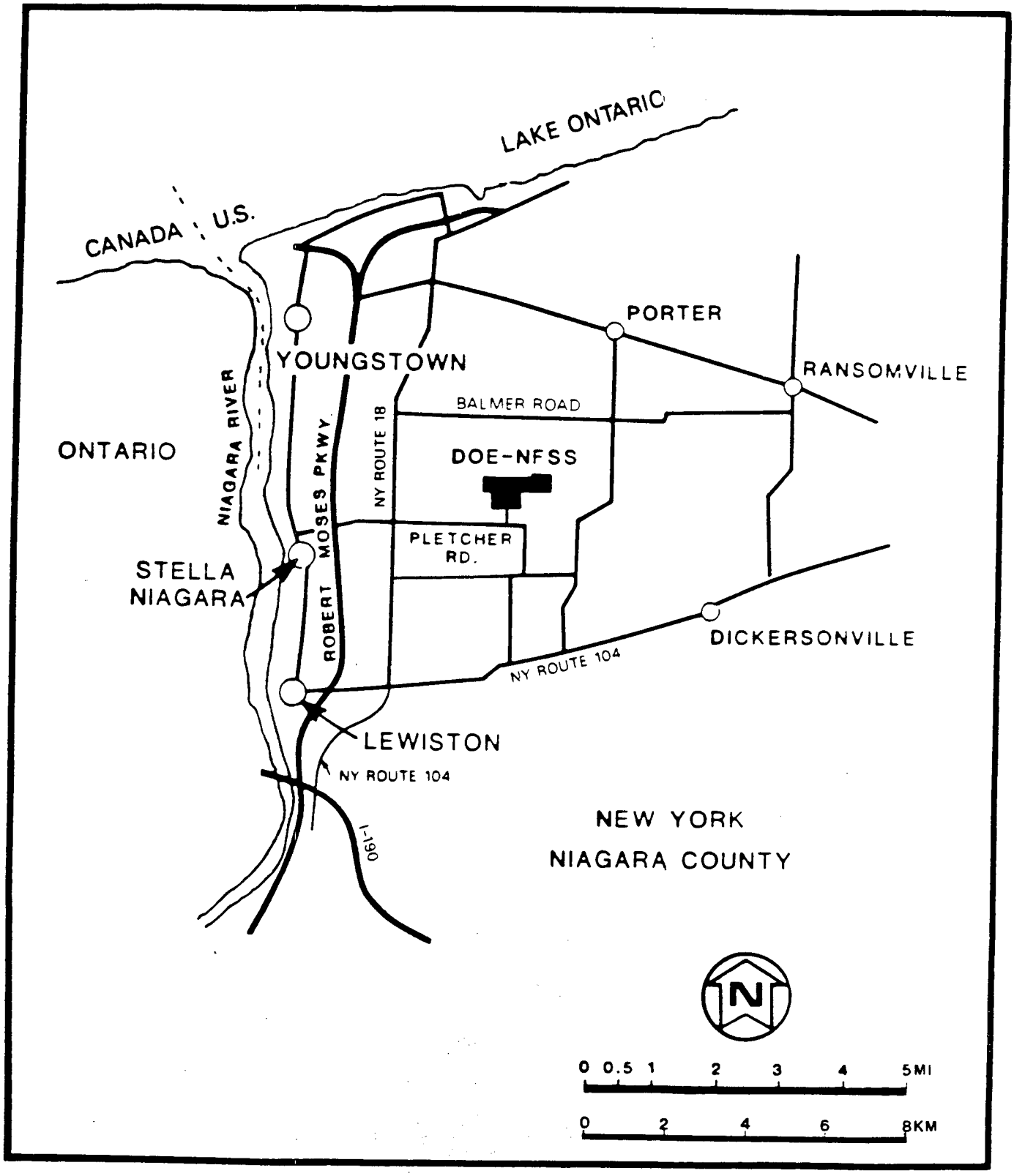


FIGURE 1-1 LOCATION OF THE NFSS

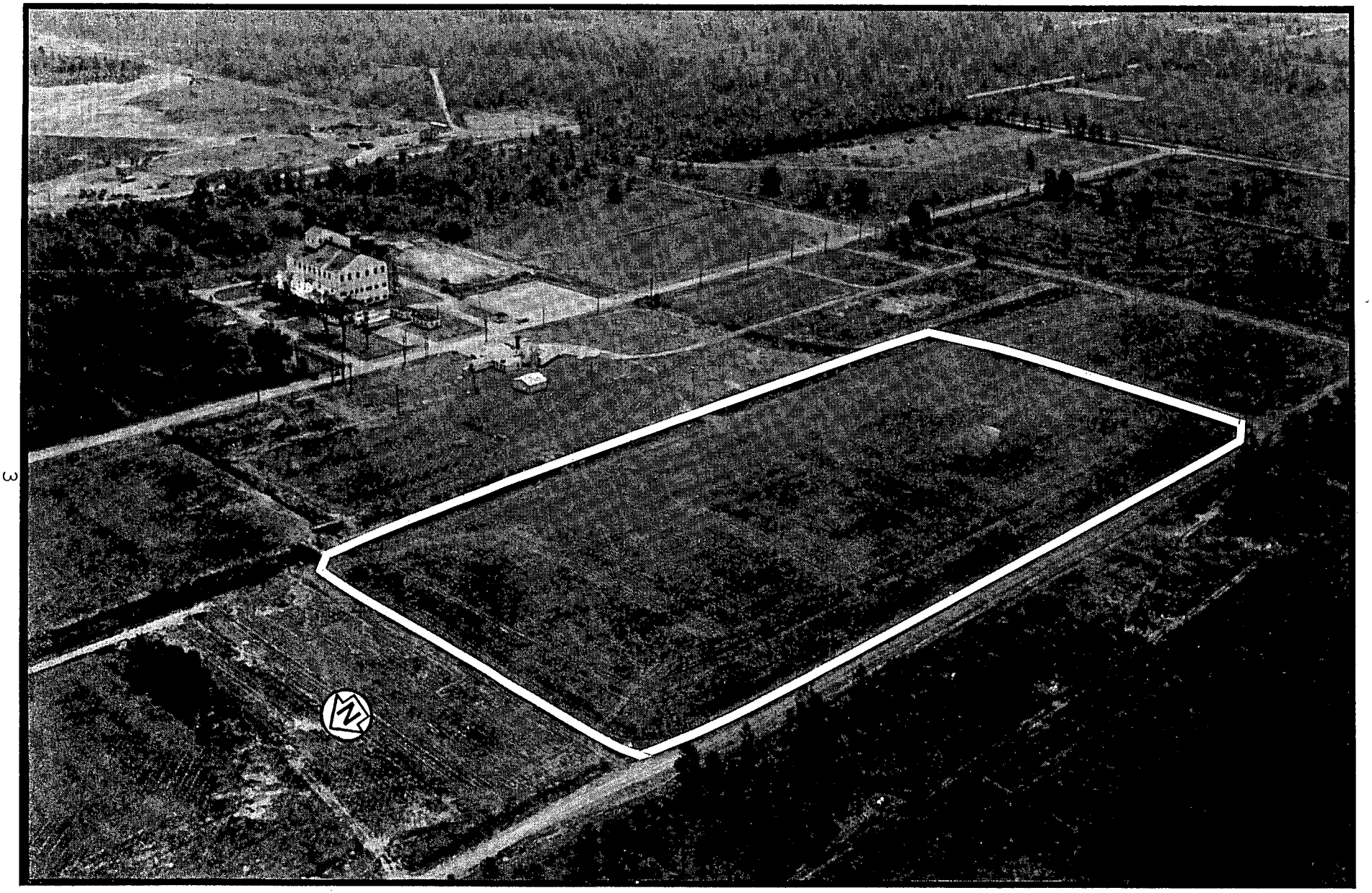


FIGURE 1-2 AERIAL VIEW OF THE NFSS INTERIM WASTE CONTAINMENT FACILITY (IWCF)

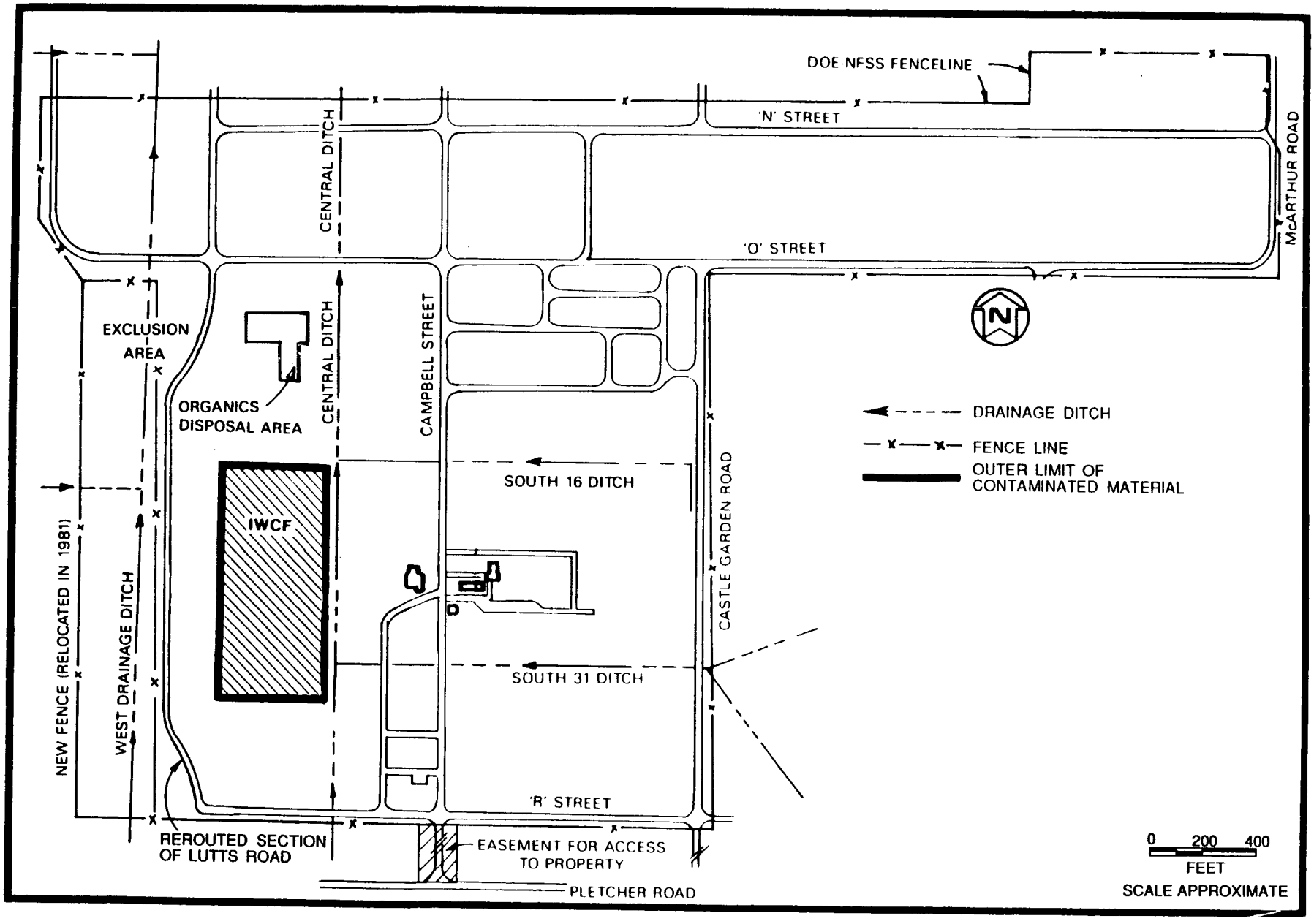


FIGURE 1-3 PRESENT CONFIGURATION OF THE NFSS

barriers in excavation areas and batch discharges of treated, impounded surface water in accordance with New York State Department of Environmental Conservation (NYSDEC) requirements.

The site is generally level but slopes gently to the northwest at elevations between 96.9 and 97.8 m (318 and 321 ft) above mean sea level (m.s.l.). The site drains poorly because of soil characteristics and the flatness of the terrain. Soils at the NFSS are predominantly silt loams underlain by a clayey glacial till and a lacustrine clay. Sand-gravel lenses are common. Bedrock lies 9.1 to 15.2 m (30 to 50 ft) beneath the surface and consists of Queenston shale.

All surface water from the site discharges via the Central Drainage Ditch and its tributary ditches into Fourmile Creek, located northwest of the site (see Figure 3-3). Groundwater is present in a sand-gravel zone above bedrock and in fractures in the bedrock surface (the primary groundwater system beneath the site) and in saturated clay zones at depths of 1.5 to 6.1 m (5 to 20 ft). Groundwater level contours indicate that the surface of the groundwater flows to the north-northwest at a hydraulic gradient of approximately 3 m/km (16 ft/mi). The groundwater probably discharges into the northern reaches of the Niagara River close to Lake Ontario (Ref. 2).

Lake and river water are the predominant sources of potable water in the area surrounding the NFSS; approximately 90 percent of the population in Niagara and Erie Counties uses these sources. Water from Lake Erie serves 65 percent of the population, and water from the upper Niagara River serves 25 percent of the population (Ref. 3). Communities north of the Niagara escarpment, including Lewiston and Porter Townships, receive much of their water from these sources.

Groundwater is used to supply approximately 10 percent of the population in Niagara and Erie Counties. The primary uses are for small domestic and farm supplies in rural sections. The dominant

source of this water, the Lockport dolomite aquifer, is absent north of the Niagara escarpment, where the NFSS is located. Wells in the vicinity of the NFSS generally have a low yield and supply water of poor quality. The upper groundwater systems in the glacial deposits near the NFSS are sometimes capable of supplying adequate groundwater for domestic use, although these sources may be depleted during dry seasons (Ref. 3).

The climate of the NFSS is classified as humid continental, with a considerable moderating influence from Lake Ontario. The normal temperature range is -3.9 to 24.4°C (25 to 76°F), with a mean annual temperature of 8.9°C (48°F). Mean annual precipitation is 80 cm (32 in.). Snowfall averages 140 cm/yr (56 in./yr), accounting for about 10 percent of the annual total precipitation (Ref. 4).

Wind speeds and directions recorded in the vicinity of the NFSS are given in Figure 1-4. The data show that the wind originates predominantly from the southwest. The average monthly wind speed ranges from 15.9 to 23 km/h (9.9 to 14.3 mph) (Ref. 4).

The primary areas of population near the NFSS are the towns of Lewiston (population: 16,200), Niagara (population: 9,650), Porter (population: 7,250), and Niagara Falls City (population: 71,400) (Ref. 3). Almost three-fourths of the 227,000 people residing in Niagara County live in urban areas. Population density in Niagara County in 1980 was about 168 persons/km^2 (430 persons/mi^2) (Ref. 3). Land uses immediately adjacent to the site are varied (see Figure 1-5). The site is bordered by a hazardous waste disposal site, a sanitary landfill, and land that is currently vacant.

Land in the vicinity is also used for truck farms, orchards, and rural single-family dwellings. Lewiston-Porter Central Schools are located 3.1 km (1.5 mi) west of the site on Blairville/Creek Road. The nearest permanent residence is 1.1 km (0.7 mi) southwest of the site.

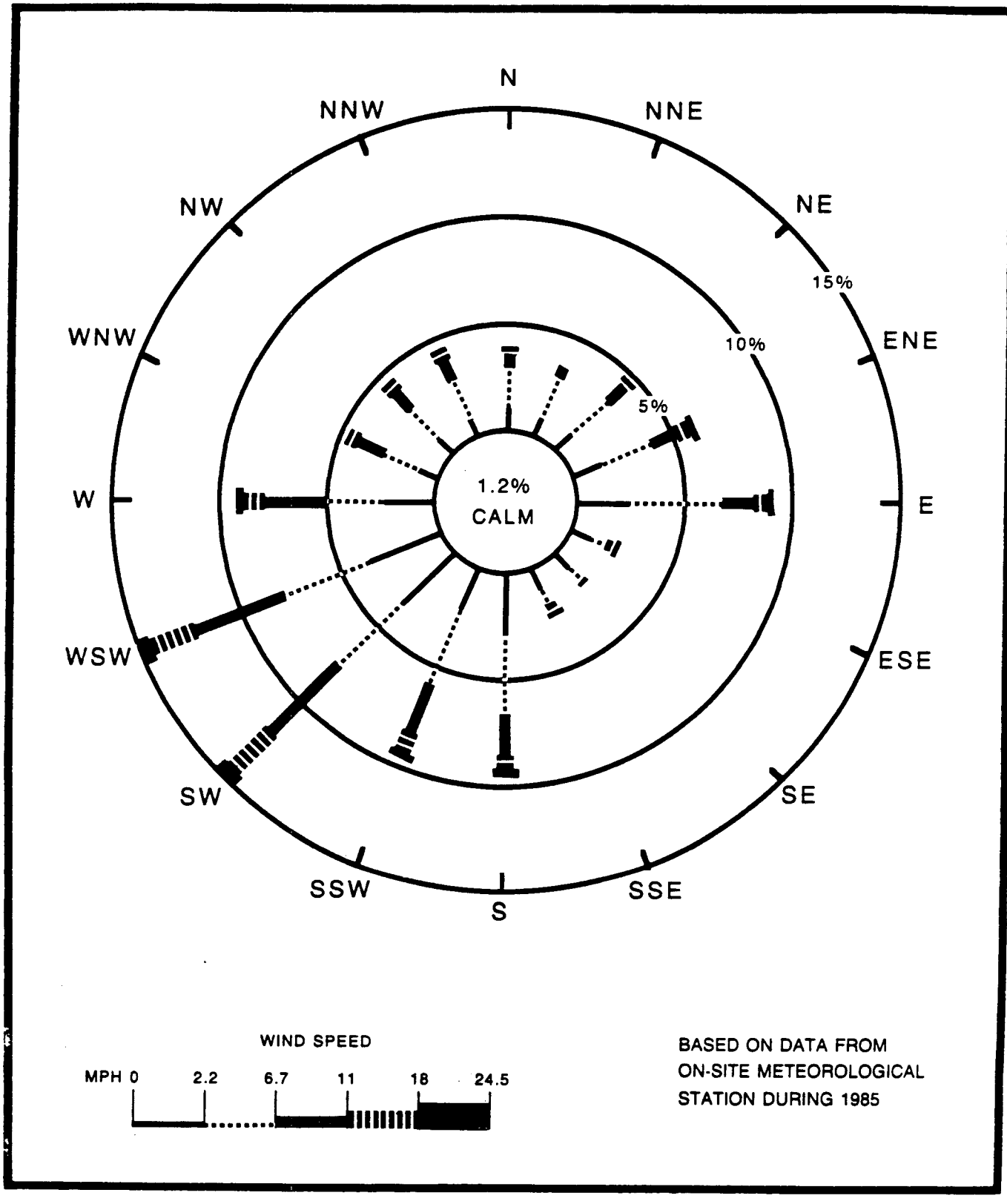
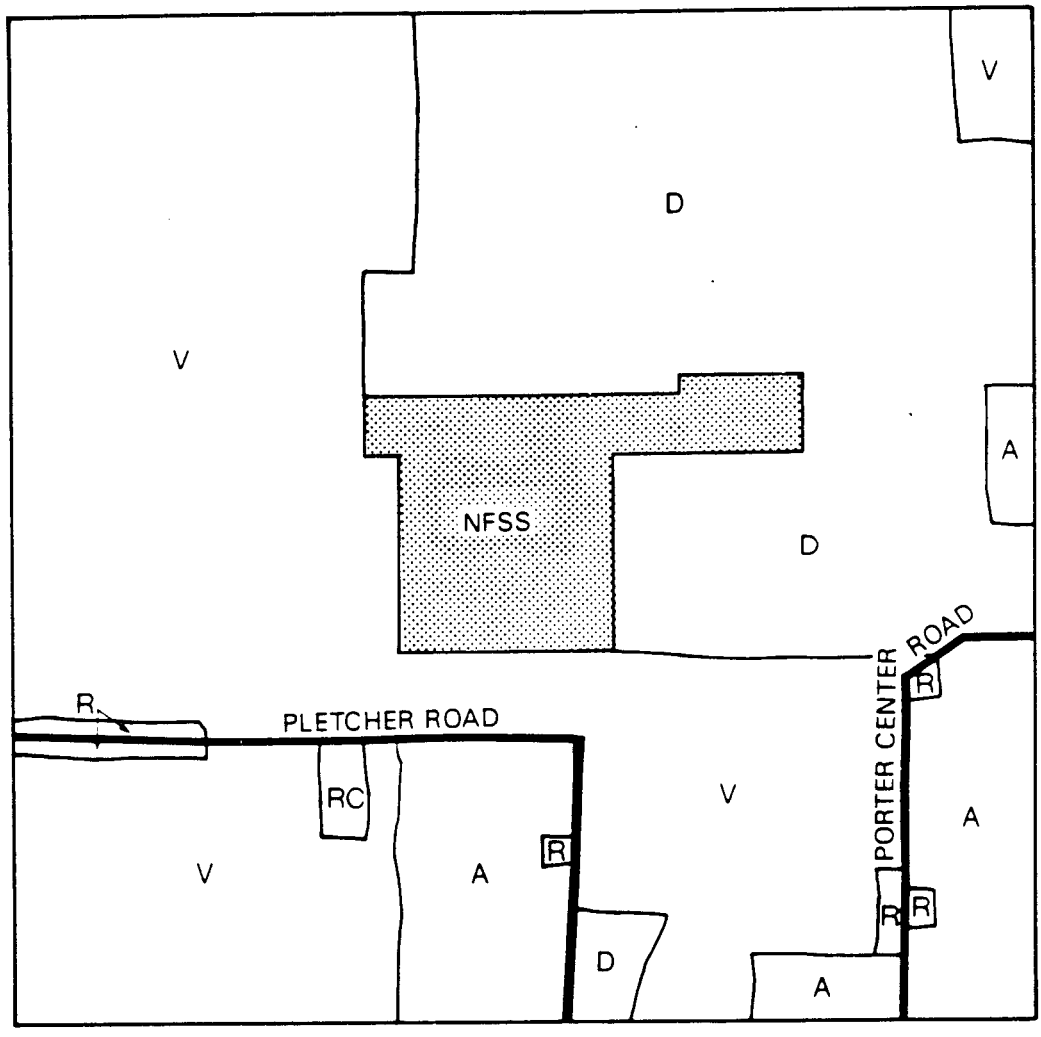


FIGURE 1-4 ANNUAL WIND ROSE FOR THE NFSS



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS, AND USGS TOPOGRAPHIC MAP, 1:24000 SCALE, RANSOMVILLE QUADRANGLE, (PHOTO REVISED 1980)

R RESIDENTIAL
RC RECREATIONAL
A AGRICULTURAL
D WASTE DISPOSAL
V VACANT

N

0 0.5 MI
0 0.8 KM

FIGURE 1-5 GENERALIZED LAND USE IN THE VICINITY OF THE NFSS

1.2 SITE HISTORY

The NFSS is a remnant of the original 612-ha (1,511-acre) site that was used during World War II by the Manhattan Engineer District (MED) project and was a portion of the Department of the Army's Lake Ontario Ordnance Works (LOOW). Except for nonradioactive boron-10 enriching operations during the periods 1954 to 1958 and 1964 to 1971, the site's major use from 1944 to the present has been for the storage of radioactive residues produced as by-products of uranium production during the MED project and subsequent Atomic Energy Commission (AEC) projects. The weight and volume of the residues and sands stored at the NFSS are summarized in Table 1-1. Buildings and other features of the NFSS before recent interim remedial actions are illustrated in Figure 1-6.

The first materials to arrive at the site were low-grade residues and by-products from the Linde Air Products Division in Tonawanda, New York (the L-30, L-50, and R-10 residues) and from the Middlesex Sampling Plant in Middlesex, New Jersey (the F-32 residues). The L-30 and L-50 residues were stored in Buildings 411, 413, and 414, and the F-32 residues were stored in the recarbonation pit directly west of Building 411. The R-10 residues and associated iron cake were stored in an open area north of Building 411. These residues were subject to environmental processes that transported contaminants into the soil and drainage pathways, resulting in the contamination of other portions of the site and of off-site drainage pathways. The small quantity of Middlesex sands resulting from decontamination activities at the Middlesex Sampling Plant was stored in Building 410. In 1949 pitchblende residues (the K-65 residues) resulting from uranium extraction conducted at a St. Louis plant were transported to the LOOW in drums. Some of these were stored outdoors along existing roads and rail lines; others were stored in Building 410. From 1950 to 1952, the K-65 residues were transferred to a renovated concrete water tower (Building 434).

In 1979, Battelle Columbus Laboratories performed a radiological survey of the NFSS. The survey report published by Battelle in June

TABLE 1-1

RESIDUES AND MIDDLESEX SANDS STORED AT THE NFSS[a]

Residue	Weight (tons)	Volume [m^3 (yd^3)]
K-65	3,051	2,447 (3,200)
L-30	8,227	6,050 (7,960)
L-50	1,878	1,634 (2,150)
F-32	138	334 (440)
R-10	8,235	7,144 (9,400)
Middlesex Sands	2	174 (229)

[a]Source: Reference 5.

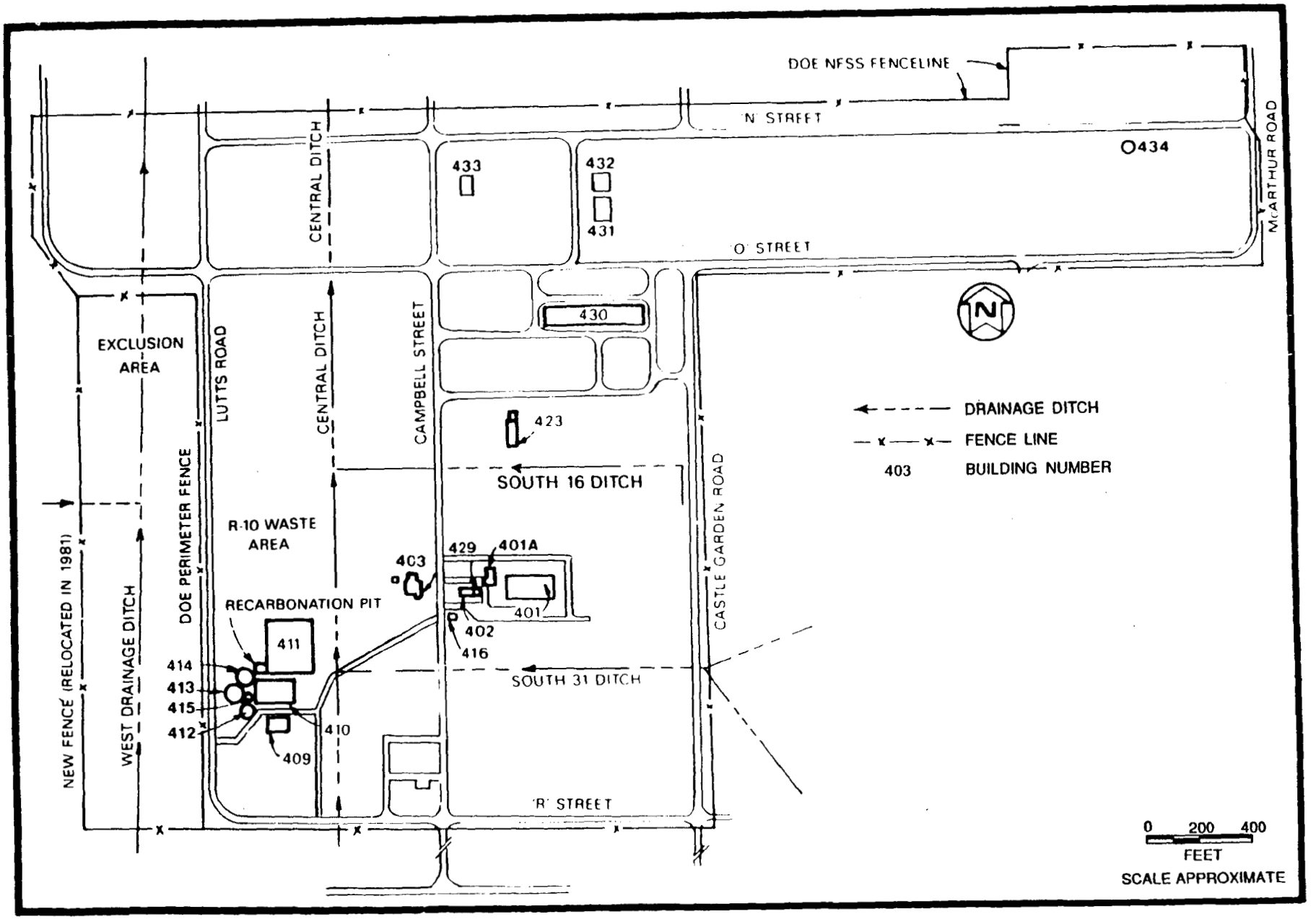


FIGURE 1-6 THE NFSS PRIOR TO INTERIM REMEDIAL ACTIONS

1981 served as the basis for initial interim remedial action planning for the site (Ref. 5). Bechtel National, Inc. (BNI) was chosen by DOE as the project management contractor for the NFSS project in 1981. BNI helped plan and execute interim remedial action at the site. BNI currently maintains site security, performs maintenance as required, and implements the environmental monitoring program. Access to the site is controlled by a 2.1-m- (7-ft-) high fence that encloses the DOE property.

Since 1980, various steps have been taken at the NFSS to minimize potential radiological risks and prevent migration of residues. In the fall of 1980, the vent at the top of Building 434 (the former water tower in which the K-65 residues were stored) was capped to reduce radon emissions to the environment. Also during 1980, pipes penetrating the walls of the residue storage buildings were sealed or resealed as necessary to prevent radionuclide migration.

Because radon levels at the site's western boundary were exceeding DOE limits, the site fence was relocated approximately 152.4 m (500 ft) to the west in mid-1981, creating an exclusion area to protect the public from exposure to the higher radon levels. Radon levels at the new boundary were well below applicable guidelines. In 1981, remedial action was performed on a triangular-shaped area adjacent to the NFSS, bounded by Vine and O Streets and Castle Garden Road. Approximately 342 m^3 (450 yd^3) of contaminated material was excavated from this vicinity property and placed in storage.

To further reduce the levels of radon emanating from the site, Buildings 413 and 414 (used for storing the L-50 residues) were upgraded and sealed in 1982. Also in 1982, to prevent further migration of residues, contaminated soil near the R-10 pile was moved onto the pile, and a dike and cutoff wall were constructed around the R-10 area. The R-10 pile was then covered with an ethylene propylene diene monomer (EPDM) liner, which markedly reduced radon emanation from the R-10 area. This action effectively

reduced radon concentrations at the old site boundary (along Lutts Road) to levels that were below DOE guidelines.

In 1983 and 1984 the EPDM liner was removed, additional contaminated soils and rubble from on- and off-site areas were placed on the pile, and the pile was covered with the first layer of the interim clay cap. These actions constituted the origin of the IWCF. In 1984, 93 percent of the K-65 residues were transferred from Building 434 to Building 411.

Construction activities during 1985 included completion of the transfer of K-65 residues from Building 434 to the IWCF, demolition of Building 434, completion of remedial action on vicinity properties near the site, and continuation of installation of the cap over the wastes in the IWCF. These activities involved excavating approximately 10,640 m^3 (14,000 yd^3) of contaminated materials from on- and off-site areas, transferring 1,102 m^3 (1,450 yd^3) of building rubble to the IWCF, and discharging 12,047,691 liters (3,183,000 gal) of treated, impounded water in accordance with NYSDEC permit requirements. The permit, which expired May 1, 1988, was not renewed because the site is inactive except for environmental monitoring and surveillance and maintenance of the IWCF.

During 1986, the cap over the IWCF was completed and vibrating wire pressure transducers and pneumatic pressure transducers were installed to monitor the integrity of the waste facility. Also in 1986, another 25.8 million liters (6.8 million gal) of contaminated water was treated and released, and four of the six water treatment ponds were reduced to grade. In 1987 the impounded water in the remaining two ponds was treated and released [an additional 38.8 million liters (10.2 million gal)]. These two ponds were reduced to grade, and the NFSS was closed.

The DOE Record of Decision on the long-term disposition of the NFSS was issued in August 1986. For the radioactive wastes, DOE has selected long-term, in-place management consistent with the guidance

provided in the U.S. Environmental Protection Agency (EPA) regulations governing uranium mill tailings. For the radioactive residues, it is the DOE intent to provide for long-term, in-place management consistent with future applicable EPA guidance. If future analyses show that in-place management cannot meet EPA guidance, another option will be selected that meets EPA guidance and is environmentally acceptable.

In 1988, several isolated areas of residual radioactivity were excavated and placed in temporary storage. This material will remain in temporary storage until the IWCF is reopened so that additional materials can be added. At the present time all of the residual radioactivity on-site has been remediated, with the exception of one localized area suspected to be both radiologically and chemically contaminated. This remaining area will be remediated in the future.

There are no continuing commercial or industrial activities at the NFSS; therefore, no radioactive effluents exist at the site.

1.3 HYDROGEOLOGICAL CHARACTERISTICS OF THE SITE

This section presents data on the hydrogeology at the NFSS. The interpretations are based on groundwater levels measured during calendar year 1988. Active groundwater monitoring wells (Figures 1-7 and 1-8) were installed at the NFSS site at three different times. The first set of wells was installed by Acres American, Inc. in 1981 (Ref. 6); these wells are designated with a "BH-" prefix (Figures 1-7 and 1-8). The second set was installed by BNI in 1982 (Ref. 2), and these are designated with an "A-" prefix (Figures 1-7 and 1-8). The third set, also installed by BNI in 1986-1987 as part of the post-closure activities for the disposal cell (Ref. 7), are designated with an "OW-" prefix and an "A" or "B" suffix (Figure 1-8). A summary of well construction information is shown in Tables 1-2 and 1-3. Examples of well construction details are presented in Appendix E.

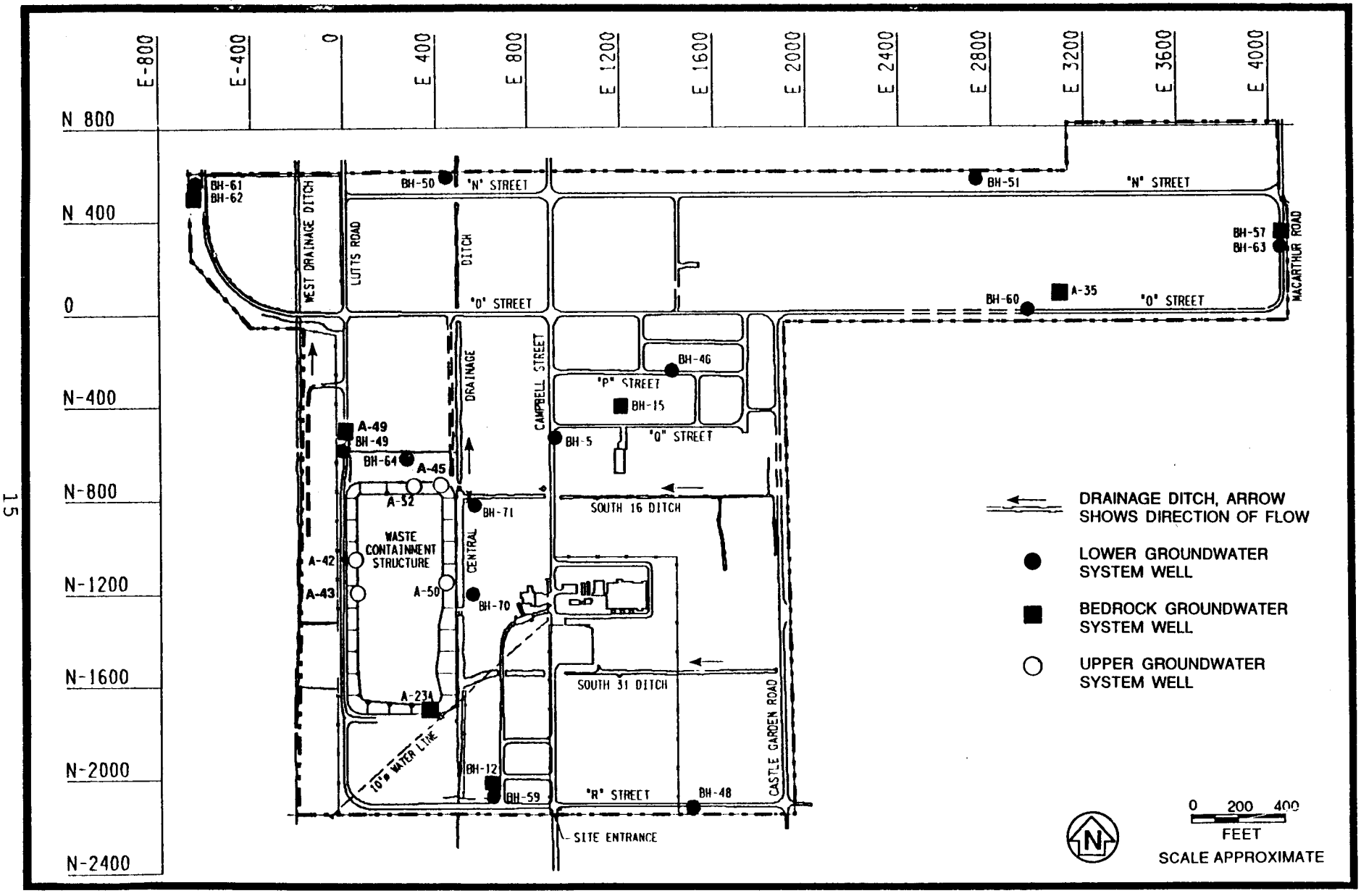


FIGURE 1-7 LOCATIONS OF GROUNDWATER MONITORING WELLS OUTSIDE IWCF

GRB: [42,30] 202WNS10.DGN

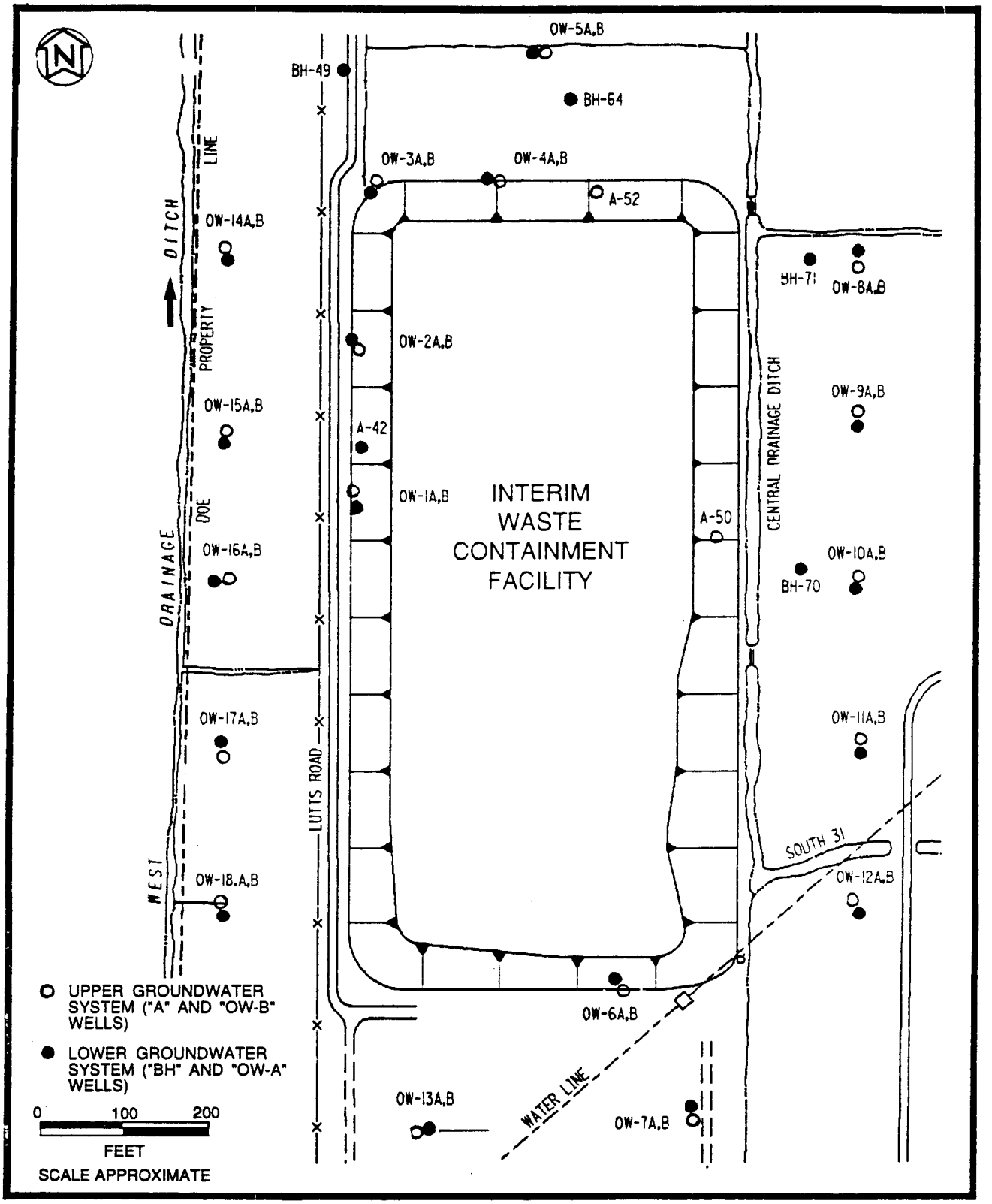


FIGURE 1-8 LOCATIONS OF GROUNDWATER MONITORING WELLS SURROUNDING INTERIM WASTE CONTAINMENT FACILITY

TABLE 1-2

NFSS UPPER SYSTEM MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
A-42	Mar. 1983	6.9 (22.5)	3.2-6.9 (10.4-22.5)	PVC[a]
A-43	Mar. 1983	4.3 (14.0)	2.1-4.3 (7.0-14.0)	PVC
A-45	Mar. 1983	6.1 (20.0)	2.4-6.1 (8.0-20.0)	PVC
A-50	Mar. 1983	7.0 (23.0)	3.0-6.7 (10.0-22.0)	PVC
A-52	Mar. 1983	4.6 (15.0)	1.8-4.6 (6.0-15.0)	PVC
OW-1B	Oct. 1986	5.2 (17.0)	3.1-4.7 (10.2-15.5)	316 Stainless Steel
OW-2B	Sept. 1986	6.1 (20.0)	4.1-5.6 (13.5-18.5)	316 Stainless Steel
OW-3B	Oct. 1986	4.9 (16.0)	2.9-4.4 (9.5-14.5)	316 Stainless Steel
OW-4B	Oct. 1986	5.2 (17.0)	3.1-4.6 (10.2-15.5)	316 Stainless Steel
OW-5B	Oct. 1986	5.2 (17.0)	2.9-4.4 (9.5-14.5)	316 Stainless Steel
OW-6B	Oct. 1986	5.2 (17.0)	3.1-4.7 (10.3-15.5)	316 Stainless Steel
OW-7B	Oct. 1986	4.0 (13.0)	1.9-3.4 (6.3-11.3)	316 Stainless Steel
OW-8B	Nov. 1986	3.7 (12.0)	1.7-3.2 (5.5-10.5)	316 Stainless Steel
OW-9B	Nov. 1986	4.5 (14.6)	2.5-4.0 (8.2-13.2)	316 Stainless Steel
OW-10B	Nov. 1986	8.8 (29.0)	5.3-8.4 (17.3-27.6)	316 Stainless Steel
OW-11B	Nov. 1986	4.9 (16.0)	2.3-3.8 (7.5-12.5)	316 Stainless Steel
OW-12B	Nov. 1986	3.7 (12.0)	1.7-3.3 (5.8-10.8)	316 Stainless Steel
OW-13B	Nov. 1986	4.3 (14.0)	2.2-3.7 (7.2-12.2)	316 Stainless Steel
OW-14B	Oct. 1986	4.6 (15.2)	2.6-4.1 (8.5-13.5)	316 Stainless Steel
OW-15B	Oct. 1986	3.7 (12.0)	1.7-3.3 (5.7-10.7)	316 Stainless Steel
OW-16B	Oct. 1986	4.0 (13.0)	2.1-3.6 (6.9-11.9)	316 Stainless Steel
OW-17B	Oct. 1986	5.2 (17.0)	3.2-4.7 (10.5-15.5)	316 Stainless Steel
OW-18B	Oct. 1986	5.1 (16.6)	3.1-4.6 (10.2-15.2)	316 Stainless Steel

[a]PVC - polyvinyl chloride.

TABLE 1-3

NFSS LOWER SYSTEM MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
Wells Installed in Bedrock				
A-23A	Mar. 1983	23.9 (78.5)	12.2-23.3 (40.0-76.3)	PVC[a]
A-35	Mar. 1983	24.4 (80.1)	12.2-24.7 (40.0-81.0)	PVC
A-49	Mar. 1983	27.4 (90.0)	14.0-27.4 (46.0-90.0)	PVC
BH-12	June 1981	29.0 (95.0)	13.4-29.0 (44.0-95.0)	PVC
BH-15	June 1981	31.9 (104.5)	16.5-31.9 (54.0-104.5)	PVC
BH-57	June 1981	30.9 (101.5)	14.9-30.9 (49.0-101.5)	PVC
BH-62	June 1981	30.0 (98.0)	14.9-30.0 (49.0-98.0)	PVC
Wells Installed in Soil				
BH-46	June 1981	16.5 (54.0)	7.6-14.7 (25.0-48.3)	PVC
BH-48	May 1981	13.4 (44.0)	5.5-11.3 (18.0-37.1)	PVC
BH-49	May 1981	15.5 (50.9)	8.2-14.3 (27.0-47.0)	PVC
BH-5	June 1981	15.9 (52.2)	7.3-14.4 (24.0-47.2)	PVC
BH-50	May 1981	13.4 (44.0)	6.2-11.7 (20.3-38.3)	PVC
BH-51	May 1981	15.8 (52.0)	7.6-14.0 (25.0-46.0)	PVC
BH-59	May 1981	12.3 (40.5)	7.0-11.5 (23.0-37.7)	PVC
BH-60	May 1981	13.9 (45.8)	6.4-12.3 (21.0-40.5)	PVC
BH-61	May 1981	14.0 (46.0)	7.3-12.7 (24.0-41.6)	PVC
BH-63	May 1981	14.8 (48.7)	8.5-14.8 (28.0-48.4)	PVC
BH-64	June 1981	14.8 (48.7)	8.5-13.1 (28.0-43.0)	PVC
BH-70	June 1981	13.7 (45.0)	6.1-12.2 (20.0-40.0)	PVC
BH-71	June 1981	30.5 (100.0)	8.5-14.0 (28.0-46.0)	PVC
OW-1A	Oct. 1986	14.3 (47.0)	10.6-13.7 (34.8-45.0)	316 Stainless Steel
OW-2A	Oct. 1986	14.0 (46.0)	10.3-13.4 (33.7-44.0)	316 Stainless Steel
OW-3A	Oct. 1986	12.8 (42.0)	9.9-11.4 (32.4-37.4)	316 Stainless Steel

TABLE 1-3

(continued)

Well Number	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
Wells Installed in Soil (continued)				
OW-4A	Oct. 1986	12.4 (40.6)	8.6-11.7 (28.1-38.4)	316 Stainless Steel
OW-5A	Oct. 1986	13.5 (44.3)	9.8-12.8 (32.0-42.0)	316 Stainless Steel
OW-6A	Oct. 1986	12.2 (40.2)	8.6-11.7 (28.1-38.4)	316 Stainless Steel
OW-7A	Oct. 1986	12.0 (39.6)	8.5-11.6 (27.9-38.2)	316 Stainless Steel
OW-8A	Nov. 1986	13.6 (44.6)	10.0-13.1 (32.7-43.0)	316 Stainless Steel
OW-9A	Nov. 1986	12.5 (41.1)	8.7-11.9 (28.6-38.9)	316 Stainless Steel
OW-10A	Nov. 1986	12.3 (40.3)	10.2-11.7 (33.5-38.5)	316 Stainless Steel
OW-11A	Nov. 1986	11.3 (37.2)	7.7-10.8 (25.2-35.5)	316 Stainless Steel
OW-12A	Nov. 1986	11.6 (38.3)	7.8-12.1 (25.0-39.7)	316 Stainless Steel
OW-13A	Oct. 1986	12.5 (41.1)	9.0-13.2 (29.4-43.4)	316 Stainless Steel
OW-14A	Oct. 1986	13.7 (44.8)	10.1-13.2 (33.1-43.4)	316 Stainless Steel
OW-15A	Oct. 1986	13.9 (45.5)	11.9-13.4 (39.0-44.0)	316 Stainless Steel
OW-16A	Oct. 1986	13.8 (45.2)	9.9-13.0 (32.4-42.7)	316 Stainless Steel
OW-17A	Oct. 1986	12.9 (42.5)	9.2-12.3 (30.1-40.4)	316 Stainless Steel
OW-18A	Oct. 1986	14.6 (47.8)	10.9-14.0 (35.7-46.0)	316 Stainless Steel

[a]PVC - polyvinyl chloride.

The three groundwater systems monitored at the NFSS have been referred to as "upper," "lower," and "bedrock" by previous investigators. The lower and bedrock systems are thought to be hydraulically connected, but for the purposes of this discussion they are described separately. Further background information on site geology, hydrogeology, and well installation methods can be found in Refs. 6-8.

Groundwater levels in wells at the NFSS site were measured with an electric downhole probe water level indicator. Water level measurements for 1988 were taken at monthly intervals for the BH and A wells and at weekly intervals for the OW wells.

1.3.1 Upper Groundwater System

The upper groundwater system occurs in a zone of discontinuous silts, sands, and clays approximately 1.5 to 8.5 m (5 to 28 ft) below ground surface (Ref. 2). Wells in this zone are screened in unconsolidated silts and sands at depths of 2.4 to 6.7 m (8 to 22 ft). Elevations of water levels measured in 1988 for the A wells installed in the upper groundwater system are shown as hydrographs in Figure 1-9. Precipitation records for NFSS as measured on site are presented in Figure 1-9 with the hydrographs. Water level elevations measured in 1988 for the OW wells installed in the upper system are shown as hydrographs in Figures 1-10 through 1-14. The hydrographs display seasonal variation, with the highest water level elevations in the spring [about 319 ft above mean sea level (ft msl)] and the lowest in the fall (about 307 ft msl).

Figure 1-9 shows poor correlation in groundwater levels from well to well, which may be due to the lateral discontinuity of the screened materials and the relatively long distances between the wells (Figure 1-7). The low water level in well A-42 during July reflects residual drawdown after pumping during a sample collection cycle (Figure 1-9). Figures 1-10 through 1-14 show a more consistent correlation in groundwater levels from well to well for the OW wells

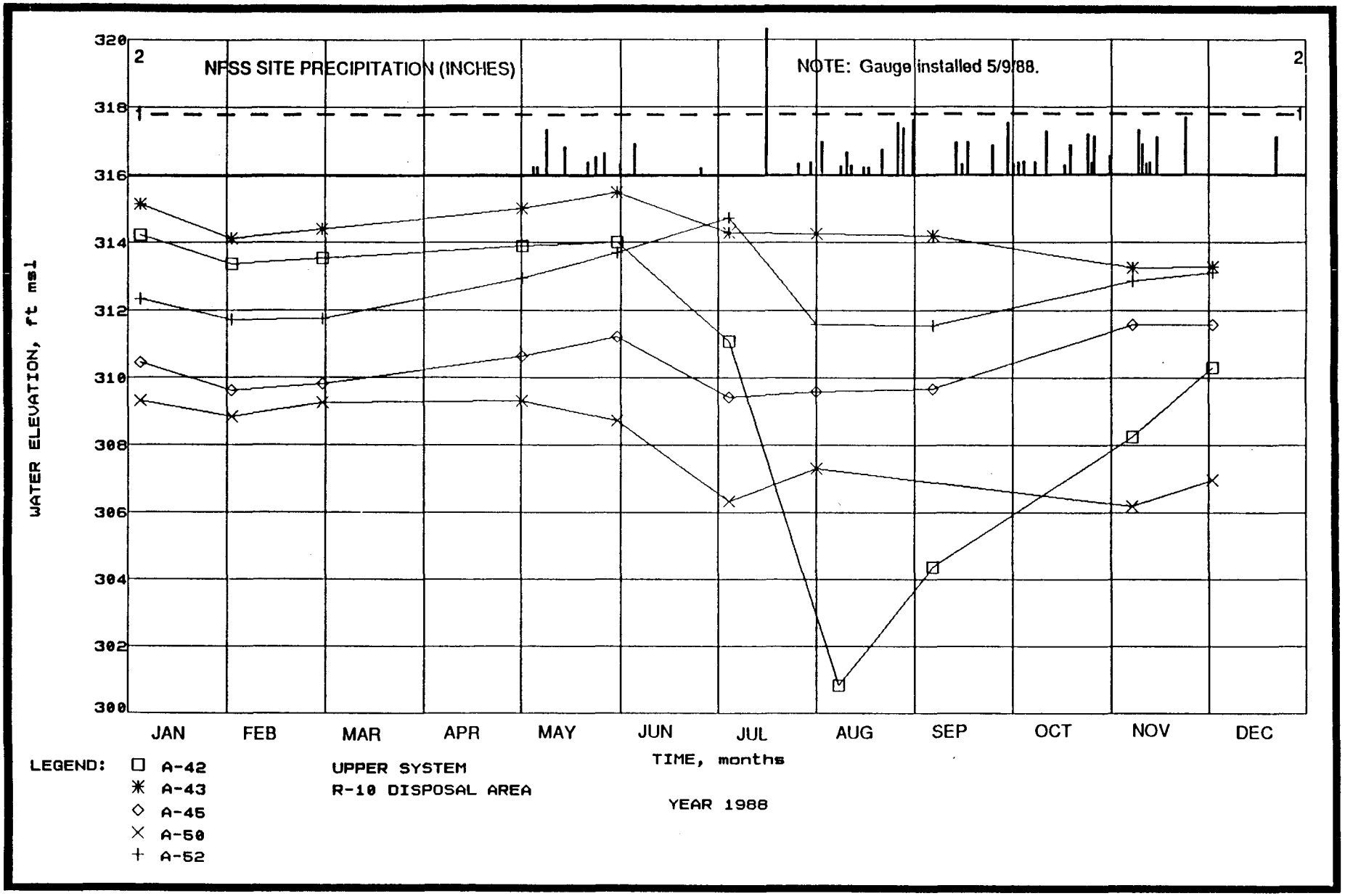


FIGURE 1-9 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM
WELLS A-42, A-43, A-45, A-50, AND A-52

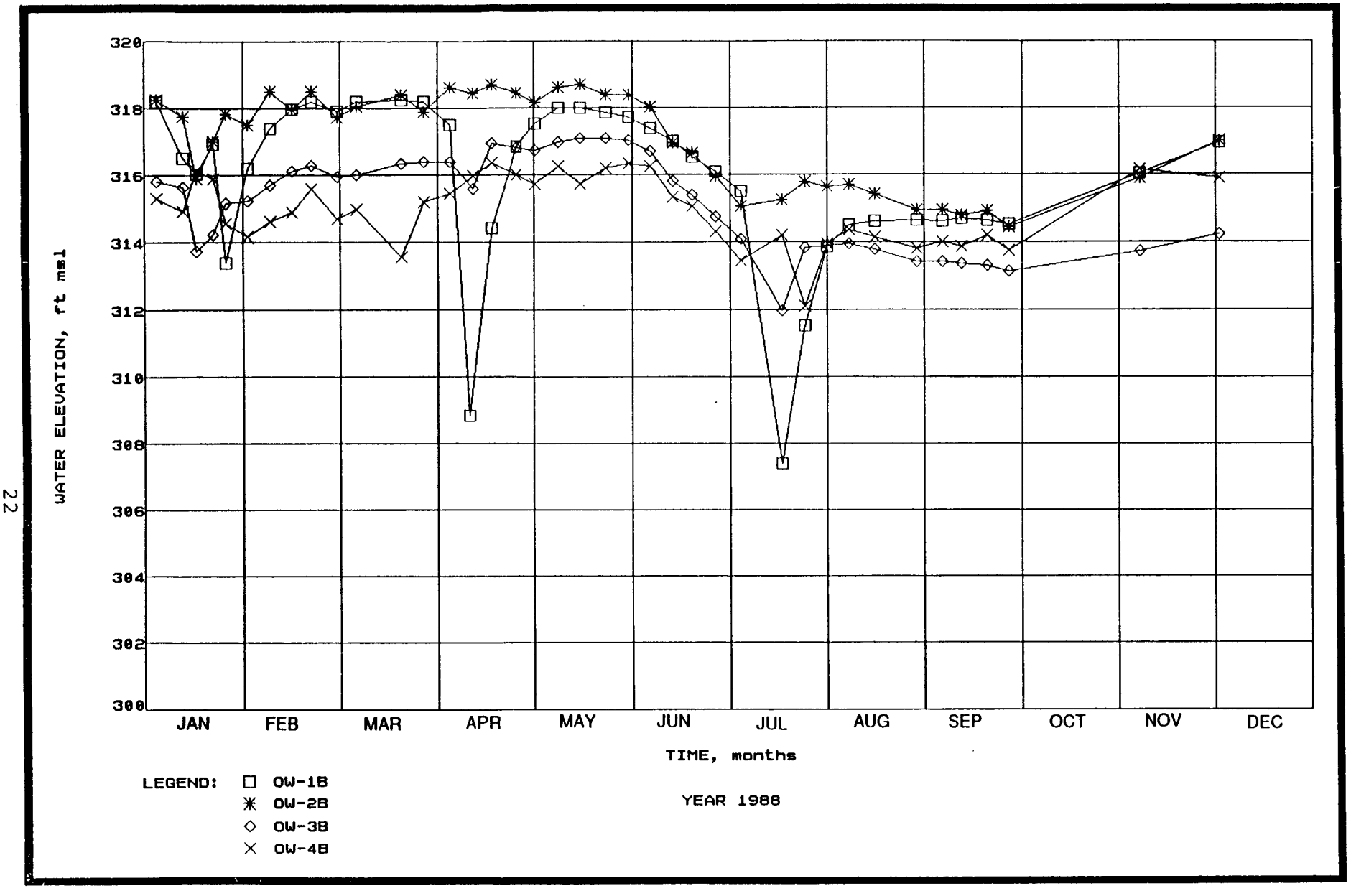


FIGURE 1-10 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS OW-1B, OW-2B, OW-3B, AND OW-4B

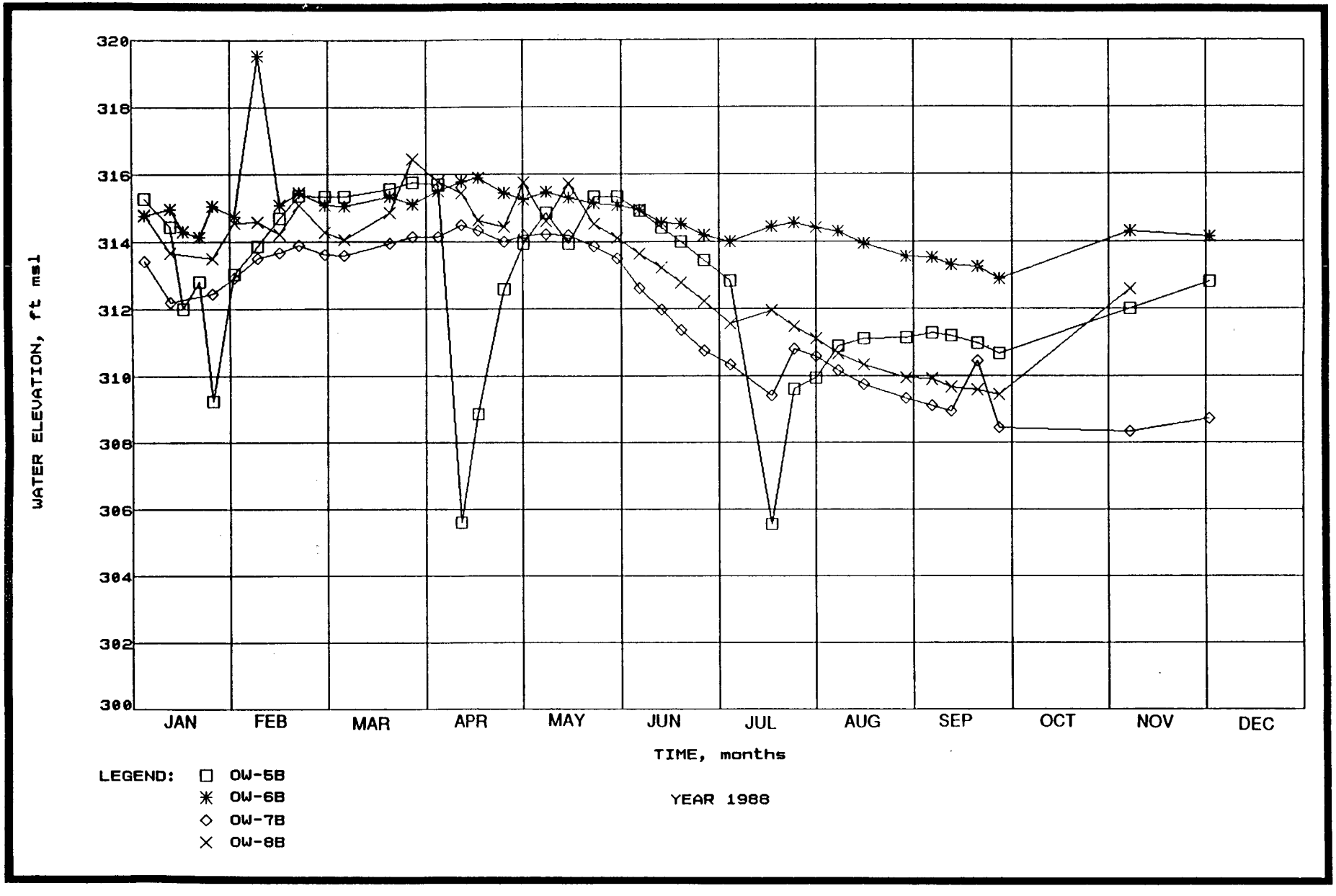


FIGURE 1-11 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS OW-5B, OW-6B, OW-7B, AND OW-8B

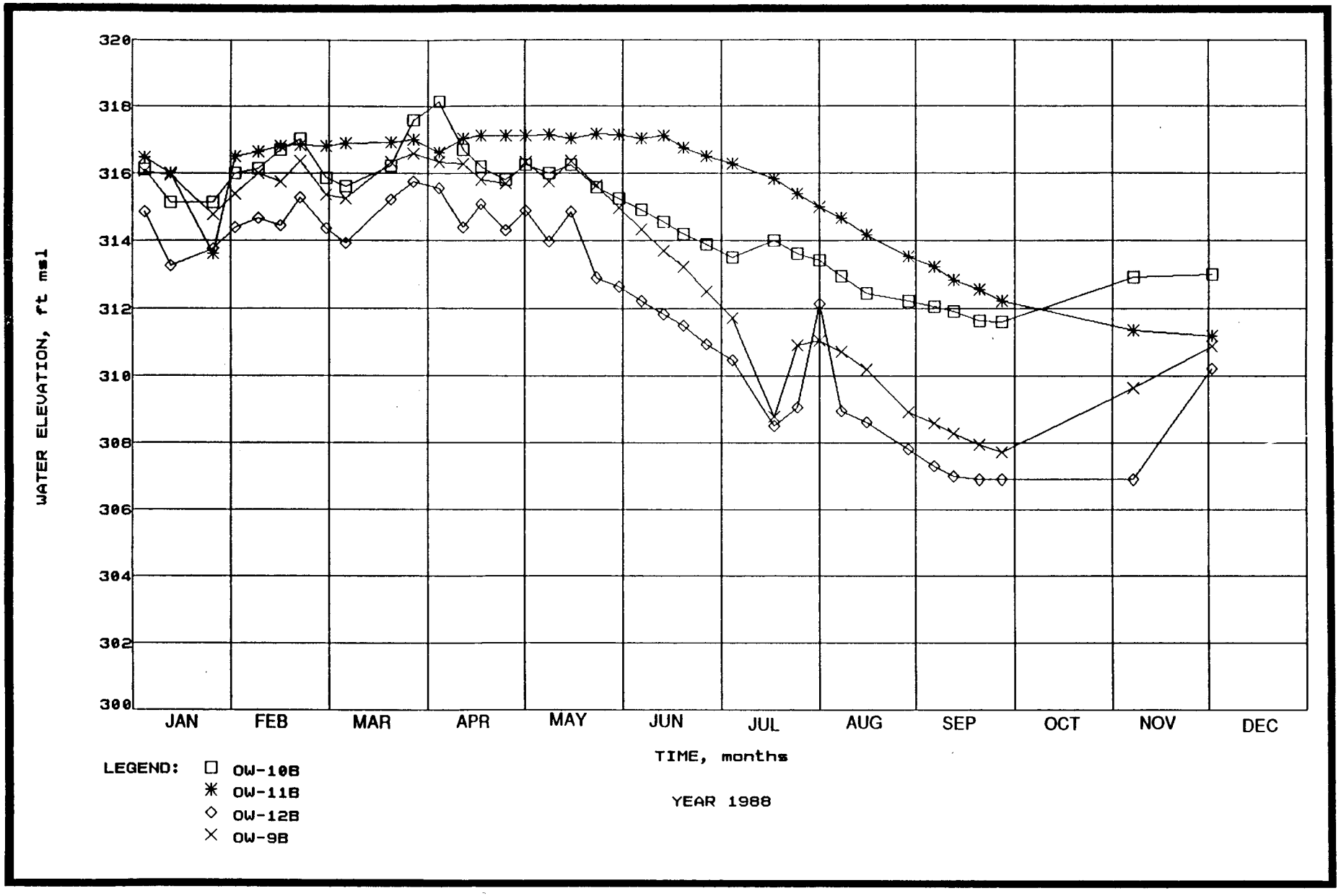


FIGURE 1-12 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS OW-10B, OW-11B, OW-12B, AND OW-9B

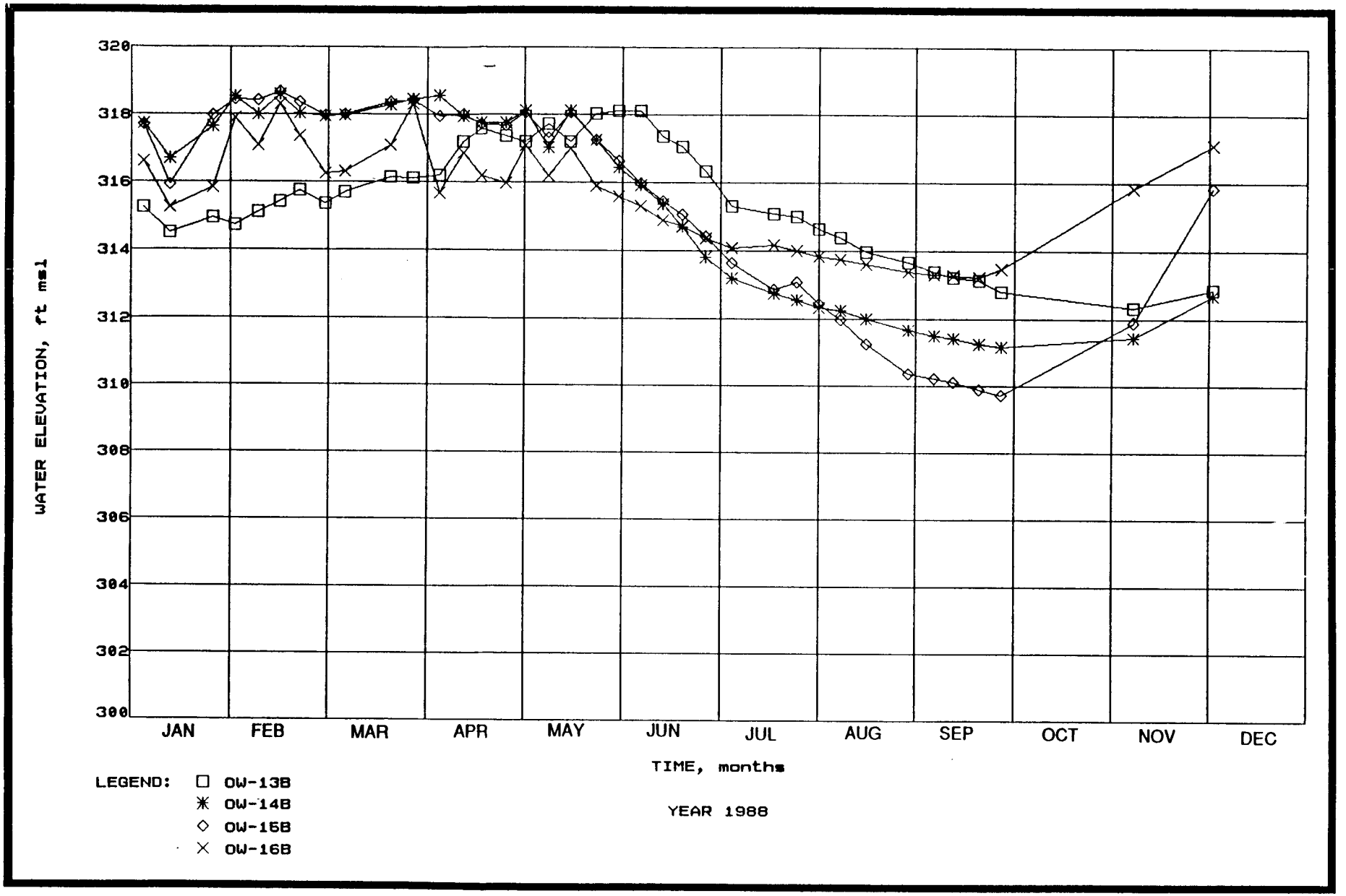


FIGURE 1-13 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS OW-13B, OW-14B, OW-15B, AND OW-16B

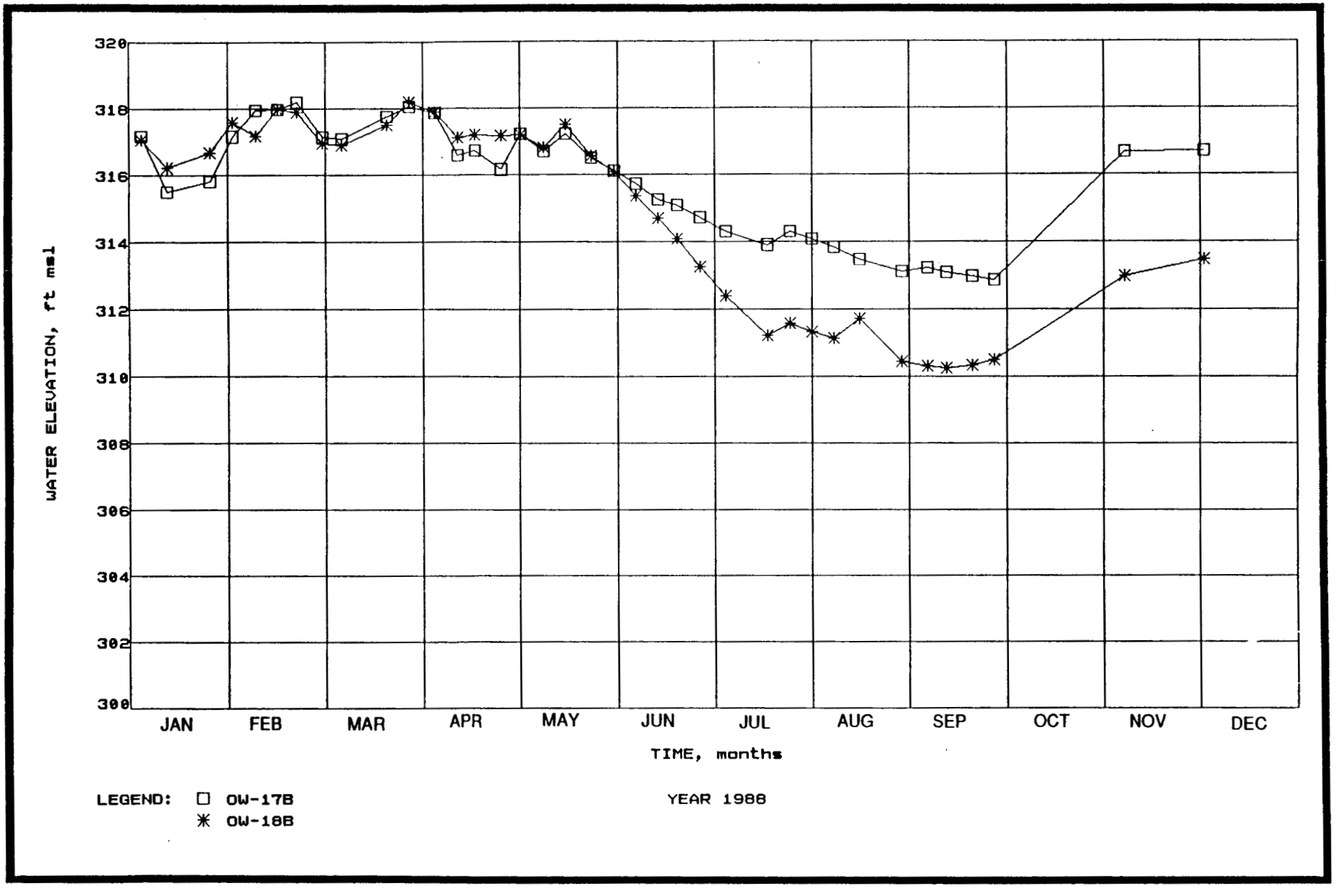


FIGURE 1-14 HYDROGRAPHS OF UPPER GROUNDWATER SYSTEM WELLS OW-17B AND OW-18B

than for the A wells. The better correlation reflects the shorter separation between the OW wells (Figure 1-8).

The quarterly decline in water levels for some of the wells (OW-9B, OW-5B, OW-1B; Figures 1-10 through 1-12) is due to well purging for water quality sampling and subsequent slow recoveries in the wells. Above-background uranium concentrations in A-42 brought about an investigation in late 1988 (Ref. 8). Results of this investigation are presented in Subsection 4.2.

The discontinuous nature of the unconsolidated materials that contain the upper groundwater system precludes useful preparation of representative potentiometric surface maps. (Potentiometric surface is defined as the level to which water will rise in tightly cased wells. Delineation of the potentiometric surface of an aquifer indicates groundwater slope and flow direction.) Therefore, slope and flow direction are not presented for this system.

1.3.2 Lower Groundwater System

The zone containing the lower groundwater system is located approximately 9.1 to 13.7 m (30 to 45 ft) below ground surface. The lower system occurs in a silt and sand zone between an underlying red silt and an overlying gray clay and is in hydraulic connection with the bedrock fracture system. The water-bearing zone above bedrock is absent in a few locations across the site (Ref. 2).

Hydrographs of the wells screened in the lower groundwater system (Figures 1-15 through 1-22) show a definite seasonal variation of water levels. The water levels in the wells are highest in the spring (about 318 ft msl) and lowest in the fall (308 ft msl) and show good correlation between wells, with few exceptions, over the entire year. The correlation between wells demonstrates the hydraulic continuity of the lower groundwater system.

Wells BH-64 (Figure 1-15) and OW-11A (Figure 1-20) show irregular water level elevations with respect to the other lower system

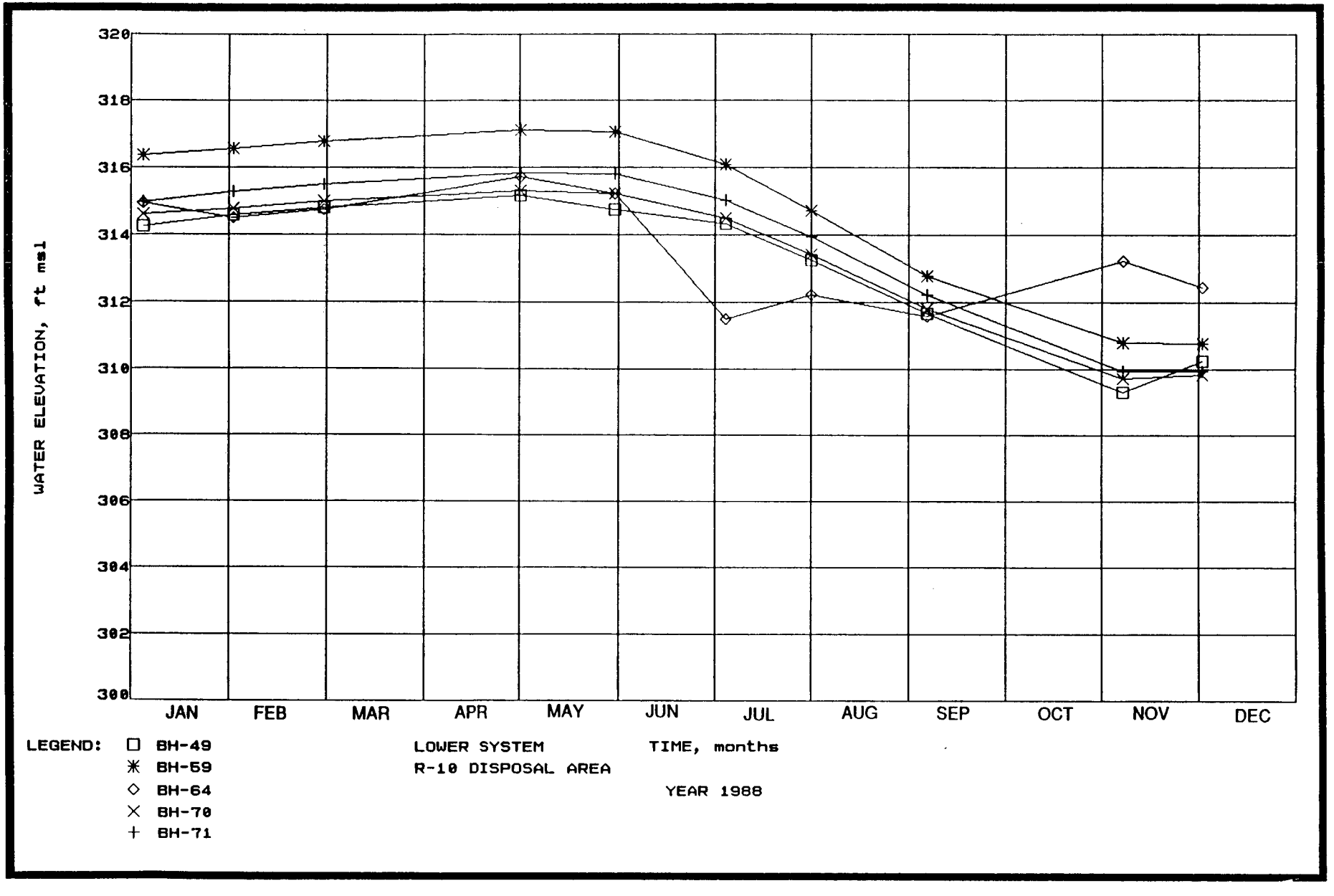


FIGURE 1-15 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS BH-49, BH-59, BH-64, BH-70, AND BH-71

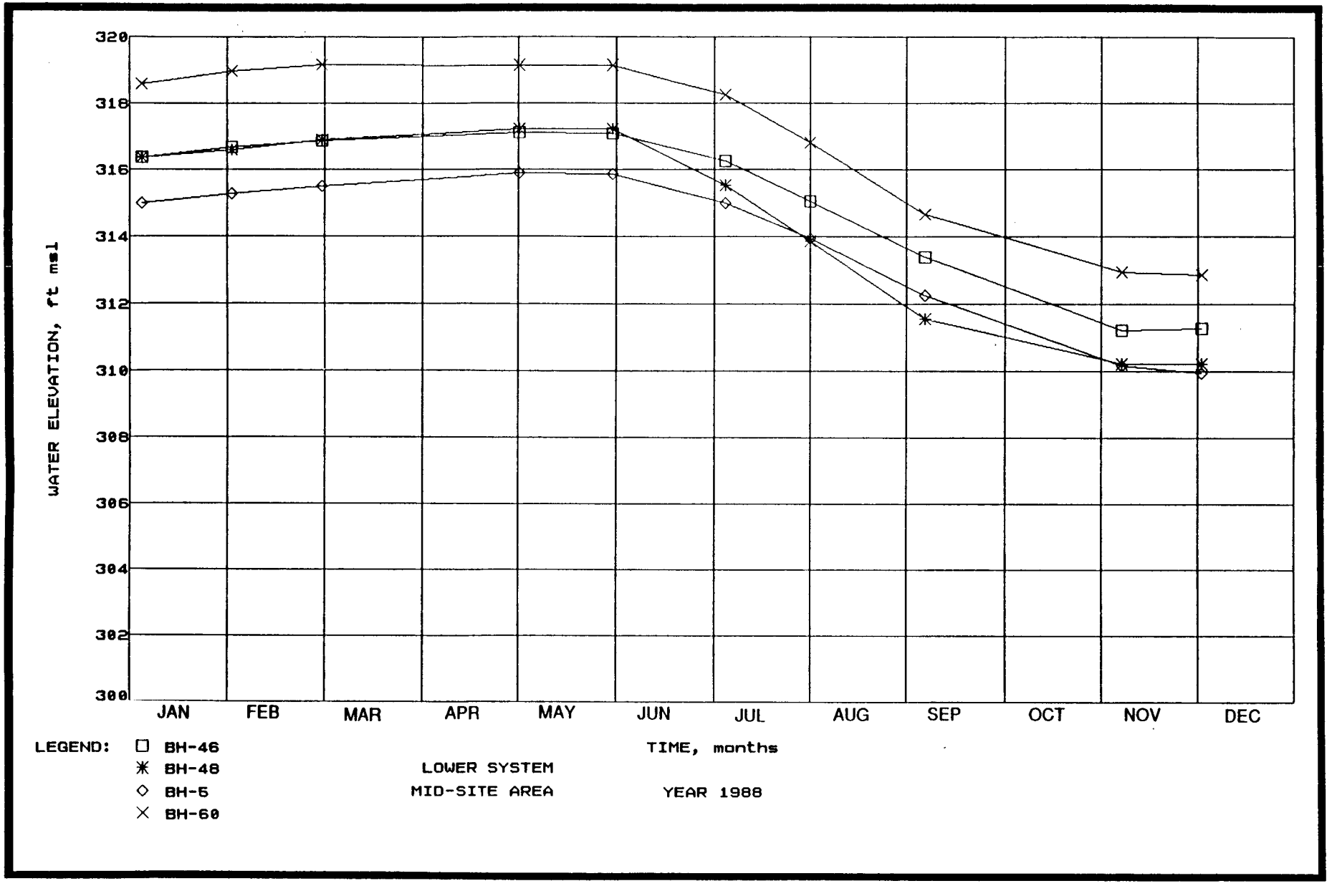


FIGURE 1-16 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS BH-46, BH-48, BH-5, AND BH-60

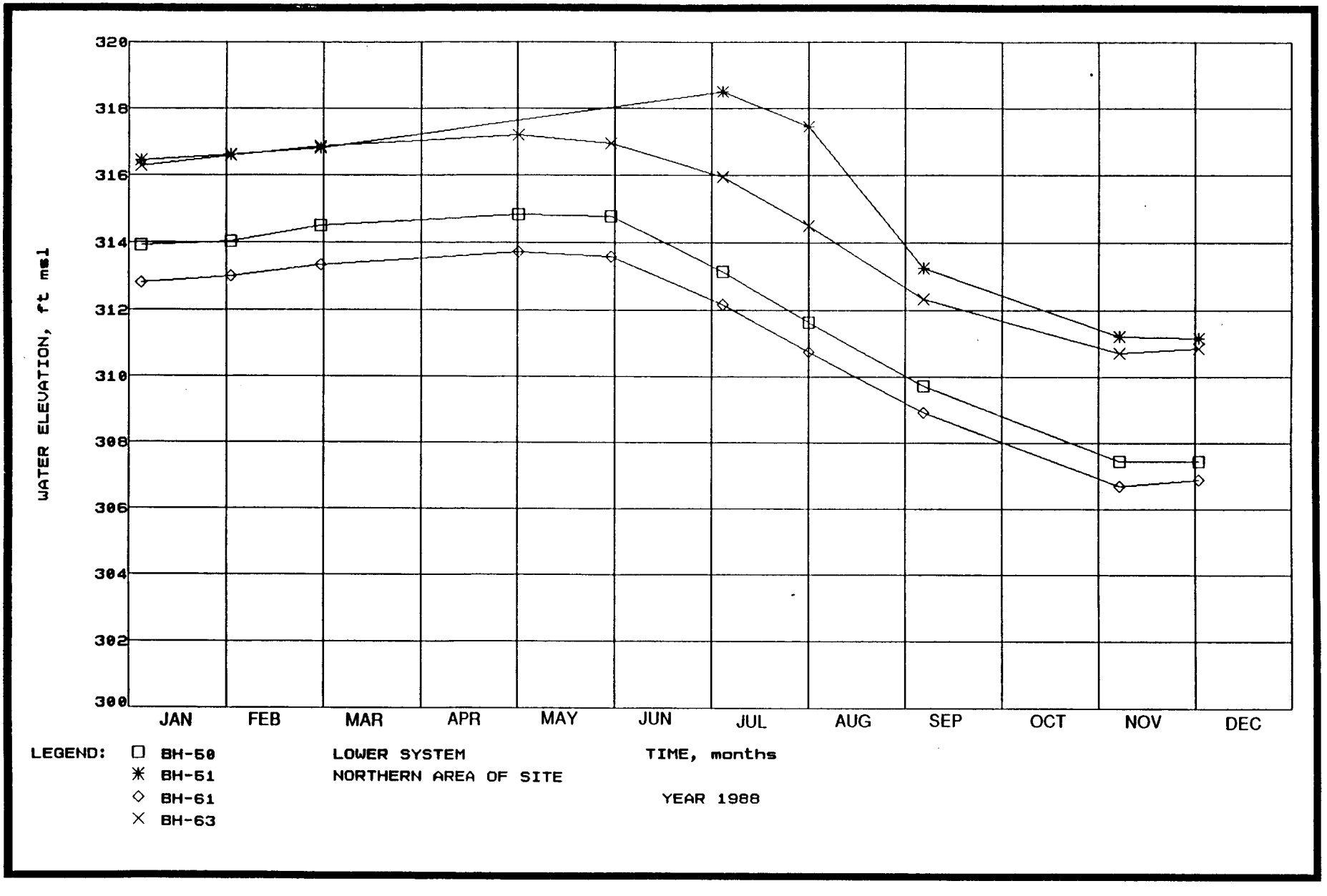


FIGURE 1-17 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS BH-50, BH-51, BH-61, AND BH-63

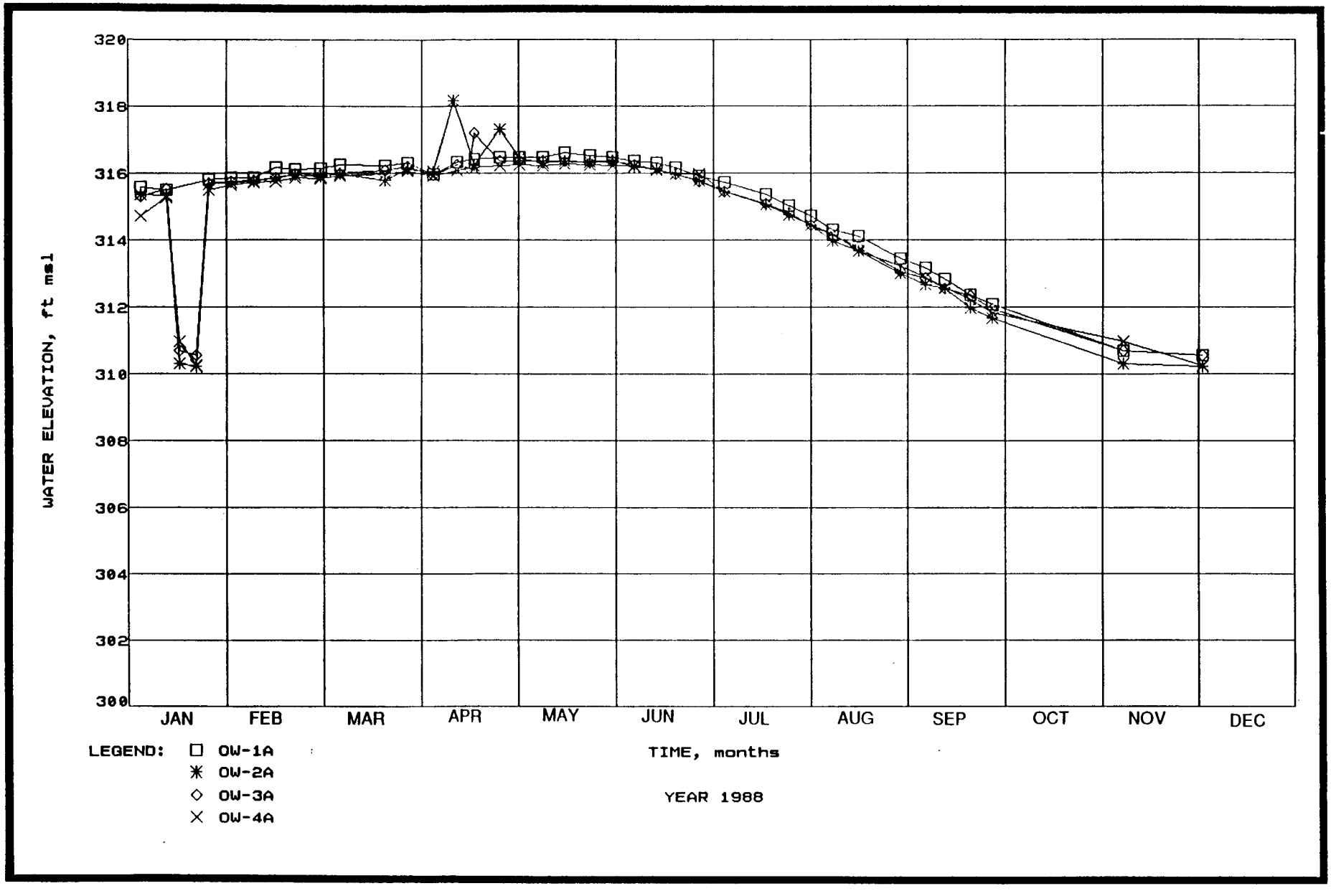


FIGURE 1-18 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS OW-1A, OW-2A, OW-3A, AND OW-4A

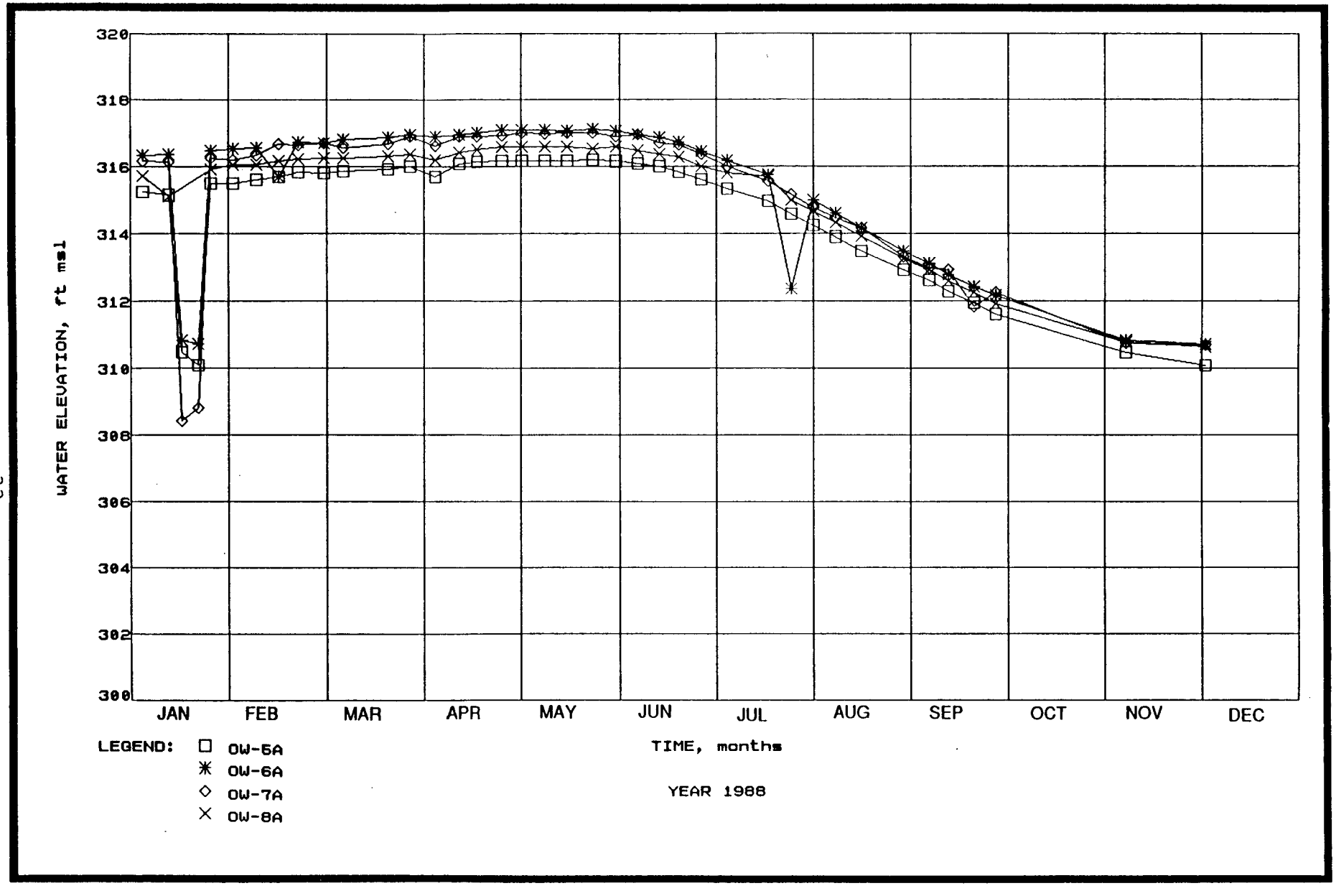


FIGURE 1-19 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS OW-5A, OW-6A, OW-7A, AND OW-8A

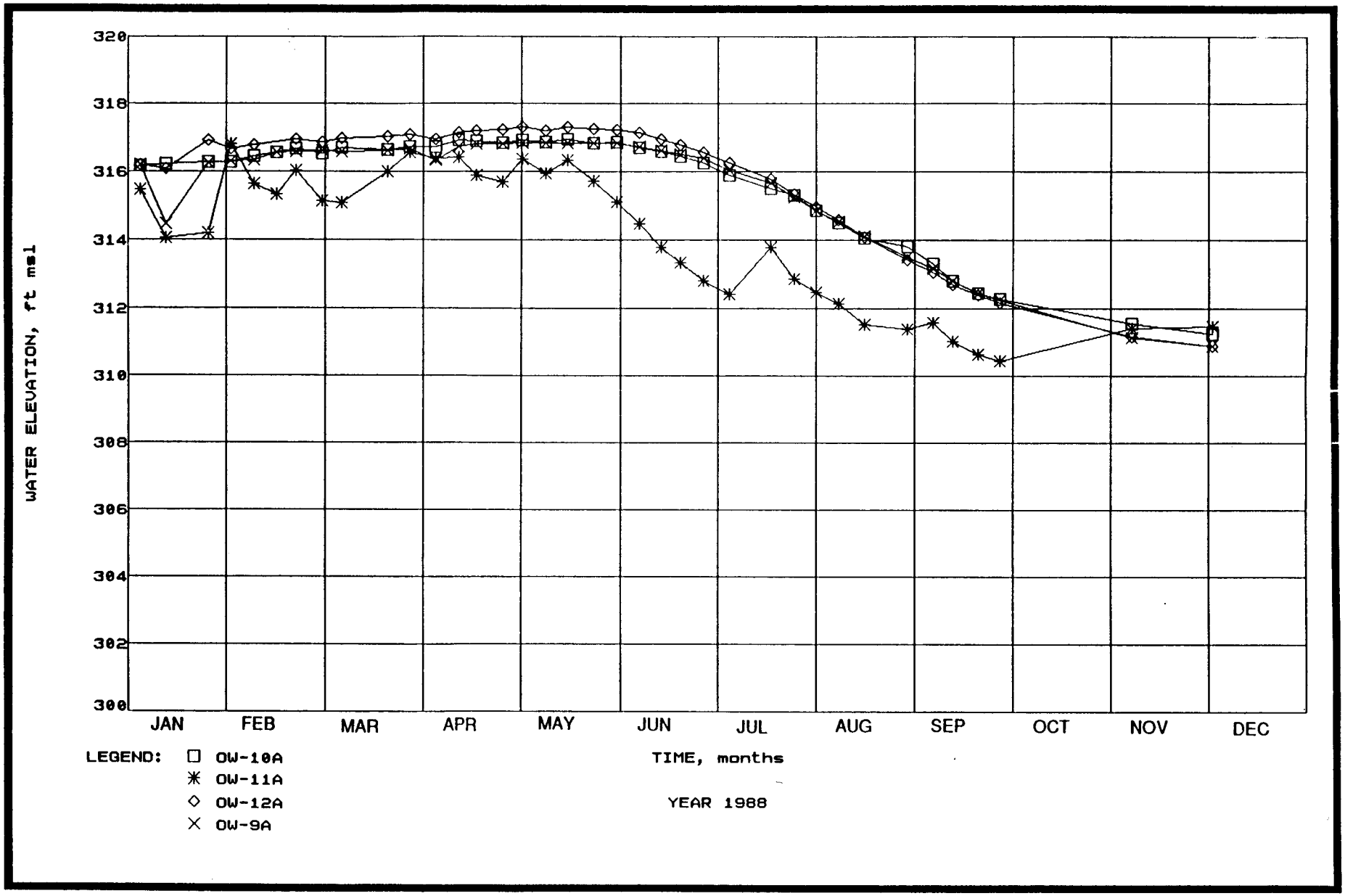


FIGURE 1-20 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS OW-10A, OW-11A, OW-12A, AND OW-9A

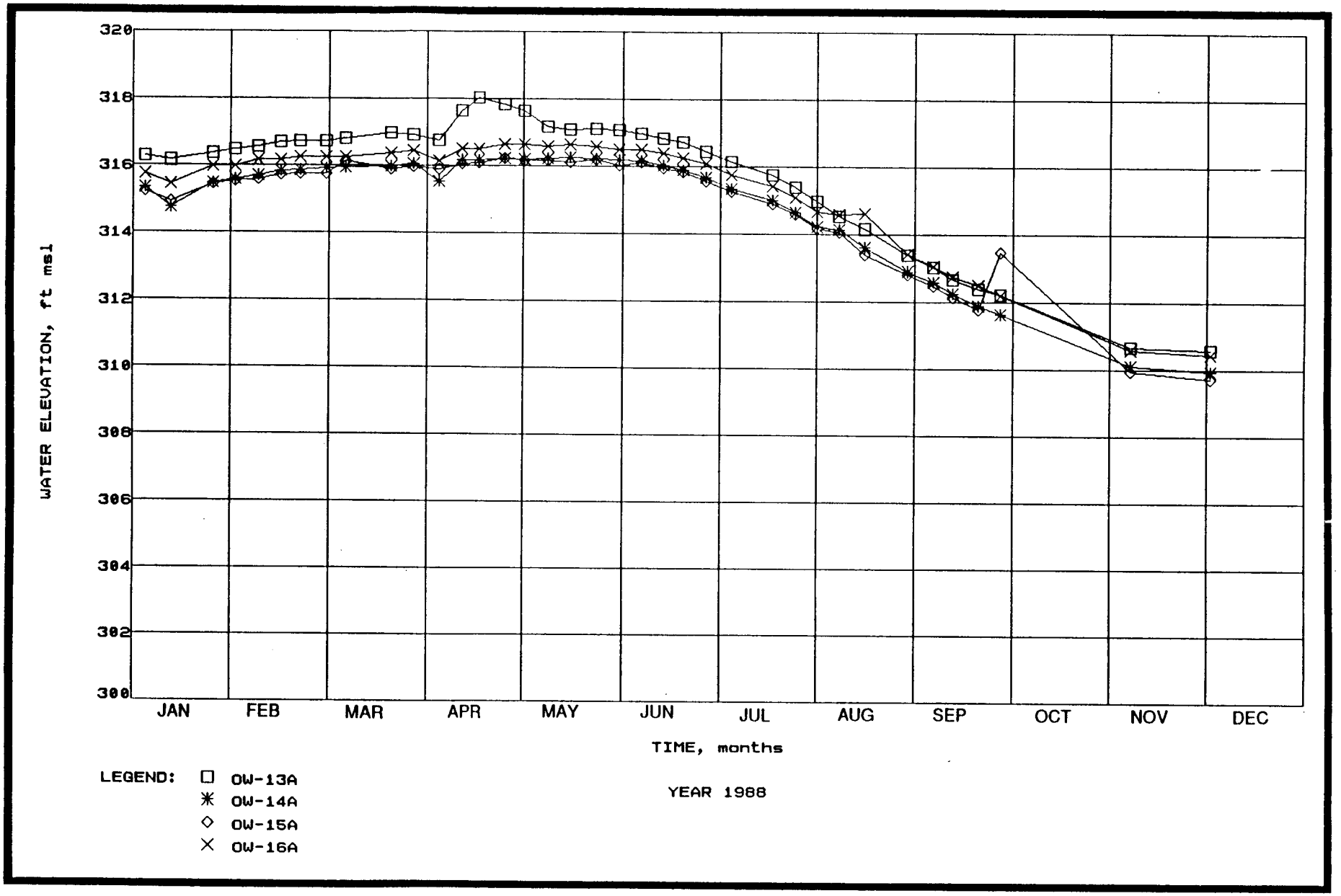


FIGURE 1-21 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS OW-13A, OW-14A, OW-15A, AND OW-16A

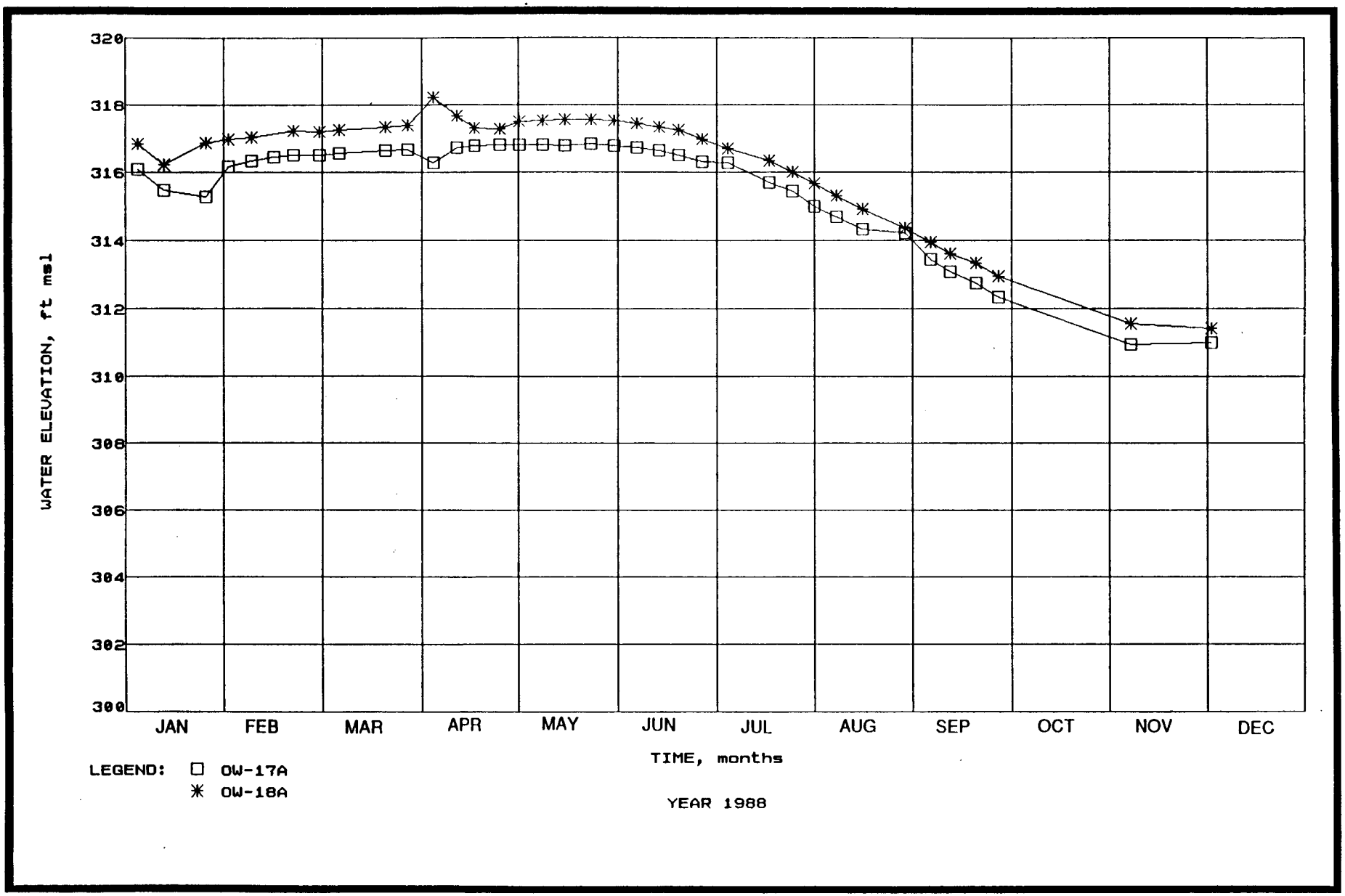


FIGURE 1-22 HYDROGRAPHS OF LOWER GROUNDWATER SYSTEM WELLS OW-17A AND OW-18A

wells. These wells are included in the water level measurement activity and will be closely observed to detect ground surface or other conditions that may be responsible for the unusual water level variations.

Slope and flow direction for the lower groundwater system were determined using two potentiometric surface maps (Figures 1-23 and 1-24). The dates chosen represent water levels during high and low periods.

Figures 1-23 and 1-24 show a generalized flow direction from east to northwest, with a slope of approximately 0.002. Seasonal variations in slope or flow direction are not evident.

1.3.3 Bedrock Groundwater System

The bedrock groundwater system occurs in the Queenston formation, located more than 30.5 m (100 ft) below ground surface at the site. The Queenston formation consists of shales, siltstone, and mudstone, and is slightly to moderately weathered along its upper surface (Ref. 2). Elevations of water levels in wells, measured in 1988 for the bedrock system, are shown as hydrographs in Figures 1-25 and 1-26.

Because the lower and bedrock systems are in hydraulic connection, the wells in the bedrock system show the same seasonal variation in water levels as those in the lower system, with highest levels in the spring and lowest in the fall. The water levels from well to well correlate, except for BH-15. BH-15 shows a drop in water level elevations during the summer, which changes the groundwater flow direction (Figure 1-25). This behavior has been observed in previous years and is discussed below.

The slope and flow direction of the bedrock groundwater system were determined using potentiometric surface maps (Figures 1-27 and 1-28). These maps were prepared using water levels for the same days as those used to prepare Figures 1-23 and 1-24.

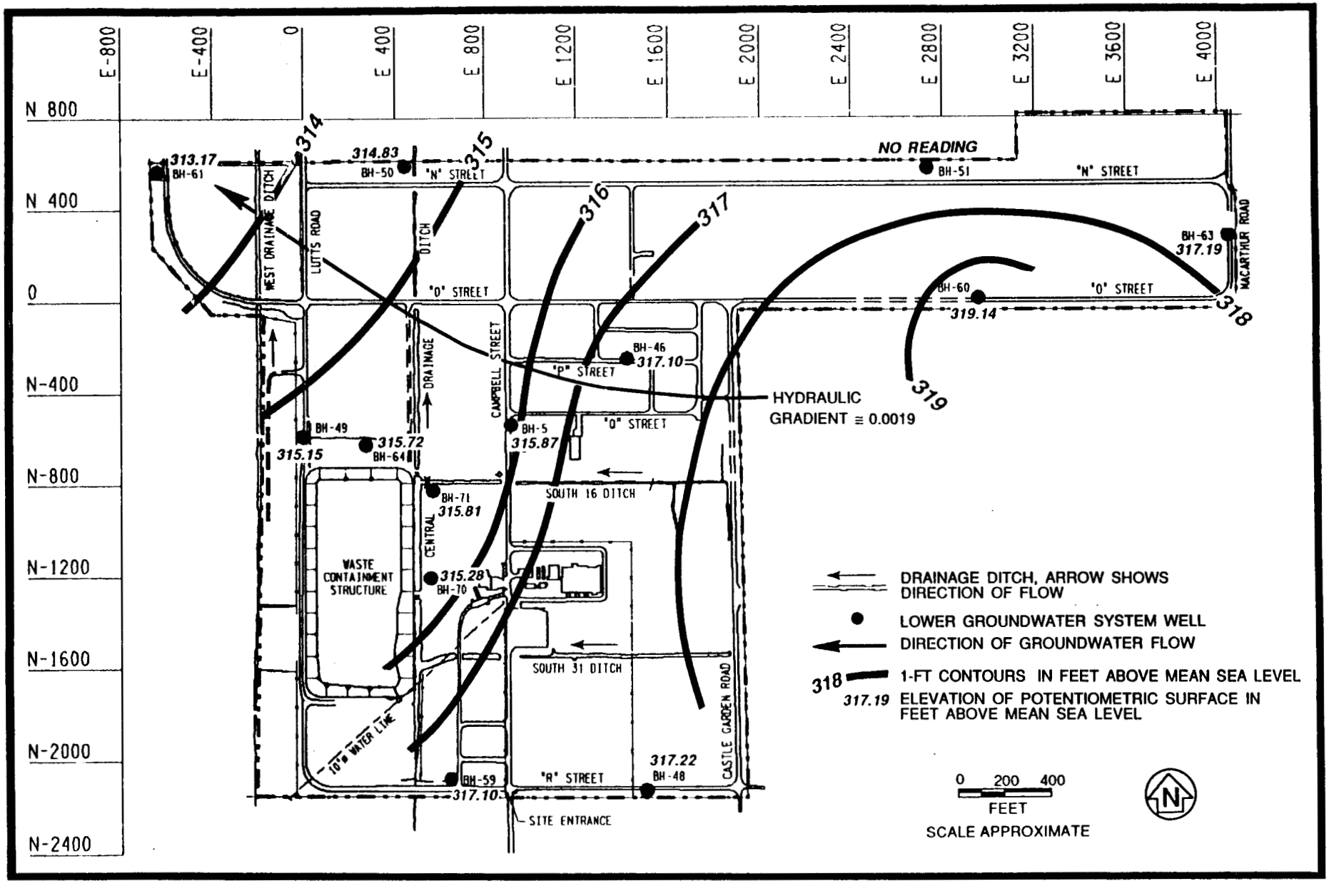


FIGURE 1-23 LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (5/2/88)

GRH: [42,30] 202WNS10.DGN

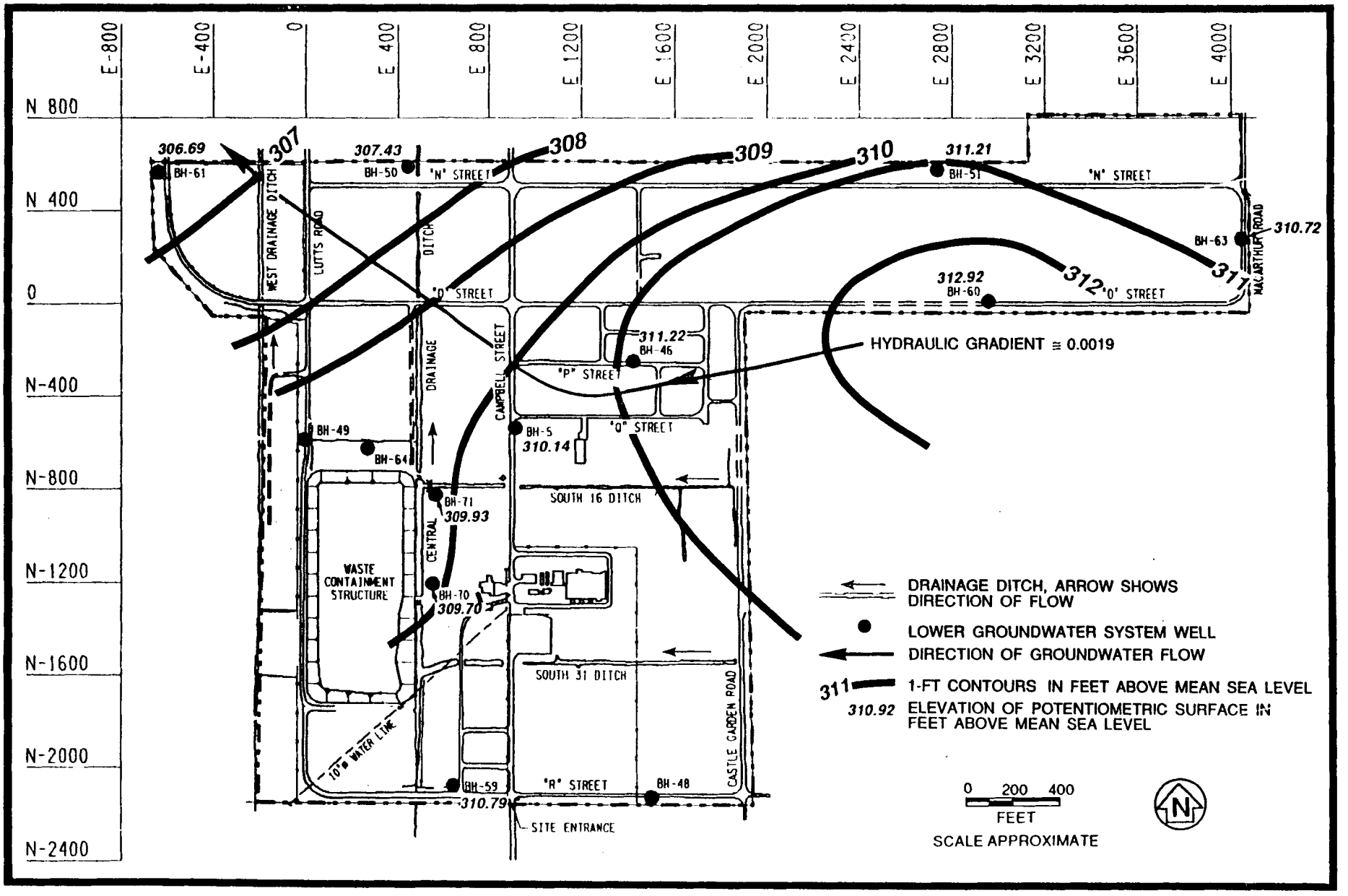


FIGURE 1-24 LOWER GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (11/7/88)

GRB: [42,30] 202WNS10.DGN

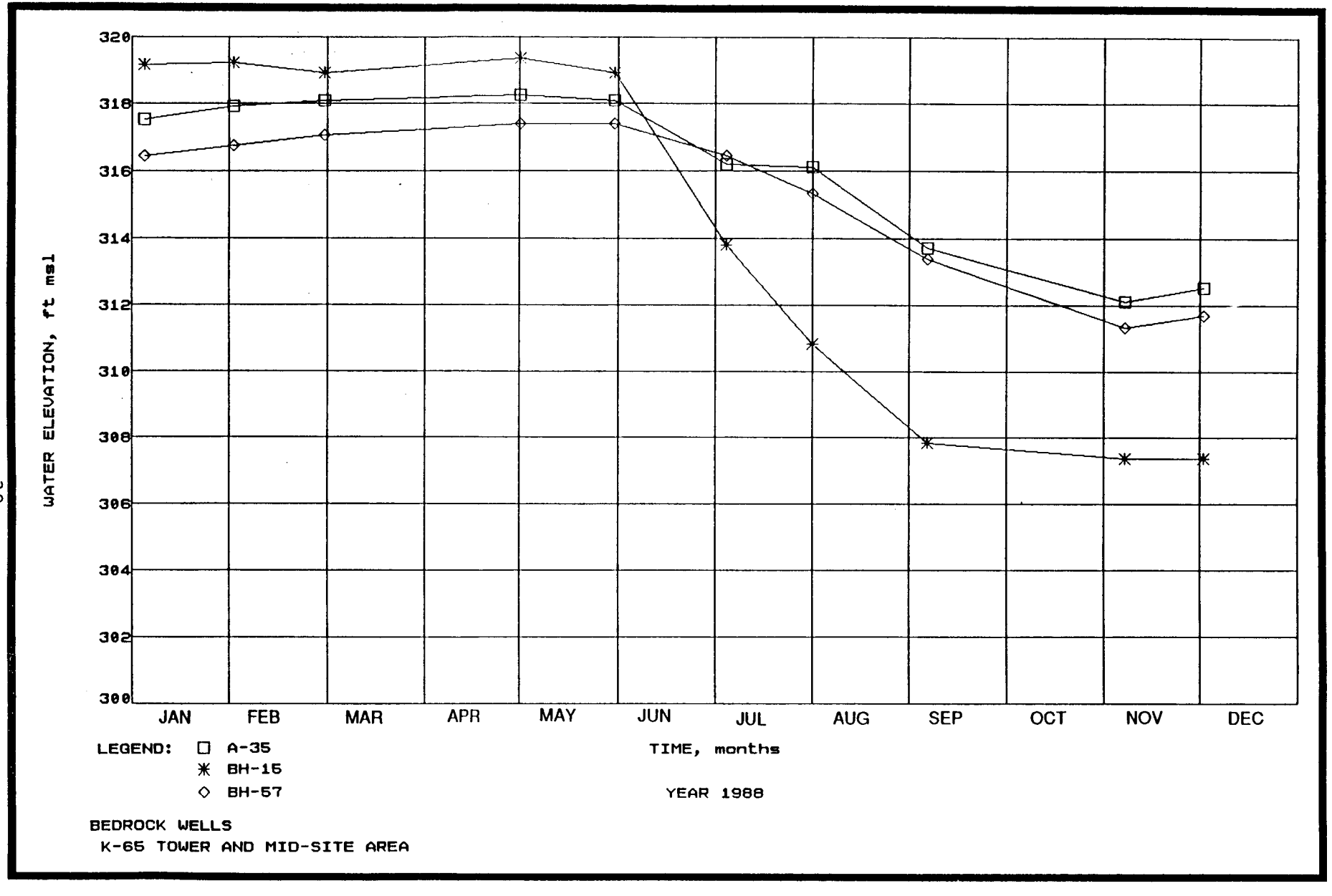


FIGURE 1-25 HYDROGRAPHS OF BEDROCK GROUNDWATER SYSTEM WELLS A-35, BH-15, AND BH-57

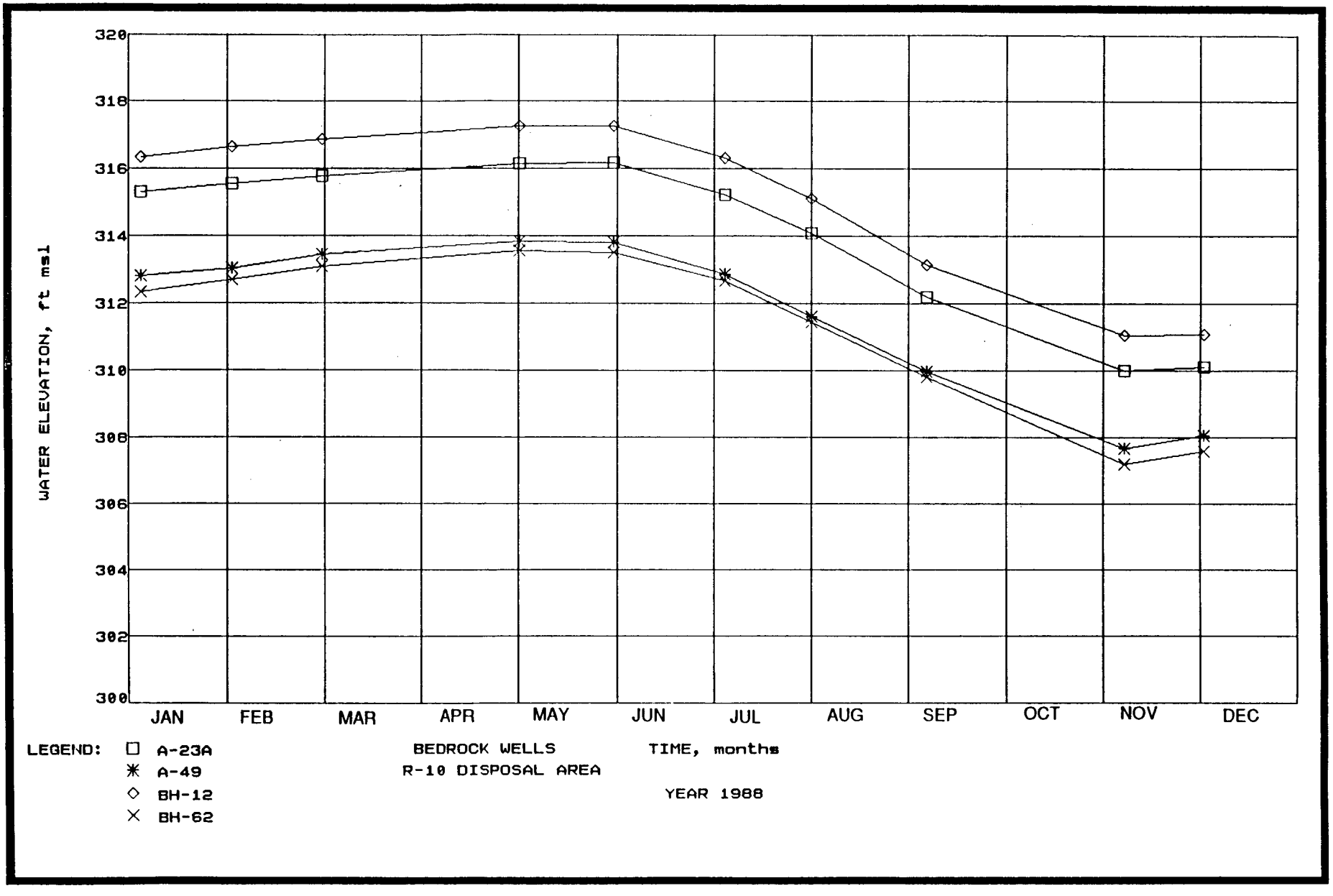


FIGURE 1-26 HYDROGRAPHS OF BEDROCK GROUNDWATER SYSTEM WELLS A-23A, A-49, BH-12, AND BH-62

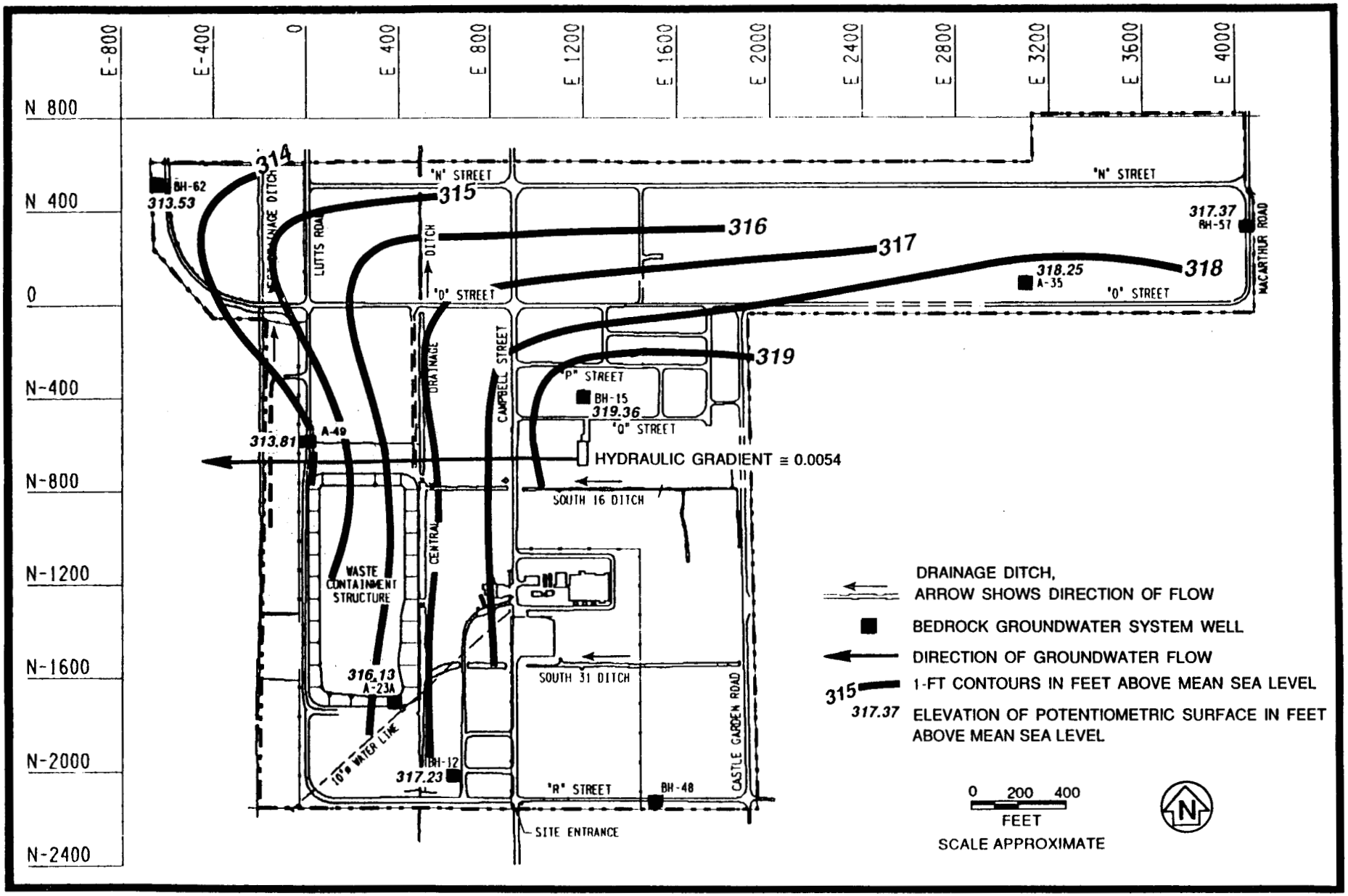


FIGURE 1-27 BEDROCK GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (5/2/88)

GRH: [42,30] 202WMS10.DGN

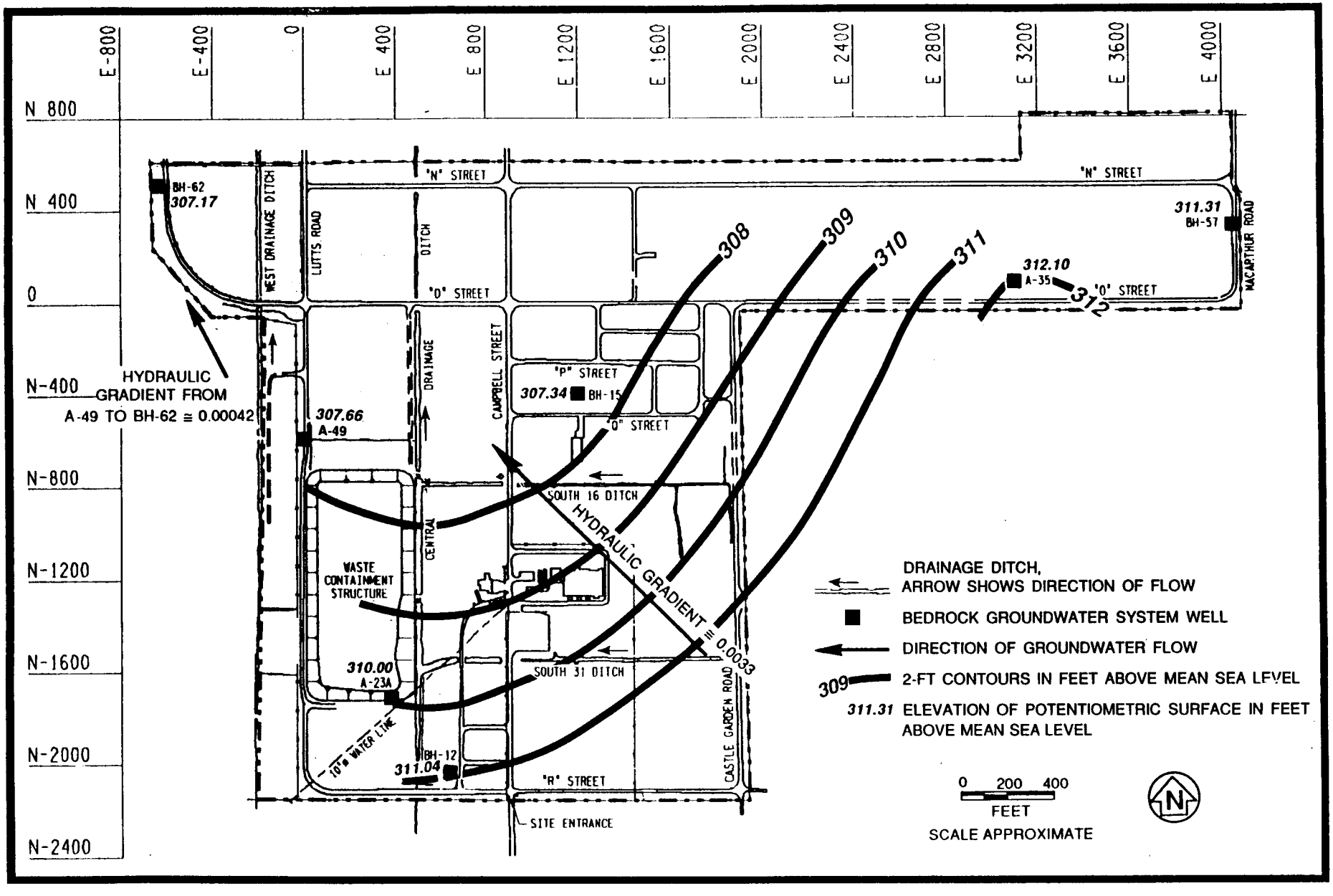


FIGURE 1-28 BEDROCK GROUNDWATER SYSTEM POTENTIOMETRIC SURFACE (11/7/88)

GRB: [42,30] 202WNS10.DGN

The spring flow direction is to the north and to the west, away from BH-15 (Figure 1-27). The fall flow direction alters slightly so that flow is toward the northwest because of the lower water levels in BH-15. This behavior has been observed for three consecutive years, and is thought to result from subsurface inhomogeneities or unknown pumping activities at the adjacent upgradient property.

The slope varies along with the change in flow direction. The slope for May 1988 (Figure 1-27) is 0.0054, and that for November 1988 (Figure 1-28) is 0.0033.

1.3.4 Conclusions

- All of the groundwater systems monitored at the site display highest water level elevations in the spring and lowest elevations in the fall.
- The upper groundwater system occurs 1.5 to 8.5 m (5 to 28 ft) below the ground surface in discontinuous media.
- The lower groundwater system occurs 10.7 to 12.2 m (35 to 40 ft) below the ground surface in a mostly continuous silt and sand layer, and is confined by a gray clay unit 3.4 to 8.8 m (11 to 29 ft) thick. The lower system has a year-round flow direction from the east to the northwest, with a slope of approximately 0.002.
- The bedrock groundwater system occurs in the upper portion of the Queenston formation, located 30.5 m or more (100 or more ft) below the site, and is in hydraulic connection with the lower groundwater system. The system has a seasonal variation to the hydraulic flow direction that is to the north in the spring and to the northwest in the fall. This shift in the flow direction is due to fluctuations in BH-15, a condition that has been observed for the past three years. The slope is 0.0054 in the spring and 0.0033 in the fall.

2.0 SUMMARY OF MONITORING RESULTS

The environmental monitoring program, which began in 1981, continued in 1988. Air, water, and sediments were sampled, and gamma radiation levels were monitored to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 9). The potential radiation dose that might be received by a hypothetical maximally exposed individual was estimated to determine whether the site remains in compliance with the radiation protection standard.

Annual average radon concentrations (including background) at all monitoring locations were within the normal variation associated with background measurements for this area (see Subsection 3.1). The average background concentrations of radon ranged from 5×10^{-10} to 6×10^{-10} µCi/ml (0.5 to 0.6 pCi/l). Radon concentrations decreased noticeably from 1982 to 1986 and have remained stable since 1986 (see Subsection 3.6.1) (Refs. 10-15).

Annual average gamma radiation levels recorded at the NFSS boundary ranged from 3 mR/yr to 23 mR/yr above background (Table 3-2). These levels may be compared with naturally occurring background radiation levels in the vicinity of the NFSS, which averaged 71 mR/yr in 1988. External radiation levels are discussed in Subsection 3.2. Annual average radiation levels generally have decreased sharply since 1982 (see Subsection 3.6.2) (Refs. 10-15).

In surface waters (Subsection 3.3.1), annual average concentrations of total uranium ranged from 6×10^{-9} to 1×10^{-8} µCi/ml (6 to 10 pCi/l); radium-226 concentrations ranged from 2×10^{-10} to 1×10^{-9} µCi/ml (0.2 to 1.0 pCi/l) (see Tables 3-3 and 3-4). Average concentrations of both total uranium and radium-226 have decreased steadily since 1982 (see Subsection 3.6.3) (Refs. 10-15).

In groundwater (Subsection 3.3.2), the highest annual average concentration of total uranium in an on-site well was 5.5×10^{-8} µCi/ml (55 pCi/l), measured at on-site location A-42

(Table 3-3). Well A-42 is located in a sand lens of unknown extent. Further discussion of results of the investigation of well A-42 is provided in Subsection 4.2. For radium-226, the maximum annual average concentration was 7×10^{-10} µCi/ml (0.7 pCi/l), measured at on-site location BH-48 (Table 3-4). Over the 6-year period from 1982 through 1988, concentrations of total uranium and radium-226 have remained basically stable (see Subsection 3.6.4) (Refs. 10-15). In groundwater from wells surrounding the IWCF, the highest annual average concentrations of total uranium and radium-226 were 2.8×10^{-8} µCi/ml (28 pCi/l) and 8×10^{-10} µCi/ml (0.8 pCi/l), respectively (see Tables 3-5 and 3-6). Concentrations of radionuclides in surface water and groundwater at the NFSS can be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

In stream sediments (Subsection 3.4), the highest annual average concentration was 2.7 pCi/g for total uranium and 1.3 pCi/g for radium-226 (see Table 3-7). These concentrations are not significantly different from background and may be compared with the levels of environmental radioactivity in phosphate fertilizers listed in Appendix D.

Calculations were made of the potential radiological dose received by a hypothetical maximally exposed individual (Subsection 3.5.1). This hypothetical individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, receives the greatest dose. Evaluation of monitoring results indicates that exposure to external gamma radiation represents the only plausible route of public exposure. Accordingly, this pathway was the only one quantified.

The exposure to the hypothetical maximally exposed individual from external gamma radiation was 6 mR/yr above background. Because 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 6 percent of the DOE radiation protection standard.

The cumulative dose to the population within an 80-km (50-mi) radius of the NFSS that results from radioactive materials present at the site is indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

Analytical results for chemicals are summarized in Subsection 4.1.

Results of the 1988 monitoring show that the NFSS is in compliance with the DOE radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1988 environmental monitoring at the NFSS (Ref. 16). A description is also given of the sampling, monitoring, and analytical procedures used. Calculations were made to estimate the maximum possible radiation dose based on environmental conditions, measurements recorded, and evaluation of potential exposure pathways.

Data are presented in summary tables by sample category. Summaries of data include minimum and maximum values recorded, number of data points collected, and average values. The average value for a given sampling location is the average of individual results for that location. Individual sources of error (e.g., analytical error or sampling error) were not estimated. The "less than" notation (<) is used to denote sample analysis results that are below the limit of sensitivity of the analytical method, based on a statistical analysis of parameters. In computing the averages, where no more than one value is less than the limit of sensitivity of the analytical method, that value is considered to be equal to the limit of sensitivity and the "average" value is reported without the "less than" notation.

During 1988, the routine environmental monitoring program for NFSS included radon monitoring, external gamma radiation measurements, surface water and sediment sampling, and groundwater sampling of monitoring wells off site and within the site boundary.

Trend tables are provided for radon, external gamma radiation levels, surface water, and groundwater. These tables list annual averages for each monitoring location for 1982 through 1988 to allow for comparisons of data and identification of trends in monitoring results (see Subsection 3.6).

3.1 RADON MONITORING

Thirty-five radon detectors are maintained on site and at site boundary locations, with three of the detectors (31, 32, and 33) designated as quality controls. One detector (30) is maintained 6.4 km (4 mi) west-southwest of the site to measure the natural background level. Detectors are placed along the site boundary at intervals designed to ensure adequate detection capability under most atmospheric conditions. Detectors are more closely spaced along the perimeter of the IWCF, where the potential for release of contaminants is greater. In April 1987, monitoring stations 13, 14, 15, and 29 were moved approximately 220 m (200 yd) eastward to make them more accessible and thereby facilitate routine exchange of detectors. The locations of the radon monitors are shown in Figure 3-1. In April 1988, additional background locations were established at the Lewiston Water Pollution Control Center and the Lewiston Town Hall. These locations are listed in Table 3-1 as Locations 120 and 121, respectively. Location 120 is approximately 1.6 km (1 mi) southwest of the NFSS at Pletcher Road, Lewiston, New York; Location 121 is approximately 1.6 km (1 mi) south at the intersection of Route 104 and Swain Road, Lewiston.

Radon concentrations are determined using monitors purchased from the Terradex Corporation. These devices (Terradex Type F Track-Etch) consist of an alpha-sensitive film contained in a small plastic cup covered by a membrane through which radon can diffuse. Radon will diffuse through the membrane (in or out of the cup) when a concentration gradient exists; therefore, it will equilibrate with radon in the outside air. Alpha particles from the radioactive decay of radon and its daughters in the cup create tiny tracks when they collide with the film. When returned to Terradex for processing, the films are placed in a caustic etching solution to enlarge the tracks. Under strong magnification, the tracks can be counted. The number of tracks per unit area (i.e., tracks/mm^2) is related through calibration to the concentration of radon in air.

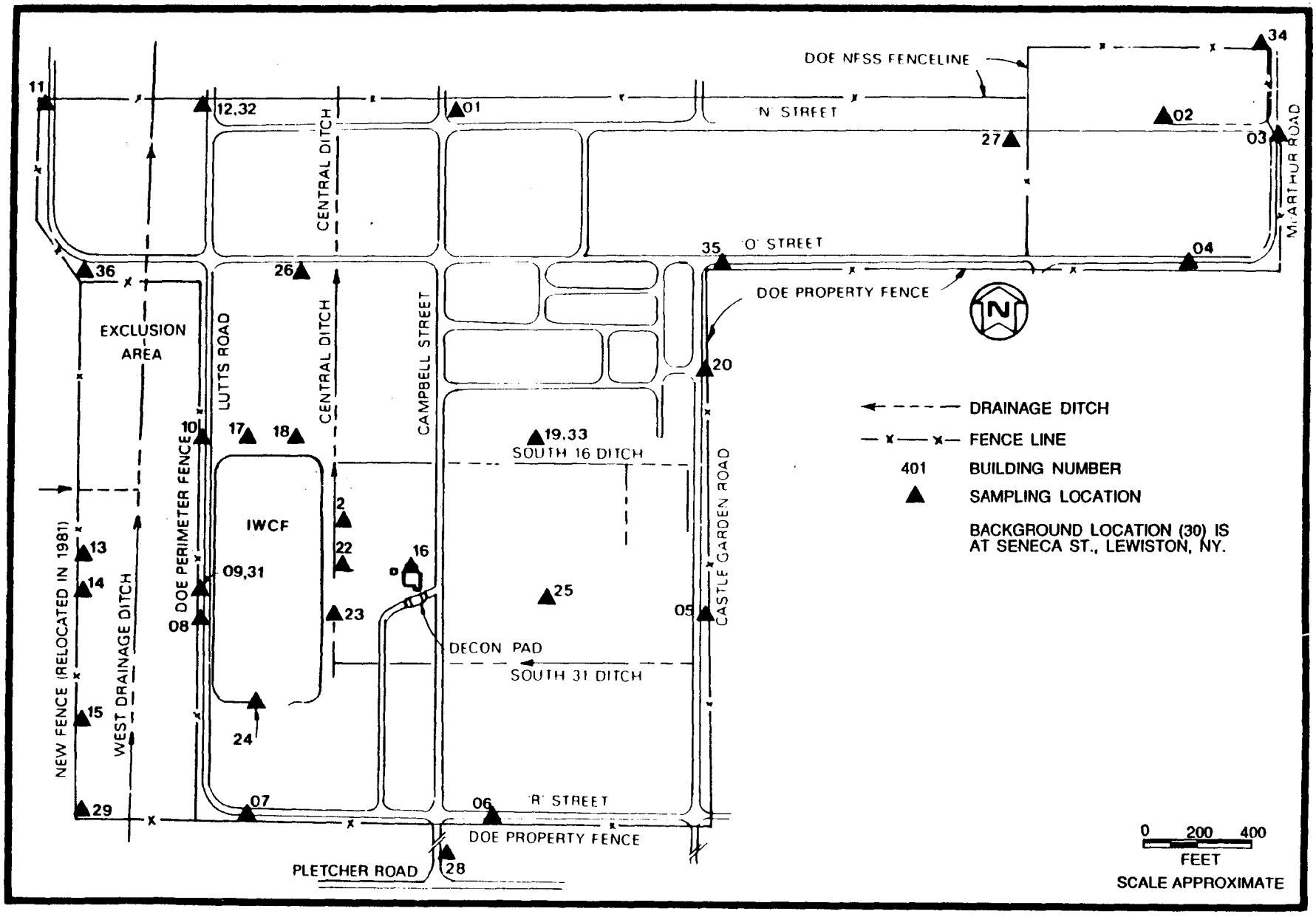


FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT THE NFSS

TABLE 3-1

CONCENTRATIONS OF RADON-222

MEASURED BY TERRADEX MONITORS AT THE NFSS BOUNDARY, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c,d] Minimum	Maximum	Average
1	4	0.3	1.4	0.5
3	4	0.3	0.4	0.2
4	4	0.3	0.3	0.2
5	4	0.3	1.3	0.5
6	4	0.3	0.8	0.4
7	4	0.3	0.7	0.4
11	4	0.3	0.4	0.2
12	4	0.3	0.4	0.3
13	4	0.3	1.5	0.5
14	4	0.3	0.5	0.3
15	4	0.3	0.5	0.3
20	4	0.3	1.0	0.5
28	4	0.3	0.6	0.3
29	4	0.3	0.6	0.3
32[e]	4	0.3	0.5	0.3
34	4	0.3	0.3	0.2
35	4	0.3	1.0	0.5
36	4	0.3	0.6	0.3
Background				
30[f]	4	0.5	0.7	0.6
120[g]	2	0.4	0.5	0.5
121[h]	1	0.5	0.5	0.5

[a]Sampling locations are shown in Figure 3-1. Only site boundary locations are reported.

[b]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.

[c]Measurement was less than or equal to the limit of sensitivity of the detector and was reported as a zero value by the laboratory.

[d]Background has not been subtracted. Note that values for several locations are below background levels.

[e]Location 32 is a quality control for Location 12.

[f]Background sampling location, located at Seneca St., Lewiston, NY, approximately 6.4 km (4 mi) southwest of the NFSS.

[g]Background sampling location, located at Pletcher Rd., Lewiston, NY, approximately 1.6 km (1 mi) southwest of the NFSS. Established in April 1988.

[h]Background sampling location, located at the intersection of Route 104 and Swain Rd., Lewiston, NY, approximately 1.6 km (1 mi) south of the NFSS. Established in April 1988. Detector was missing in the fourth quarter.

Fresh Track-Etch monitors are obtained from Terradex each quarter. Site personnel place these units in each sampling location and return the exposed monitors to Terradex for analysis.

Table 3-1 reports the radon concentrations (including background) measured in the air at site boundary monitoring locations and the background location. Annual average concentrations at the site boundary ranged from 2×10^{-10} to 5×10^{-10} μCi/ml (0.2 to 0.5 pCi/l). The annual average background measurements ranged from 5×10^{-10} to 6×10^{-10} μCi/ml (0.5 to 0.6 pCi/l). For a comparison of radon concentrations measured from 1982 through 1988, see Subsection 3.6.1.

Because of the nature of the radon source (i.e., large surface areas emanating radon at rates that vary widely with changes in climatic/atmospheric conditions), accurate determination of the annual radon release rate is not feasible. Measured radon concentrations at the site boundary and in the environs show that the on-site radon source makes a minimal contribution to natural radon concentrations in the area.

3.2 EXTERNAL GAMMA RADIATION LEVELS

External gamma radiation levels were measured at 33 monitoring locations; 17 of these are on the site boundary and 3 are on the perimeter of the former location of the tower that was used to store K-65 residues. One of the monitoring locations is off site to measure the background radiation level. In April 1987, monitoring stations 13, 14, 15, and 29 were moved approximately 220 m (240 yd) eastward to make them more accessible for quarterly exchange of detectors. All locations correspond to the radon (Terradex) detector locations shown in Figure 3-1. The locations of the detectors are selected to ensure adequate measurement of radiation levels.

External gamma radiation levels are measured by lithium fluoride (LiF) thermoluminescent dosimeters (TLDs). Beginning in 1988, the

system of measurement utilizes tissue-equivalent dosimeters to provide values that are more realistic in terms of radiation dose to the tissues of the body at a depth of 1 cm. This dosimetry system offers advantages in accuracy and sensitivity that were not available with the system used previously.

Each dosimetry station contains a minimum of four dosimeters, which are exchanged after one year of accumulated exposure. For example, a dosimeter placed in the station in October 1987 would be removed in October 1988. Each dosimeter contains five individual LiF chips (each group of which was preselected on the basis of having a reproducibility of ± 3 percent across a series of laboratory exposures), the responses of which are averaged. Analysis is performed by Thermo Analytical/Eberline (TMA/E). The average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent) and for the effect of fade.

Fade is the loss of dose information brought about by environmental effects, primarily high summer temperatures. Fade is determined by collocating dosimeters that have been exposed to a known level of radiation (called a spike) before they are placed at a minimum of two stations, generally on the eastern and western boundaries of a site. The fade factor can be determined by subtracting the station radiation value from the fade control dosimeter followed by dividing by the known spike level. The corrected value is then converted to milliroentgens per year by dividing by the number of days of exposure and subsequently multiplying by 365 days.

Some differences in external gamma radiation values may be noted in the 1988 data in comparison with the 1987 values. The current measurement system is more sensitive to low radiation levels and more accurate in its resolution than the system used previously. Therefore, some stations that previously demonstrated no measurable external gamma radiation value in excess of background now exhibit a small measurable value. Similarly, at some other stations values

are higher or lower because of the improved method of measurement, not because of deterioration of site conditions or remedial action.

Monitoring results for the 17 site boundary locations, the background location, and the quality control location are presented in Table 3-2. The annual average background radiation level for the NFSS area (71 mR) has been subtracted from the measured levels in Table 3-2 to provide an estimate of the effect of the site on measured external gamma radiation levels at the site boundary. The highest levels were measured at two locations adjacent to a sanitary landfill to which access is controlled by the owner. At these locations, the maximum annual average level was 23 mR/yr above the average background level of 71 mR/yr. Based on a very conservative 40-h/week occupancy factor, the maximum exposure to workers in this area of the landfill would be 6 mR/yr.

In April 1988, additional background locations were established at the Lewiston Town Hall and the Lewiston Water Pollution Control Center. Because of the measurement system operating parameters, the 6 months of exposure time on the TLDs is not representative of the yearly fluctuations in background that occur because of seasonal weather variations. These locations will be fully reported in the 1989 environmental report.

The background external gamma radiation value for a given location is not a static constant. Because the background value is a combination of both natural terrestrial sources and cosmic radiation sources, factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil can affect the value measured. Independent of the placement of the detector at the Earth's surface are the factors of site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Ref. 17).

Because of these factors, the background radiation level is not constant from one location to another even over a short time. Thus

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT THE NFSS, 1988

Sampling Location[a]	Number of Measurements	Radiation Level (mR/yr)[b] Minimum	Maximum	Average
Site Boundary				
1	4	6	14	11
3	4	4	14	9
4	4	-[c]	17	7
5	4	13	31	22
6	4	4	36	16
7	4	1	27	7
11	4	-[c]	12	5
12	4	3	18	8
13	4	-[c]	10	6
14	4	7	23	14
15	4	9	17	14
20	4	-[c]	30	23
28	4	5	14	10
29	4	5	19	10
32[d]	4	2	18	8
34	4	-[c]	8	3
35	4	5	19	14
36	4	5	15	10
Background[e]				
30[f]	4	66	76	71

[a]Site boundary locations only. Sampling locations are shown in Figure 3-1.

[b]Measured background has been subtracted from measurements taken at site boundary locations.

[c]Measurement was less than or equal to the measured background value.

[d]Location 32 is a quality control for Location 12.

[e]Additional background locations were established in April 1988 at the Lewiston Town Hall, approximately 1.6 km (1 mi) south of the NFSS, and at the Lewiston Water Pollution Control Center, approximately 1.6 km (1 mi) west of the NFSS. Data for these locations are not reported because they have been in operation for less than 1 year. Data will be presented in the 1989 environmental report.

[f]Located at Seneca St., Lewiston, NY, approximately 6.4 km (4 mi) southwest of the NFSS.

it is not abnormal for some stations at the boundary of a site to have an external gamma radiation value less than the background level measured some distance from the site.

For comparisons of external gamma radiation levels measured from 1982 through 1988, see Subsection 3.6.2.

3.3 WATER SAMPLING

During 1988, sampling was performed to determine the concentrations of total uranium and radium in surface water and groundwater at on-site and off-site locations. On-site sampling locations for surface water are shown in Figure 3-2, and off-site locations are shown in Figure 3-3.

3.3.1 Surface Water

Surface water samples were collected quarterly from the Central Drainage Ditch at Locations 10, 11, 12, and 20. Locations 12 and 20 are 1.6 and 3.2 km (1 mi and 2 mi) downstream, respectively, from the northern boundary of the NFSS.

Surface water collection locations were selected on the basis of potential for contaminant migration and discharge routes from the site. Because surface water runoff from the site discharges via the Central Drainage Ditch, all sampling locations were placed along the ditch.

Nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container and were analyzed by TMA/E. The concentration of total uranium was determined by a fluorometric method. Radium-226 concentrations in water were determined by radon emanation. (This method consists of precipitating radium as sulfate and transferring the treated sulfate to a radon bubbler, where radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then withdrawn into a scintillation cell

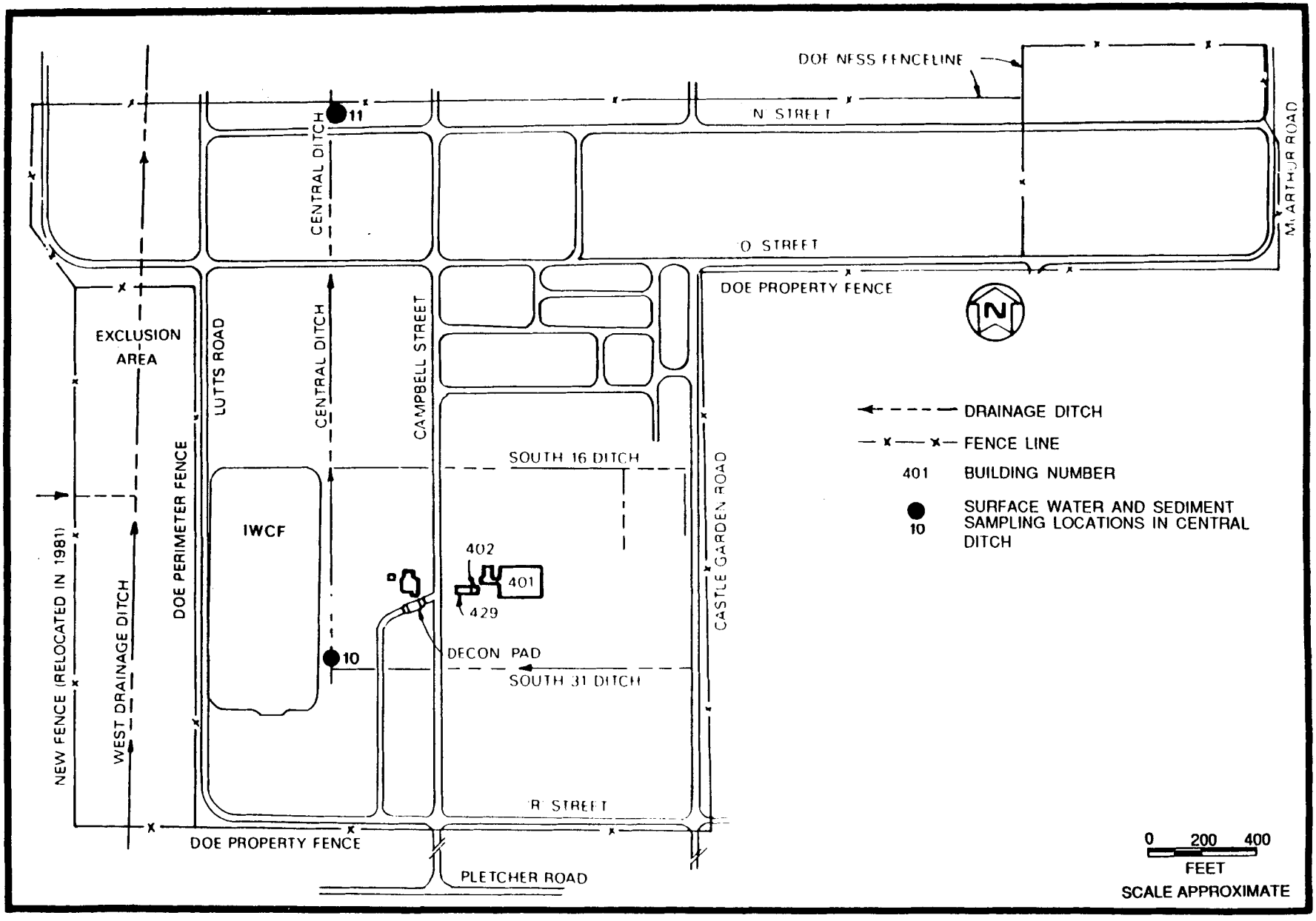


FIGURE 3-2 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS AT THE NFSS

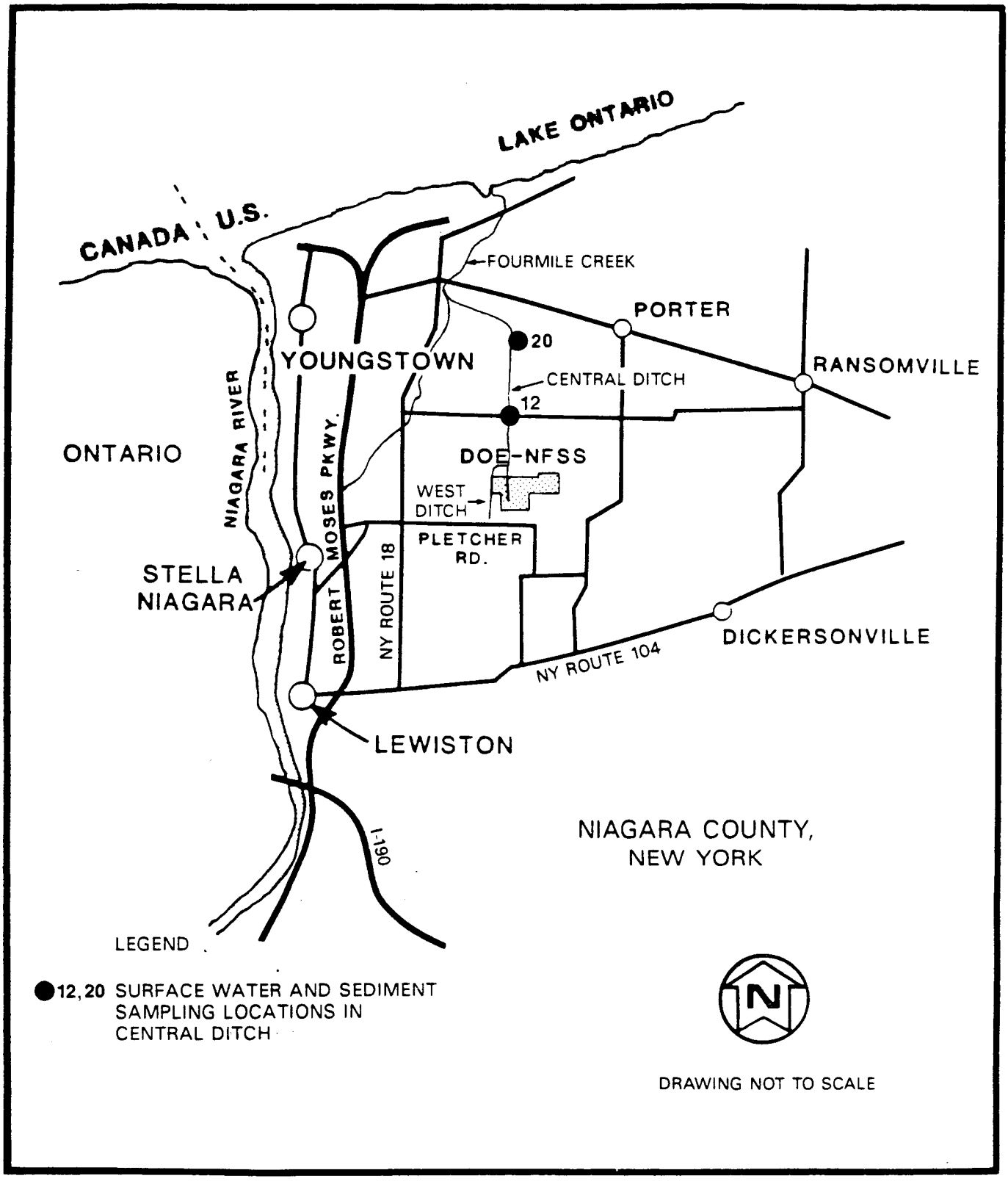


FIGURE 3-3 SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS IN THE VICINITY OF THE NFSS

and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.)

Results of the analyses of surface water for total uranium content are given in Table 3-3; radium-226 results are given in Table 3-4. Annual average total uranium concentrations in on-site surface water ranged from 7×10^{-9} to 1×10^{-8} µCi/ml (7 to 10 pCi/l); in off-site surface water, concentrations ranged from 6×10^{-9} to 7×10^{-9} µCi/ml (6 to 7 pCi/l). The highest annual average concentration of radium-226 in surface water was 1.0×10^{-9} µCi/ml (1.0 pCi/l). Radionuclide concentrations in surface water approximate background at the NFSS and may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

The sampling of water supplied by a local municipal water system was suspended in 1986. This system draws water from the upper Niagara River approximately 16 km (10 mi) south of the NFSS. Sampling was suspended because the draw point of the system was upstream of the NFSS and because data from previous years indicated no significant total uranium or radium-226 concentrations above background levels in these waters.

For comparisons of radionuclide concentrations in surface water measured at the site from 1982 through 1988, see Subsection 3.6.3.

3.3.2 Groundwater

During 1988, groundwater samples were collected quarterly from 48 on-site wells. Sampling locations were selected based on the inventory of radioactive materials in various areas of the site and available hydrogeological data. The majority of monitoring wells are located near the IWCF. Other wells are located both upgradient and downgradient to provide background data and to monitor any migration of contaminants off-site. In late 1986, 36 wells were installed along the perimeter of the IWCF to monitor its

TABLE 3-3

CONCENTRATIONS OF TOTAL URANIUM IN NFSS WATER SAMPLES, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Average
Surface Water				
On-Site				
10	1[d]	7	7	7
11	2[e]	8	12	10
Off-Site				
12	2[e]	<3	8	6
20	2[e]	<3	10	7
Background				
9	1[f]	8	8	8
Groundwater[g]				
On-Site				
BH-5	4	<3	<3	<3
BH-48[h]	4	<3	3	<3
BH-61	4	<3	4	3
A-42	4	33	64	55
A-50	4	<3	<3	<3
BH-49	4	<3	7	4
BH-51	4	<3	5	4
BH-63	4	<3	<3	<3
A-52	2[i]	17	21	19
BH-64	4	<3	9	7
BH-70	4	<3	5	4
BH-71	4	<3	<3	<3

[a]Sampling locations are shown in Figures 3-2 and 3-3 (surface water) and 1-7 and 1-8 (groundwater).
[b]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.
[c]Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average value is reported without the notation "less than."
[d]Location was frozen in the first quarter and dry in the third quarter. The ditch was filled in the fourth quarter.
[e]Location was frozen in the first quarter and dry in the third quarter.
[f]Background location established on-site at the South 31 Ditch. Established in October 1988.
[g]Wells with the prefix "A" are in the upper groundwater system; those with the prefix "BH" are in the lower groundwater system.
[h]Upgradient well.
[i]Well was dry in the second and fourth quarters.

TABLE 3-4

CONCENTRATIONS OF RADIUM-226 IN NFSS WATER SAMPLES, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Average
Surface Water				
On-Site				
10	1[d]	0.2	0.2	0.2
11	2[e]	1.0	1.1	1.0
Off-Site				
12	2[e]	0.1	0.4	0.3
20	2[e]	0.1	1.9	1.0
Background				
9	1[f]	0.2	0.2	0.2
Groundwater[g]				
On-Site				
BH-5	4	0.1	0.3	0.3
BH-48[h]	4	0.5	0.8	0.7
BH-61	4	0.1	0.5	0.3
A-42	4	0.3	0.8	0.5
A-50	4	0.2	0.5	0.3
BH-49	4	0.1	0.6	0.3
BH-51	4	0.1	0.5	0.4
BH-63	4	0.3	0.5	0.4
A-52	2[i]	0.2	0.3	0.3
BH-64	4	0.2	0.7	0.4
BH-70	4	0.4	0.6	0.5
BH-71	4	0.2	0.4	0.3

[a]Sampling locations are shown in Figures 3-2 and 3-3 (surface water) and 1-7 and 1-8 (groundwater).
[b]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.
[c]Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average value is reported without the notation "less than."
[d]Location was frozen in the first quarter and dry in the third quarter. The ditch was filled in the fourth quarter.
[e]Location was frozen in the first quarter and dry in the third quarter.
[f]Background location established on-site at the South 31 Ditch. Established in October 1988.
[g]Wells with the prefix "A" are in the upper groundwater system; those with the prefix "BH" are in the lower groundwater system.
[h]Upgradient well.
[i]Well was dry in the second and fourth quarters.

performance. These wells were added to the environmental monitoring program in April 1987. Their locations are shown in Figure 1-8.

Wells BH-5, BH-48, BH-49, BH-51, BH-63, BH-64, and BH-70 monitor the lower aquifer. Well BH-71 monitors the bedrock aquifer. Wells A-42, A-50, and A-52 monitor the upper aquifer around the IWCF (but are not among the 36 new wells). Well A-42 is drilled into a sand lens of unknown extent. An investigation of this well's chemical, radiological, and hydrogeological behavior was conducted in December 1988. Results are presented in Subsection 4.2. Well BH-48 is an upgradient (background) monitoring location, and BH-61 is a downgradient monitoring location.

In addition, to provide information on the chemical substances present in the groundwater, programs were initiated to monitor baseline chemical constituents and to determine the identities and concentrations of various indicator parameters and heavy metals. A more detailed discussion of the chemical monitoring program is presented in Subsection 4.2.

Groundwater samples were collected after the wells had been bailed dry or three casing volumes had been removed and a 24-h period for well recharge had been allowed. Nominal 1-liter (0.26-gal) grab samples were collected with a bailer to fill a 4-liter (1-gal) container. Samples were analyzed by TMA/E for total uranium and dissolved radium-226 by the methods applied to surface water analyses (Subsection 3.3.1).

Analysis results for total uranium concentrations in groundwater are listed in Table 3-3; radium results are given in Table 3-4. Table 3-5 shows analysis results for total uranium in the monitoring wells along the perimeter of the IWCF; Table 3-6 shows the results for radium-226. Annual average concentrations of total uranium in groundwater ranged from less than 3×10^{-9} to 5.5×10^{-8} μCi/ml (less than 3 to 55 pCi/l). Annual average concentrations of

TABLE 3-5

CONCENTRATIONS OF TOTAL URANIUM IN NFSS IWCF MONITORING WELLS, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Average
OW-1A	4	<3	<3	<3
OW-1B	4	<3	6	5
OW-2A	4	<3	3	<3
OW-2B	4	5	9	8
OW-3A	4	<3	5	4
OW-33B	4	11	15	14
OW-4A	4	<3	<3	<3
OW-4B	4	5	9	7
OW-5A	4	<3	5	4
OW-5B	3[d]	9	12	10
OW-6A	4	<3	<3	<3
OW-6B	4	13	16	14
OW-7A	3[e]	7	11	10
OW-7B	4	<3	9	5
OW-8A	4	<3	4	3
OW-8B	4	16	26	20
OW-9A	4	<3	5	4
OW-9B	4	17	23	20
OW-10A	4	<3	5	4
OW-10B	4	3	8	6
OW-11A	4	19	43	28
OW-11B	4	<3	5	4
OW-12A	4	<3	7	5
OW-12B	3[d]	13	15	14
OW-13A	4	<3	5	4
OW-13B	4	15	21	17
OW-14A	4	<3	4	4
OW-14B	4	5	8	7
OW-15A	4	<3	5	4
OW-15B	3[d]	5	9	7
OW-16A	4	4	7	5
OW-16B	4	<3	11	7
OW-17A	4	<3	5	4
OW-17B	4	7	9	8
OW-18A	4	<3	5	4
OW-18B	4	16	21	18

[a]Sampling locations are shown in Figure 1-8.
[b]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.
[c]Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average is reported without the notation "less than."
[d]Well was dry in the fourth quarter.
[e]Well was dry in the first quarter.

TABLE 3-6

CONCENTRATIONS OF RADIUM-226 IN NFSS IWCF MONITORING WELLS, 1988

Sampling Location[a]	Number of Samples	Concentration (10^{-9} µCi/ml)[b,c] Minimum	Maximum	Average
OW-1A	4	0.3	0.6	0.4
OW-1B	4	0.3	0.5	0.4
OW-2A	4	0.2	0.6	0.4
OW-2B	4	0.2	0.5	0.4
OW-3A	4	0.3	0.5	0.4
OW-3B	4	0.3	0.6	0.5
OW-4A	4	0.2	0.6	0.4
OW-4B	4	0.2	0.4	0.3
OW-5A	4	0.3	0.7	0.4
OW-5B	3[d]	0.6	0.8	0.7
OW-6A	4	0.2	0.6	0.4
OW-6B	4	0.4	0.6	0.5
OW-7A	3[d]	0.3	0.9	0.5
OW-7B	4	0.2	0.7	0.4
OW-8A	4	0.3	0.6	0.5
OW-8B	4	0.3	1.8	0.8
OW-9A	4	0.3	0.6	0.4
OW-9B	4	0.1	1.6	0.7
OW-10A	4	0.2	0.4	0.3
OW-10B	4	0.2	0.5	0.3
OW-11A	4	0.3	1.0	0.6
OW-11B	4	0.4	0.6	0.5
OW-12A	4	0.3	0.7	0.5
OW-12B	3[e]	0.4	0.9	0.6
OW-13A	4	0.4	0.6	0.5
OW-13B	4	0.4	1.0	0.7
OW-14A	4	0.3	0.7	0.5
OW-14B	4	0.4	1.2	0.8
OW-15A	4	0.2	0.7	0.5
OW-15B	3[e]	0.4	0.9	0.6
OW-16A	4	0.3	0.5	0.4
OW-16B	4	0.2	1.4	0.8
OW-17A	4	0.3	0.6	0.5
OW-17B	4	0.2	0.4	0.3
OW-18A	4	0.3	0.8	0.5
OW-18B	4	0.3	0.7	0.4

[a]Sampling locations are shown in Figure 1-8.
[b]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.
[c]Where no more than one value is less than the limit of sensitivity of the analytical method, values are considered equal to the limit of sensitivity, and the average is reported without the notation "less than."
[d]Well was dry in the fourth quarter.
[e]Well was dry in the first quarter.

radium-226 in groundwater ranged from 3×10^{-10} to 7×10^{-10} μCi/ml (0.3 to 0.7 pCi/l). Annual averages for total uranium in water in the wells monitoring the waste containment area ranged from $<3 \times 10^{-9}$ to 2.8×10^{-8} μCi/ml (<3 to 28 pCi/l). Radium-226 annual average values ranged from 3.0×10^{-10} to 8.0×10^{-10} μCi/ml (0.3 to 0.8 pCi/l). These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

For a comparison of radionuclide concentrations measured in groundwater at the NFSS from 1982 through 1988, see Subsection 3.6.4.

3.4 SEDIMENT SAMPLING

During 1988, sediment samples consisting of composites weighing approximately 500 g (1.1 lb) were collected on site and off site at surface water sampling Locations 11, 12, and 20 (see Figures 3-2 and 3-3). The rationale for selecting sampling locations is as stated in Section 3.3.1.

TMA/E analyzed the samples for total uranium and radium-226. The uranium concentration was obtained by summing the results from isotopic uranium analyses. Isotopic uranium was determined by alpha spectrometry, where the uranium has been leached and organically extracted and electroplated on a metal substrate. Radium-226 concentrations were determined by radon emanation.

The analysis results (based on dry weight) for total uranium and radium are presented in Table 3-7. The average on-site and off-site concentrations are approximately the same and probably reflect background concentrations. These concentrations may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

TABLE 3-7

TOTAL URANIUM AND RADIUM-226 CONCENTRATIONS

IN NFSS SEDIMENT SAMPLES, 1988

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Uranium				
On-Site				
10	1[b]	2.7	2.7	2.7
11	2[c]	1.1	1.8	1.5
Background				
9	1[d]	2.0	2.0	2.0
Off-Site				
12	2[c]	1.7	2.1	1.9
20	2[c]	1.4	2.1	1.8
Radium-226				
On-Site				
10	1[b]	0.8	0.8	0.8
11	2[c]	0.6	1.4	1.0
Background				
9	1[d]	1.3	1.3	1.3
Off-Site				
12	2[c]	0.8	1.7	1.3
20	2[c]	0.7	1.0	0.9

[a]Sampling locations are shown in Figures 3-2 and 3-3.

[b]Location was frozen in the first quarter and dry in the third quarter. The Central Drainage Ditch was filled in during the fourth quarter.

[c]Location was frozen in the first quarter and dry in the third quarter.

[d]Location was established in October 1988 at the South 31 Ditch.

3.5 RADIATION DOSE

To assess the environmental significance of possible release of radionuclides from radioactive materials stored at the NFSS, radiological exposure pathways were evaluated to calculate the dose to a hypothetical maximally exposed individual. This hypothetical individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, receives the largest dose. An appraisal of potential pathways (exposure to external gamma radiation, ingestion of water, and inhalation of radon) suggested that exposure to external gamma radiation was the only plausibly significant exposure mode.

The potential dose from ingesting groundwater or surface water from sources on the NFSS property was not calculated because it was considered unrealistic to assume that ingestion of this water would occur. The NFSS is fenced and locked and security is well maintained, so a member of the public could consume significant volumes of water on the site only by trespassing on the property and consuming water daily. To consume groundwater from a well at the NFSS, the member of the public would also have to be equipped with a means of removing the well cap (which is locked) and would need a power source, a pump, and a hose.

Radon concentrations measured at the boundary of the NFSS were within the normal variation associated with background measurements for this area. Consequently, this pathway would not contribute additional dose to the maximally exposed individual.

3.5.1 Dose to the Maximally Exposed Individual

To identify the individual in the vicinity of the NFSS who would receive the highest dose from on-site low-level radioactive materials, potential exposures from external gamma radiation were calculated at various monitoring locations that could be accessible to the public. These exposures were then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring

points. From these calculations, it was determined that the highest exposure would be received by an individual directly east of the site.

The highest measured radiation level above background, 23 mR/yr, was recorded at TLD Location 20. As shown in Figure 1-5, the area adjacent to TLD Location 20 is used as a sanitary landfill. Exposure to people in this area is therefore conservatively based on a 40-h work week, although it is highly unlikely that a worker would spend an entire 40-h work week near this sampling location. Applying a 40-h/week occupancy factor, the exposure to landfill workers would be a maximum of 6 mR/yr above background. Because 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 6 percent of the DOE radiation protection standard. This scenario is highly conservative in that it is highly unlikely that any individual would spend so much time at this location. A more realistic assessment would demonstrate that the incremental dose is less than 1 mrem/yr. By comparison, this exposure is less than a person would receive during two round-trip flights from New York to Los Angeles resulting from the greater amounts of cosmic radiation at higher altitudes (see Appendix D).

3.5.2 Dose to the Population in the Vicinity of the NFSS

The dose to the population represents the conceptual cumulative radiation dose to all residents within an 80-km (50-mi) radius of a given site. This estimated dose includes contributions from all potential pathways. For the NFSS, these pathways are direct exposure to gamma radiation, inhalation of radon, and ingestion of water containing radioactivity.

The contribution to the population dose made by gamma radiation from on-site radioactive materials is too small to be measured because gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma exposure rate at a distance of 0.9 m (3 ft) from a small-area radioactive source

were 100 mR/yr, the exposure rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon is known to dissipate rapidly as distance from the radon source increases (Ref. 13). Therefore, radon exposure does not contribute significantly to population dose.

On the basis of radionuclide concentrations measured in water leaving the site, it also appears that there is no predictable pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels.

Because the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within an 80-km (50-mi) radius of the NFSS that results from radioactive materials present at the site is indistinguishable from the dose that the same population receives from naturally occurring radioactive sources.

3.6 TRENDS

The environmental monitoring program at the NFSS was established to allow an annual assessment of the environmental conditions at the site, provide a historical record for year-to-year comparisons, and permit detection of trends. In the following subsections, 1988 annual averages for each monitoring location for radon, external gamma radiation, and radionuclide concentrations in surface water and groundwater are compared with results for 1982-1988 for the corresponding locations.

In some cases, sampling locations monitored in earlier years no longer exist (because of adjustments in the monitoring program or changes resulting from remedial action). Data from such locations

would not be valid for comparisons or trends and therefore are not reported in the trend tables. Comparisons and trends are based on current monitoring locations; when there are gaps or anomalies in the data reported for these locations in past years, these are footnoted and explained in the tables. As the environmental monitoring program continues at the NFSS and more data are collected, comparisons and analyses of trends will become more meaningful.

3.6.1 Radon

As Table 3-8 shows, radon concentrations at the NFSS site boundary have decreased noticeably since 1982. The fluctuations in levels at some monitoring locations can be attributed to remedial action at the NFSS. Statistical analyses of radon data for the period 1982 through 1988 indicate that significant decreases in radon concentrations at the NFSS began in late 1984 and continued into mid-1986. This period coincides with the period during which construction of the IWCF was begun and completed. Radon concentrations at the NFSS stabilized in late 1986 and have remained at the background level for the area. Radon concentrations measured in 1988 do not differ significantly from 1987 levels.

3.6.2 External Gamma Radiation Levels

As shown in Table 3-9, although there has been some fluctuation in external gamma radiation levels (especially during the years 1983 to 1985 when remedial activities were in full progress), 1986 levels in most cases were much lower than levels measured in 1982. This overall downward trend can be attributed to the effects of remedial action at the NFSS. External gamma radiation levels in 1988 remained stable as compared with those measured from 1985 through 1987.

TABLE 3-8

ANNUAL AVERAGE CONCENTRATIONS OF RADON-222 MEASURED BY TERRADEX MONITORS AT THE NFSS BOUNDARY, 1982-1988[a]

Page 1 of 2

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c,d]						
	1982	1983	1984	1985	1986	1987	1988
Site Boundary							
1	1.2	0.8	0.9	0.4	0.3	0.2	0.5
3	0.6	0.5	0.7	0.5	0.3	0.3	0.2
4	0.7	0.6	0.6	0.4	0.3	0.4	0.2
5	0.6	0.4	0.5	0.2	0.3	0.2	0.5
6	0.7	0.5	0.5	0.4	0.2	0.2	0.4
7	1.0	0.5	0.4	0.6	0.2	0.3	0.4
11	0.9	0.5	0.3	0.4	0.4	0.2	0.2
12	0.8	0.6	0.4	0.4	0.2	0.3	0.3
13	0.9	0.4	0.7	0.5	0.4	0.1	0.5
14	0.7	0.4	0.5	0.3	0.8	0.4	0.3
15	0.8	0.5	0.5	0.3	0.3	0.2	0.3
20	0.7	0.5	0.5	0.5	0.2	0.2	0.5
28	0.7	0.4	0.5	0.4	0.3	0.2	0.3
29	-[e]	0.6	0.4	0.6	0.4	0.3	0.3
32	1.0	0.4	1.0	0.4	0.3	0.3	0.3
34	0.4	0.5	0.5	0.5	0.3	0.8	0.2
35	-[f]	-[f]	-[f]	0.3	0.2	0.2	0.5
36	-[f]	-[f]	-[f]	0.4	0.3	0.2	0.3
Background							
30	-[g]	-[h]	1.0	0.4	0.3	0.3	0.6
120[i]	-[i]	-[i]	-[i]	-[i]	-[i]	-[i]	0.5
121[j]	-[j]	-[j]	-[j]	-[j]	-[j]	-[j]	0.5

[a]Data sources for 1982-1987 are the annual site environmental reports for those years (Refs. 10-15).

[b]Sampling locations are shown in Figure 3-1.

[c]1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.

[d]Background has not been subtracted. Note that some locations have concentrations below background.

[e]Sampling Location 29 was moved to its present location in the fourth quarter of 1982. As such, 1982 data are not directly comparable to data for other years.

[f]Sampling Locations 35 and 36 were added to the monitoring program in January 1985.

TABLE 3-8

(continued)

[g]Background monitoring location was added to the monitoring program in January 1983 at Seneca St., Lewiston, NY, approximately 6.4 km (4 mi) southwest of the NFSS.

[h]Background detector was improperly exposed during one sampling period. Annual average background, therefore, was invalid.

[i]Background location established in April 1988 at the Lewiston Water Pollution Control Center, 1.6 km (1 mi) southwest of the NFSS at Pletcher Rd., Lewiston, NY.

[j]Background location established in April 1988 at the Lewiston Town Hall, 1.6 km (1 mi) south of the NFSS at the intersection of Route 104 and Swain Rd., Lewiston, NY.

TABLE 3-9

ANNUAL AVERAGE EXTERNAL GAMMA RADIATION LEVELS AT THE NFSS, 1982-1988[a]

Sampling Location[b]	Radiation Level (mR/yr)[c]						
	1982[d]	1983	1984	1985	1986	1987	1988
Site Boundary							
1	22	19	34	18	16	11	11
3	156	127	119	24	4	11	9
4	261	192	167	48	14	13	7
5	90	86	84	24	14	16	22
6	26	15	35	21	8	3	16
7	43	17	31	20	8	11	7
11	-[e]	12	17	12	4	2	5
12	-[e]	12	24	11	2	6	8
13	-[e]	14	42	14	0[f]	0[f]	6
14	8	8	13	6	3	7	14
15	22	0[f]	8	3	6	6	14
20	173	121	127	65	26	24	23
28	-[e]	8	26	14	14	14	10
29	5	12	31	14	0[f]	0[f]	10
32[g]	13	17	16	10	6	5	8
34	85	78	79	16	6	8	3
35	-[h]	-[h]	-[h]	16	15	14	14
36	-[h]	-[h]	-[h]	6	5	16	10
Background[i]							
30	-[i]	-[i]	-[i]	91	69	64	71

[a]Data sources for 1982-1987 data are the annual site environmental reports for those years (Refs. 10-15).

[b]Site boundary locations only. Sampling locations are shown in Figure 3-1.

[c]Measured background has been subtracted from readings taken at site boundary locations.

[d]Current external gamma radiation sampling locations were established in the fourth quarter of 1982. Therefore, 1982 data represent only one quarter's measurements.

[e]Detectors were missing from sampling location.

[f]Measurement was equal to or less than measured background value.

[g]Location 32 is a quality control for Location 12.

TABLE 3-9

(continued)

[h]Sampling Locations 35 and 36 were added to the monitoring program in January 1985.

[i]Location 30 was established in 1985, approximately 6.4 km (4 mi) southwest of the NFSS at Seneca St., Lewiston, NY. Additional background locations were established in April 1988 at the Lewiston Town Hall, approximately 1.6 km (1 mi) south of the NFSS, and the Lewiston Water Pollution Control Center, approximately 1.6 km (1 mi) southwest of the NFSS. Data for these locations are not reported because the exposure time is less than a year. Data will be presented in the 1989 environmental report.

3.6.3 Surface Water

As shown in Tables 3-10 and 3-11, the concentrations of total uranium and radium-226 in surface water have decreased since 1982. This decrease can be attributed to remedial action conducted at the site, although construction activities during remedial action contributed to a sharp increase in uranium concentration at Location 10 from 1982 to 1983. A comparison of 1986 data with 1982 data shows the extent to which remedial action has been successful in reducing radionuclide concentrations in surface water at the NFSS.

Total uranium and radium-226 levels in 1988 remained stable as compared with the 1984 values. Significant decreases were measured at off-site locations from 1982 through 1987.

3.6.4 Groundwater

As shown in Tables 3-10 and 3-11, there have been no noticeable trends in the concentrations of uranium or radium-226 in groundwater at the NFSS. Since the current monitoring wells were installed in 1983, most locations have reported concentrations that have remained basically stable.

Uranium levels in A-42 remained relatively stable from January through July at a value of about 64 pCi/l. The concentration dropped to around 30 pCi/l in October. This decrease may be attributed to greater than usual pumping during mid-July.

The uranium concentration in A-42 has been consistently above that measured in the other wells. This well was installed during the early days of remedial action on the site; a review of historical records indicates that it was drilled in an area that had been radioactively contaminated. An investigation was completed in an effort to determine why data for A-42 are atypical. A summary of this effort is presented in Subsection 4.2.

TABLE 3-10

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM IN NFSS WATER SAMPLES, 1982-1988[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c]						
	1982	1983	1984	1985	1986	1987	1988
Surface Water							
On-Site							
10	76	656	19	15	8	6	7
11	108	30	3	19	5	14	10
Off-Site							
12	36	23	8	9	4	5	6
20	39	22	10	4	5	6	7
Background							
9	-[d]	-[d]	-[d]	-[f]	-[d]	-[d]	8
Groundwater							
On-Site							
BH-5	-[e]	5[f]	3	3	<3	<3	<3
BH-48	-[e]	5[f]	6	5	5	4	<3
BH-61	-[e]	<3[f]	4	3	<3	<3	3
A-42	-[e]	56[f]	55	62	71	78	55
A-50	-[e]	8[f]	5	3	4	4	<3
BH-49	-[e]	<3[f]	3	3	<3	<3	4
BH-51	-[e]	9[f]	7	11	7	6	4
BH-63	-[e]	9[f]	3	3	<3	<3	<3
A-52	-[e]	8[f]	73	22	17	18	19
BH-64	-[e]	18[f]	13	15	13	10	7
BH-70	-[e]	5[f]	7	4	3	7	4
BH-71	-[e]	3[f]	4	3	<3	<3	<3
Off-Site							
17	9	<3	<3	<3	<3	<3[h]	-[h]
19	<3	<3	-[g]	<3	<3	<3[h]	-[h]

[a]Data sources for 1982-1987 are the annual site environmental reports for those years (Refs. 10-15).

[b]Sampling locations are shown in Figures 3-2 and 3-3 (surface water) and 1-7 and 1-8 (groundwater). Sampling locations that have existed in previous years but that no longer exist due to adjustments in the monitoring program or changes caused by remedial action are not reported in trend tables. Data from these locations would not be valid for comparisons or trends.

TABLE 3-10

(Continued)

[c] 1 x 10^{-9} µCi/ml is equivalent to 1 pCi/l.

[d] Location established in October 1988 at the South 31 Ditch. Represents background.

[e] On-site groundwater wells monitored in 1982 were replaced in mid-1983 with wells currently being monitored (see footnote b).

[f] New on-site groundwater wells were installed in mid-1983. Data reported represent two quarters' measurements.

[g] Sampling performed annually; sample was lost during shipment to the laboratory.

[h] Sampling of domestic water supply wells was terminated after first quarter results were obtained, since concentrations of uranium and radium in these wells have not exceeded 3.0 x 10^{-9} µCi/ml (3.0 pCi/l) and 3.0 x 10^{-10} µCi/ml (0.3 pCi/l), respectively, since 1983.

TABLE 3-11

ANNUAL AVERAGE CONCENTRATIONS OF RADIUM-226

IN NFSS WATER SAMPLES, 1982-1988[a]

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[c]						
	1982	1983	1984	1985	1986	1987	1988
Surface Water							
On-Site							
10	0.6	0.4	0.2	0.4	0.2	0.2	0.2
11	1.5	1.2	0.1	0.7	0.3	1.8	1.0
Off-Site							
12	0.8	0.8	0.4	0.2	0.3	0.3	0.3
20	0.6	0.6	0.3	0.4	0.4	0.3	1.0
Background							
9	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	0.2
Groundwater							
On-Site							
BH-5	-[e]	0.1[f]	0.2	0.5	0.5	0.4	0.3
BH-48	-[e]	0.2[f]	0.4	0.6	0.5	0.5	0.7
BH-61	-[e]	0.1[f]	0.2	0.5	0.3	0.3	0.3
A-42	-[e]	0.2[f]	0.4	0.5	0.6	0.2	0.5
A-50	-[e]	0.3[f]	0.4	0.7	0.5	0.3	0.3
BH-49	-[e]	0.2[f]	0.2	0.4	0.2	0.2	0.3
BH-51	-[e]	0.3[f]	0.3	0.5	0.3	0.3	0.4
BH-63	-[e]	0.3[f]	0.4	0.4	0.5	0.3	0.4
A-52	-[e]	-[g]	0.1	0.2	0.3	0.2	0.3
BH-64	-[e]	0.2[f]	0.1	0.3	0.4	0.2	0.4
BH-70	-[e]	0.6[f]	0.2	0.6	0.5	0.3	0.5
BH-71	-[e]	0.4[f]	0.2	0.4	0.4	0.4	0.3
Off-Site							
17	0.3	0.1	0.3	0.2	0.3	0.3[i]	-[i]
19	0.4	0.1	-[h]	0.1	0.3	0.3[i]	-[i]

[a]Data sources for 1982-1987 are the annual site environmental reports for those years (Refs. 10-15).

[b]Sampling locations are shown in Figures 3-2 and 3-3 (surface water) and 1-7 and 1-8 (groundwater). Sampling locations that have existed in previous years but that no longer exist due to adjustments in the monitoring program or changes caused by remedial action are not reported in trend tables. Data from these locations would not be valid for comparisons or trends.

TABLE 3-11

(Continued)

[c] 1×10^{-9} µCi/ml is equivalent to 1 pCi/l.

[d] Location established in October 1988 at the South 31 Ditch. Represents background.

[e] On-site groundwater wells monitored in 1982 were replaced in mid-1983 with wells currently being monitored (see footnote b).

[f] New on-site groundwater wells were installed in mid-1983. Data reported represent two quarters' measurements.

[g] Well casing was damaged and no samples could be obtained.

[h] Sampling performed annually; sample was lost during shipment to laboratory.

[i] Sampling of domestic water supply wells was terminated after first quarter results were obtained because concentrations of uranium and radium in these wells have not exceeded 3.0×10^{-9} µCi/ml (3.0 pCi/l) and 3.0×10^{-10} µCi/ml (0.3 pCi/l), respectively, since 1983.

Tables 3-12 and 3-13 give total uranium and radium-226 concentrations in containment monitoring wells in 1987 and 1988. No trends are evident at this time except to note no significant change. As more data are accumulated, trends will be further evaluated.

Environmental monitoring for various chemical parameters was initiated in 1987. A discussion of analytical results is contained in Subsection 4.1 of this report.

TABLE 3-12

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM IN NFSS CONTAINMENT MONITORING WELLS, 1987-1988

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[a] 1987	1988
OW-1A	4[c]	<3
OW-1B	4[c]	5
OW-2A	3	<3
OW-2B	5	8
OW-3A	3	4
OW-3B	10	14
OW-4A	3	<3
OW-4B	6	7
OW-5A	3	4
OW-5B	11	10
OW-6A	3	<3
OW-6B	15[c]	14
OW-7A	8[c]	10
OW-7B	3	5
OW-8A	3	3
OW-8B	17	20
OW-9A	3[c]	4
OW-9B	14[c]	20
OW-10A	5	4
OW-10B	3	6
OW-11A	36[c]	28
OW-11B	3[c]	4
OW-12A	3[c]	5
OW-12B	15[c]	14
OW-13A	3[c]	4
OW-13B	14[c]	17
OW-14A	4[c]	4
OW-14B	5[c]	7
OW-15A	3[c]	4
OW-15B	6[c]	7
OW-16A	3	5
OW-16B	6	7
OW-17A	3	4
OW-17B	7	8
OW-18A	3[c]	4
OW-18B	14[c]	18

[a] 1 x 10^{-9} µCi/l is equivalent to 1 pCi/l.

[b] Sampling locations are shown in Figure 1-8.

[c] In March 1988 it was discovered that the identifiers of several well pairs had inadvertently been reversed. This has been corrected, as reflected in the values listed here (Ref. 18).

TABLE 3-13

ANNUAL AVERAGE CONCENTRATIONS OF RADIUM-226

IN NFSS CONTAINMENT MONITORING WELLS, 1987-1988

Sampling Location[b]	Concentration (10^{-9} µCi/ml)[a] 1987	1988
OW-1A	0.4[c]	0.4
OW-1B	0.2[c]	0.4
OW-2A	0.2	0.4
OW-2B	0.2	0.4
OW-3A	0.1	0.4
OW-3B	0.1	0.5
OW-4A	0.2	0.4
OW-4B	0.2	0.3
OW-5A	0.2	0.4
OW-5B	0.2	0.7
OW-6A	0.2	0.4
OW-6B	0.2	0.5
OW-7A	0.2[c]	0.5
OW-7B	0.2[c]	0.4
OW-8A	0.2	0.5
OW-8B	0.2	0.8
OW-9A	0.2[c]	0.4
OW-9B	0.2[c]	0.7
OW-10A	0.3	0.3
OW-10B	0.2	0.3
OW-11A	0.2[c]	0.6
OW-11B	0.1[c]	0.5
OW-12A	0.2[c]	0.5
OW-12B	0.2[c]	0.6
OW-13A	0.2[c]	0.5
OW-13B	0.2[c]	0.7
OW-14A	0.2[c]	0.5
OW-14B	0.5[c]	0.8
OW-15A	0.3[c]	0.5
OW-15B	0.2[c]	0.6
OW-16A	0.2	0.4
OW-16B	0.2	0.8
OW-17A	0.2	0.5
OW-17B	0.2	0.3
OW-18A	0.3[c]	0.5
OW-18B	0.4[c]	0.4

[a] 1 x 10^{-9} µCi/l is equivalent to 1 pCi/l.

[b] Sampling locations are shown in Figure 1-8.

[c] In March 1988 it was discovered that the identifiers of several well pairs had inadvertently been reversed. This has been corrected, as reflected in the values listed here (Ref. 18).

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

Monitoring of chemicals began in 1987 and continued in 1988. This quarterly sampling program monitors several water quality parameters, including pH, specific conductance, total organic carbon, and total organic halides (Table 4-1), and select heavy metals (Table 4-2).

In 1988, pH varied from slightly acid to basic in wells across the site. Total organic halide concentrations ranged from below detectable limits to 4,100 µg/l in well 4B. This result is suspected to be due to laboratory error, based on previous observations for well 4B. Other measurements for the year ranged from 22 to 49 µg/l. Total organic halide concentrations in well 4B will be closely monitored in 1989.

Metals analyses were conducted on all the "OW" wells in addition to A-42, BH-5, BH-48, BH-61, BH-63, and BH-70. Arsenic, barium, beryllium, cadmium, cobalt, and thallium, which were not found in 1987, were detected in 1988, primarily in well OW-11B.

Comparison of the concentrations detected with maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act indicates that water beneath the NFSS would require treatment before it could be used as a public drinking water supply. The contaminants present do not exceed MCLs by more than a factor of 20, and some are present at concentrations at or below relevant MCLs. It should be noted that MCLs are enforceable standards when applied at a point of use and are not applicable to in situ groundwater contamination.

TABLE 4-1

RANGES OF WATER QUALITY PARAMETERS IN GROUNDWATER

AT THE NFSS, 1988

Sampling Location (Well No.)[b]	Parameter[a] pH (Standard Units)	Total Organic Carbon (mg/l)	Total Organic Halides (µg/l)	Specific Conductance (µmhos/cm)
OW-1A	6.8 - 9.3	1.6 - 5.1	ND - 90	1670 - 2090
OW-1B	7.5 - 7.8	1.6 - 4.3	33 - 82	956 - 1190
OW-2A	7.5 - 8.1	1.2 - 4.1	22 - 70	1560 - 1760
OW-2B	7.2 - 7.3	1.1 - 2.9	37 - 51	1330 - 1640
OW-3A	7.1 - 7.8	1.3 - 2.8	12 - 130	1750 - 1960
OW-3B	7.5 - 7.6	2.3 - 3.9	22 - 4100	1920 - 2320
OW-4A	7.5 - 8.2	1.0 - 12.7	20 - 65	1110 - 1290
OW-4B	7.5 - 7.6	1.2 - 2.4	ND - 110	1130 - 1430
OW-5A	7.5 - 8.0	ND - 3.1	66 - 170	1180 - 1610
OW-5B	7.4 - 7.9	1.6 - 4.5	ND - 490	1370 - 1690
OW-6A	7.4 - 7.9	1.6 - 3.5	17 - 110	1450 - 1690
OW-6B	7.3 - 7.4	2.1 - 4.8	33 - 61	2150 - 2300
OW-7A	7.5 - 7.7	1.1 - 2.9	ND - 31	1700 - 1880
OW-7B	7.5 - 7.9	1.4 - 2.8	34 - 280	1810 - 2060
OW-8A	7.3 - 7.8	3.0 - 6.5	18 - 300	2220 - 2430
OW-8B	7.3 - 7.4	3.2 - 42.6	31 - 69	1740 - 2020
OW-9A	7.4 - 7.8	1.9 - 11.0	ND - 58	1980 - 2210
OW-9B	7.2 - 7.4	2.2 - 4.4	22 - 71	2000 - 2550
OW-10A	7.1 - 8.4	1.9 - 41.1	ND - 140	1310 - 1390
OW-10B	7.5 - 7.8	1.6 - 45.0	12 - 38	1260 - 1370
OW-11A	7.4 - 7.6	2.0 - 8.8	ND - 42	1570 - 1700
OW-11B	7.6 - 7.8	1.2 - 2.4	ND - 55	1560 - 1640
OW-12A	7.4 - 7.6	1.2 - 2.5	ND - 35	1680 - 1770
OW-12B	7.5 - 7.6	1.0 - 4.6	14 - 26	1640 - 1720
OW-13A	8.1 - 8.6	2.6 - 3.8	ND - 45	1520 - 1920
OW-13B	7.3 - 8.6	1.9 - 4.4	24 - 310	2170 - 2270
OW-14A	7.3 - 7.5	1.5 - 5.3	ND - 58	1720 - 1850
OW-14B	7.8 - 8.7	1.0 - 7.3	ND - 110	1300 - 1470
OW-15A	7.5 - 7.7	2.4 - 5.2	ND - 110	2240 - 2300
OW-15B	7.4 - 7.9	2.9 - 5.2	ND - 33	1710 - 1760
OW-16A	7.7 - 8.2	1.7 - 2.9	ND - 38	2420 - 2520
OW-16B	7.3 - 7.5	1.1 - 10.3	ND - 53	1240 - 1290
OW-17A	7.1 - 8.0	1.4 - 26.4	ND - 62	2530 - 2860
OW-17B	7.5 - 7.6	1.6 - 4.8	ND - 67	1620 - 1690
OW-18A	7.5 - 7.9	2.5 - 5.3	ND - 53	2290 - 2400
OW-18B	7.3 - 7.6	1.5 - 7.4	ND - 33	3200 - 3390
A-42	7.2 - 7.4	2.1 - 4.6	ND - 30	1110 - 1200
A-50	7.5 - 7.8	1.8 - 3.1	ND - 49	1960 - 4910
A-52	6.9 - 7.1	2.1 - 33	24 - 66	1110 - 1440

TABLE 4-1

(continued)

Sampling Location (Well No.)[b]	Parameter[a] pH (Standard Units)	Total Organic Carbon (mg/l)	Total Organic Halides (µg/l)	Specific Conductance (µmhos/cm)
BH-5	10.7 - 11.8	4.1 - 8.8	ND - 37	1050 - 1770
BH-48[c]	7.5 - 8.4	1.0 - 1.5	39 - 330	4430 - 5200
BH-49	10.1 - 11.3	3.8 - 4.8	ND - 94	1260 - 2020
BH-51	7.2 - 7.8	1.3 - 34	ND - 160	1330 - 3000
BH-61	7.7 - 8.4	1.7 - 2.6	14 - 70	1330 - 1880
BH-63	7.2 - 7.7	1.8 - 12.5	ND - 190	1680 - 2240
BH-64	7.4 - 7.6	1.1 - 3.6	14 - 93	1450 - 1800
BH-70	7.3 - 7.4	1.7 - 4.7	ND - 260	2460 - 3080
BH-71	7.4 - 7.8	1.4 - 3.0	22 - 50	2070 - 2510

[a]ND - No detectable concentration.

[b]Monitoring well locations are shown in Figures 1-7 and 1-8.

[c]Upgradient well.

TABLE 4-2

RANGES OF CONCENTRATIONS OF METAL TONS IN GROUNDWATER AT THE NFSS, 1988[a]

Parameter (µg/l)	Ranges of Concentrations by Sampling Location (Monitoring Well Number)[b,c]										
	OW-1A	OW-1B	OW-2A	OW-2B	OW-3A	OW-3B	OW-4A	OW-4B	OW-5A	OW-5B	OW-6A
Aluminum	269	ND	ND	ND	ND	221-227	ND	ND	ND	ND	311
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	154-655	140-491	178-950	158-848	537-558	160-239	434-515	114-207	491-538	129-261	384-603
Barium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (x 1000)	86.9-137	83.4-113	120-1346	101-167	76.9-98.4	101-120	64.5-77.9	94.1-97.5	41-48.5	97.9-104	93.8-117
Cadmium	ND	5	ND	ND	8	11	6	ND	ND	6	4
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	10.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	28.3	ND	ND	ND	ND	47.5	ND	32.9-77	58
Iron	138	ND	ND	ND	145	107	118	107	ND	ND	ND
Potassium (x 1000)	8.36-20.6	2.5-16.3	ND	5.47	5.76	6.77-10.1	57.8-57.9	5	5.93-84.7	55.8-79.9	11-13.3
Magnesium (x 1000)	86.3-109	78.4-84.6	72.8-107	68.6-108	126-167	194-212	48.9-60.0	94-100	86.3-93	131-133	66.9-99.4
Manganese	24-133	116-202	33.2-150	52-134	128-176	21-145	40.4-54.8	42.1-80.8	36.5-56	44.5-52	99.5-264
Molybdenum	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium (x 1000)	67.1-156	48.5-150	60.5-183	65-144	124-158	91.4-111	101-110	39.9-45.6	93.2-97.8	43.9-47.6	84.6-107
Nickel	4.9-9	43.8-50	ND	ND	53.0	ND	ND	ND	48	ND	47.6-77
Antimony	ND	ND	88	77	ND	ND	72	ND	84	53	ND
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	187	ND	ND	ND	ND	134-190	100	ND	100	109	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	29.6-43	23.6-310	27.6-85	23-63.2	62.1-405	34.5-393	43-80.6	22-44.2	21-69.5	20.3-139	20-69.0

TABLE 4-2

(continued)

Parameter (µg/l)	Ranges of Concentrations by Sampling Location (Monitoring Well Number)[b,c]										
	OW-6B	OW-7A	OW-7B	OW-8A	OW-8B	OW-9A	OW-9B	OW-10A	OW-10B	OW-11A	OW-11B
Aluminum	244-411	363	327	251-266	244-322	208-551	265-503	251-360	244-428	228-680	252-691
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	244
Boron	167-237	197-384	779-976	1020-1170	87-204	880-1070	215-343	428-584	128-428	86-232	763-894
Barium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	285
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.7
Calcium (x 1000)	123-144	92.8-115	102-119	134-171	127-145	137-177	16.5-18.2	76.2-90.4	45.5-74	113-141	78.3-96.8
Cadmium	8	5	5	ND	6	5	7	ND	ND	7	6
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	53.6
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20.9
Copper	28.3-61	38-59	46	45	26.1-49	50-60	30.1-51.5	41.2-42	55-62.9	28.6-80.4	38-82.1
Iron	106	151	144	221	ND	159-223	137-146	107	ND	102	146
Potassium (x 1000)	53.8-63.6	2.14-5	6.55-10.2	10.2-14.1	2.2	8.88-17.7	2.99	7.11-13.8	3.72-8.78	1.97-7.87	8.39-14.2
Magnesium (x 1000)	201-234	151-1876	133-152	103-114	155-177	74.8-89.8	21.8-23.4	55.9-87.7	79.3-127	13.2-15.3	92.8-124
Manganese	128-182	26.2-190	93.2-135	118-204	30.8-73.4	41.8-170	33-192	20.4-58	23-98.5	38-198	75-199
Molybdenum	ND	ND	ND	ND	ND	106	ND	ND	ND	102	110
Sodium (x 1000)	62.3-81.8	54.7-78.9	121-147	176-235	53.8-63.5	138-164	61.4-72.1	73.1-90.9	34.5-65.6	37.5-51.2	76.5-101
Nickel	45-99	ND	41	ND	ND	ND	ND	ND	24-57.5	ND	63.9-88
Antimony	43.5-75.4	ND	ND	40.3-60.5	50	68.2-80.6	80.7	ND	ND	74.3-85.9	82.5-82.7
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	253
Thallium	189	186	ND	ND	ND	ND	128-164	ND	ND	155	211
Vanadium	56.3	50.3	ND	ND	ND	61.5	ND	ND	ND	92.5	114
Zinc	93.7	20-61.9	22-80	29-124	27.3-98.7	51-125	126-167	23.7-133	28.2-137	141-191	44.6-194

TABLE 4-2

(continued)

Parameter (µg/l)	Ranges of Concentrations by Sampling Location (Monitoring Well Number)[b,c]										
	OW-12A	OW-12B	OW-13A	OW-13B	OW-14A	OW-14B	OW-15A	OW-15B	OW-16A	OW-16B	OW-17A
Aluminum	214-271	210-1290	208	252-332	316	108-224	278-542	326	247-545	236-263	283-453
Arsenic	ND	ND	16	ND	ND	ND	ND	ND	ND	ND	ND
Boron	891-1090	165-285	604-825	85-251	593-875	ND	1040-1170	127-208	756-923	140-809	634-885
Barium	ND	ND	ND	ND	ND	ND	ND	ND	201	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (x 1000)	126-139	11.9-13.2	39.7-119	150-172	100-131	84.9-96.1	160-181	91.6-10.2	12.8-14.6	10.1-82.8	14.9-208
Cadmium	5	5	ND	8	ND	ND	ND	ND	ND	8	7
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	42	45-159	46	30.3-47	42	37.1-45	43-58.5	70.3-73.5	59.6	25.1-45	30.1-49.2
Iron	144	174	ND	ND	122-220	112	114-171	107	100	145-208	115
Potassium (x 1000)	10.1-12	2.1-23	14.1-66.5	1.92-5	6.94-15.2	1.81	7.16-18	1.36	1.37	6-7.14	1.71-21.4
Magnesium (x 1000)	93.2-108	133-158	66.5-119	199-229	72.9-83.6	98.9-118	86.5-97	136-148	19.5-22.3	9.3-193	138-193
Manganese	159-340	29-84.8	26.4-45.4	20.6-160	91-195	61.6-173	95.9-202	43.6-244	18.5-78.8	80-696	116-225
Molybdenum	ND	186	ND	ND	ND	ND	107	ND	132	ND	109
Sodium (x 1000)	90.3-109	43.5-56.5	104-169	61.4-78.3	141-185	48.8-64.5	166-217	67.9-84.9	145-180	4.88-180	136-197
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	70.5
Antimony	ND	84.8	ND	63.2	41.2	72.2	46.3	51.6	ND	49.7	43.5
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	124	ND	161	ND	ND	ND	116	188	133	ND
Vanadium	ND	163	ND	ND	ND	ND	56.8	ND	ND	ND	50.6
Zinc	26-163	29-258	33-48.2	26.8-60.5	43.7-148	23-50.5	37-110	28.9-137	82.9	28-463	26.5

TABLE 4-2

(continued)

Parameter (µg/l)	Ranges of Concentrations by Sampling Location (Monitoring Well Number)[b,c]								
	OW-17B	OW-18A	OW-18B	A-42	BH-5	BH-48[d]	BH-61	BH-63	BH-70
Aluminum	347-395	351-1100	263-991	235-1540	136-329	336-466	274	335	363-418
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	94-265	650-813	121-247	120-267	165-195	2770-2870	788-948	1000-1050	1360-1428
Barium	ND	ND	ND	68	211	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (x 1000)	94.3-107	124-139	162-178	148-170	65.2-110	532-544	98.6-119	133-153	350-396
Cadmium	5	5	16	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	15.3-65.9	ND	ND	ND	ND
Copper	27.6-57.3	22-130	27-126	192	ND	36.7	ND	25.3	ND
Iron	116	105	137-164	ND	ND	121-203	ND	ND	200-406
Potassium (x 1000)	1.85	7.86-26.7	3.25-13.8	3.33-30.1	12.5-14.2	24.8-29.2	6.96-9.61	7.74	9.49-12.2
Magnesium (x 1000)	128-159	151-194	319-377	55.9-69.1	ND	94.4-107	70.2-96.6	72.4-76.6	137-154
Manganese	60.8-183	148-333	36-208	214-577	ND	743-787	47.9-86.7	18.5-23	327-490
Molybdenum	ND	201	201	204	ND	ND	ND	ND	ND
Sodium (x 1000)	61.6-89.3	134-188	137-186	23-47.5	50.2-71.9	402-612	157-215	180-202	135-164
Nickel	44.2-82.5	40-81.5	44.8	ND	ND	ND	ND	ND	ND
Antimony	65.4	58.7	118	ND	ND	ND	60.5	ND	ND
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	104-109	ND	ND	ND	ND	ND	ND
Vanadium	24-28.7	50.1-125	69.1-128	167	ND	62.2	ND	ND	58.3
Zinc	31.7-114	24.4-162	22-616	29.2-143	136	44.9-147	37.3-136	70-244	34.2-209

TABLE 4-2

(continued)

[a]Does not include parameters for which the concentrations were below the limit of sensitivity of the analytical method used.

[b]ND - No detectable concentration. Where only one value is listed, the concentration ranged from ND to the value in the table.

[c]Sampling locations are shown in Figures 1-7 and 1-8.

[d]Upgradient well.

4.2 SPECIAL STUDIES

A pump test was performed on monitoring well A-42 during December 1988 to evaluate potential hydraulic connection between well A-42 and the NFSS containment cell. The well was pumped continuously for 25 h, during which time the water levels in adjacent monitoring wells were measured at frequent intervals. The vibrating wire transducers inside the waste containment cell were automatically cycled during the test period to detect any potentiometric surface elevation change caused by pumpage of well A-42. In addition, time-sequenced water samples were taken during the pump test and subsequently analyzed for total uranium and radium-226.

The test results indicate:

- Well A-42 is completed in a sand body that is apparently not in efficient hydraulic connection with the zones of completion of adjacent wells.
- Removal of water from well A-42 had no effect on the pore pressure distribution inside the IWCF.
- Results from sequential sampling indicate that radiological contamination in the well may be associated with contaminated solids in or near the well. Further tests will be conducted to explore this possibility.

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APPENDIX A
QUALITY ASSURANCE

APPENDIX A
QUALITY ASSURANCE

A comprehensive quality assurance (QA) program was maintained to ensure that the data collected were representative of actual concentrations in the environment. First, extensive environmental data were obtained to prevent reliance on only a few results that might not be representative of the existing range of concentrations. Second, current monitoring data were compared with historical data for each environmental medium to ensure that deviations from previous conditions were identified and evaluated. Third, samples at all locations were collected using published procedures to ensure consistency in sample collection. Fourth, each analytical laboratory verified the quality of the data by conducting a continuing program of analytical quality control (QC), participating in interlaboratory cross-checks, performing replicate analyses, and splitting samples with other recognized laboratories. Fifth, chain-of-custody procedures were implemented to maintain traceability of samples and corresponding analytical results. This program ensures that the monitoring data can be used to evaluate accurately the environmental effects of site operations.

The majority of the routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by TMA/E, Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was ensured through the use of standards traceable to the National Bureau of Standards, when available. The laboratory also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared and distributed

to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed.

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the DOE, the Nuclear Regulatory Commission, and the EPA. Table A-1 summarizes results of the EPA comparison studies for water samples.

To ensure the accuracy of dose calculations, all computed doses were double-checked by the originator and by an independent third party who also checked all input data and assumptions used in the calculations.

Chemical analyses were performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard practices manual was reviewed and accepted by BNI. The laboratory maintains an internal QA program that involves the following.

For inorganic analyses, the program includes:

- Initial calibration and calibration verification
- Continuing calibration verification
- Reagent blank analyses
- Matrix spike analyses
- Duplicate sample analyses
- Laboratory control sample analyses

TABLE A-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS

(EPA and TMA/E)

Analysis and Sample Date	Value (pCi/l) EPA	Value (pCi/l) TMA/E	Ratio (TMA/E:EPA)
Alpha			
1/88	28.0 ± 7.0	40.0 ± 2.0	1.43
2/88	4.00 ± 5.00	3.33 ± 0.60	0.83
5/88	6.0 ± 5.0	5.3 ± 0.6	0.88
7/88	46.0 ± 11.0	53.3 ± 2.9	1.16
8/88	15.0 ± 5.0	12.7 ± 0.6	0.85
11/88	8.00 ± 5.00	7.00 ± 1.00	0.88
Beta			
1/88	72.0 ± 5.0	90.0 ± 4.0	1.25
2/88	8.00 ± 5.00	9.30 ± 0.6	1.16
5/88	13.0 ± 5.0	16.3 ± 0.6	1.25
7/88	57.0 ± 5.0	69.7 ± 2.9	1.22
8/88	4.0 ± 5.0	5.0 ± 1.0	1.25
11/88	10.00 ± 5.00	10.00 ± 1.00	1.00
Ra-226			
1/88	4.80 ± 0.72	4.70 ± 0.26	0.98
1/88	4.80 ± 0.72	4.53 ± 0.15	0.94
5/88	7.60 ± 1.14	7.27 ± 0.25	0.96
7/88	6.40 ± 0.96	6.37 ± 0.59	1.00
8/88	10.0 ± 1.51	9.90 ± 0.53	0.99
11/88	8.40 ± 1.30	8.53 ± 0.15	1.02
Ra-228			
1/88	5.30 ± 0.80	4.35 ± 1.4	0.82
1/88	3.60 ± 0.54	4.60 ± 0.95	1.28
5/88	7.70 ± 1.16	8.73 ± 0.5	1.13
7/88	5.60 ± 0.84	6.50 ± 0.10	1.16
8/88	12.40 ± 1.86	14.80 ± 0.72	1.19
11/88	5.40 ± 0.80	5.33 ± 0.35	0.99
U (Natural)			
1/88	3.0 ± 6.0	3.33 ± 0.58	1.11
4/88	3.0 ± 6.0	3.7 ± 0.6	1.23
7/88	6.00 ± 6.00	6.33 ± 0.58	1.06
10/88	6.0 ± 6.0	7.0 ± 0.0	1.17

The laboratory for organic analyses conforms to QC procedures for the following:

- o GC/MS instrumentation for both volatile and semivolatile compound analysis
- o Initial multilevel calibration for each hazardous substance list (HSL) compound
- o Continuing calibration for each HSL compound
- o Addition of surrogate compounds to each sample and blanks for determining percent recovery information
- o Matrix spike analyses
- o Reagent blank analyses

Weston is currently an EPA-designated Contract Laboratory Program (CLP) laboratory for both organic and inorganic analyses. This requires passing EPA's blind performance evaluation testing each quarter. The technical specifications in BNI's subcontract with Weston specify QA/QC at, and in some cases beyond, the CLP level.

They participate in water studies to demonstrate technical competence for state drinking water certification programs. They also participate in water pollution studies to demonstrate technical competence for state wastewater certification programs. Currently, they participate in drinking water, wastewater, and/or hazardous waste certification programs. They are certified (or pending) in 35 such state programs. Continued certification hinges upon Weston's ability to pass the performance evaluation testing, and many of these tests are conducted semiannually.

Weston's QA program also includes an independent overview by their project QA coordinator and a corporate vice president who audits their program activities quarterly.

The FUSRAP sampling program was designed to provide for spikes, blanks, and QC duplicate sampling. Samples are tracked by chain-of-custody procecdures to maintain traceability.

APPENDIX B

ENVIRONMENTAL STANDARDS

APPENDIX B
ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr includes exposure from all pathways except medical treatments (Ref. 9). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as occupancy factors in determining the dose from external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represents actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

1 year	=	8,760 hours
1 liter	=	1,000 ml
1 mR	=	1 mrem
1 mrem	=	1,000 μR
100 mrem/yr	=	11.4 μR/h (assuming 8,760 hours of exposure per year)
1 μCi	=	1,000,000 pCi
1 pCi	=	0.000001 μCi
1 pCi/l	=	10^{-9} μCi/ml
1 pCi/l	=	0.000000001 μCi/ml
1 μCi/ml	=	1,000,000,000 pCi/l
10^{-6}	=	0.000001
10^{-7}	=	0.0000001
10^{-8}	=	0.00000001
10^{-9}	=	0.000000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

APPENDIX C

ABBREVIATIONS

APPENDIX C
ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
ft msl	feet above mean sea level
g	gram
gal	gallon
h	hour
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
lb	pound
m	meter
m^3	cubic meter
mg	milligram
mg/l	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mR	milliroentgen
mrem	millirem
mR/yr	milliroentgens per year
mrem/yr	millirem per year
µCi/ml	microcuries per milliliter
µR/h	microroentgens per hour
pCi	picocurie
pCi/g	picocuries per gram
pCi/l	picocuries per liter
yd^3	cubic yard
yr	year

APPENDIX D

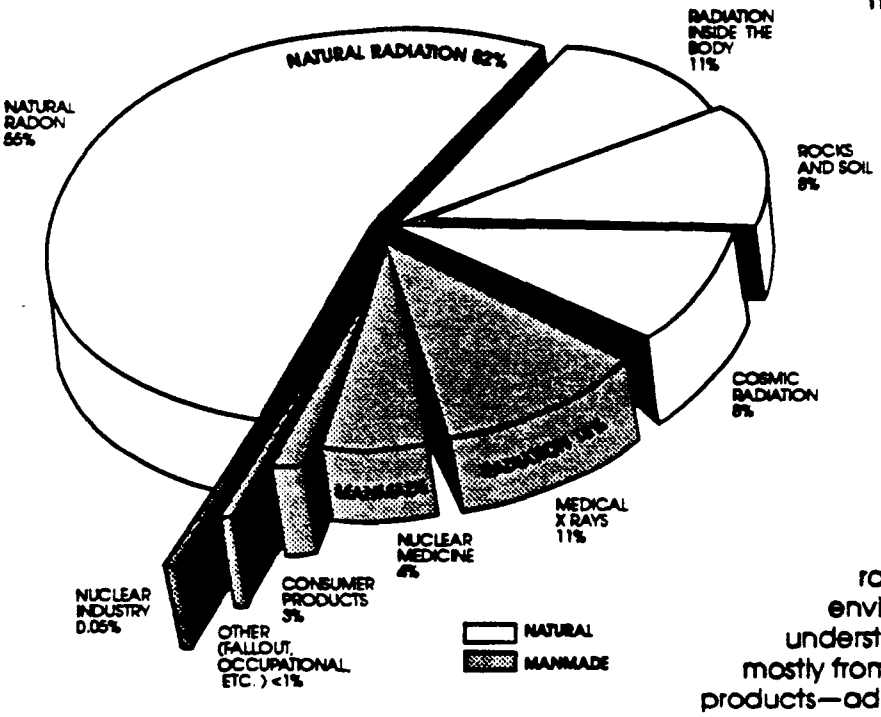
RADIATION IN THE ENVIRONMENT

Radiation in the Environment

Radiation is a natural part of our environment. When our planet was formed, radiation was present—and radiation surrounds it still. Natural radiation showers down from the distant reaches of the cosmos and continuously radiates from the rocks, soil, and water on the Earth itself.

During the last century, mankind has discovered radiation, how to use it, and how to control it. As a result, some manmade radiation has been added to the natural amounts present in our environment.

Sources of Radiation



Many materials—both natural and manmade—that we come into contact with in our everyday lives are radioactive. These materials are composed of atoms that release energetic particles or waves as they change into more stable forms. These particles and waves are referred to as *radiation*, and their emission as *radioactivity*.

As the chart on the left shows, most environmental radiation (82%) is from natural sources. By far the largest source is radon, an odorless, colorless gas given off by natural radium in the Earth's crust. While radon has always been present in the environment, its significance is better understood today. Manmade radiation—mostly from medical uses and consumer products—adds about eighteen percent to our total exposure.

TYPES OF IONIZING RADIATION

Radiation that has enough energy to disturb the electrical balance in the atoms of substances it passes through is called *ionizing radiation*. There are three basic forms of ionizing radiation.

Alpha

Alpha particles are the largest and slowest moving type of radiation. They are easily stopped by a sheet of paper or the skin. Alpha particles can move through the air only a few inches before being stopped by air molecules. However, alpha radiation is dangerous to sensitive tissue inside the body.

Beta

Beta particles are much smaller and faster moving than alpha particles. Beta particles pass through paper and can travel in the air for about 10 feet. However, they can be stopped by thin shielding such as a sheet of aluminum foil.

Gamma

Gamma radiation is a type of electromagnetic wave that travels at the speed of light. It takes a thick shield of steel, lead, or concrete to stop gamma rays. X rays and cosmic rays are similar to gamma radiation. X rays are produced by manmade devices; cosmic rays reach Earth from outer space.

Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either 1) the total amount of radioactivity present in a substance, or 2) the level of radiation being given off.

The radioactivity of a substance is measured in terms of the number of transformations (changes into more stable forms) per unit of time. The *curie* is the standard unit for this measurement and is based on the amount of radioactivity contained in 1 gram of radium. Numerically, 1 curie is equal to 37 billion transformations per second. The amounts of radioactivity that people normally work with are in the millicurie (one-thousandth of a curie) or microcurie (one-millionth of a curie) range. Levels of radioactivity in the environment are in the picocurie, or pCi (one-trillionth of a curie) range.

Levels of radiation are measured in various units. The level of gamma radiation in the air is measured by the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroentgens. Radiation absorbed by humans is measured in either *rad* or *rem*. The rem is the most descriptive because it measures the ability of the specific type of radiation to do damage to biological tissue. Again, typical measurements will often be in the millirem (mrem), or one-thousandth of a rem, range. In the international scientific community, absorbed dose and biological exposure are expressed in *grays* and *seiverts*. 1 gray (Gy) equals 100 rad. 1 seivert (Sv) equals 100 rem. On the average, Americans receive about 360 mrem of radiation a year. Most of this (97%) is from natural radiation and medical exposure. Specific examples of common sources of radiation are shown in the chart below.

RADIATION IN THE ENVIRONMENT

Because the radioactivity of individual samples varies, the numbers given here are approximate or represent an average. They are shown to provide a perspective for concentrations and levels of radioactivity rather than dose.

mrem = millirem
pCi = picocurie

Cosmic Radiation

Cosmic radiation is high-energy gamma radiation that originates in outer space and filters through our atmosphere.

Sea Level ..... 26 mrem/year
(increases about 1/2 mrem for each additional 100 feet in elevation)
Atlanta, Georgia (1,050 feet) ..... 31 mrem/year
Denver, Colorado (5,300 feet) ..... 50 mrem/year
Minneapolis, Minnesota (815 feet) ..... 30 mrem/year
Salt Lake City, Utah (4,400 feet) ..... 46 mrem/year

Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as uranium, radium, and thorium. Average levels of these elements are 1 pCi/gram of soil.

United States (average) ..... 26 mrem/year
Denver, Colorado ..... 63 mrem/year
Nile Delta, Egypt ..... 350 mrem/year
Paris, France ..... 350 mrem/year
Coast of Kerala, India ..... 400 mrem/year
McAlpe, Brazil ..... 2,558 mrem/year
Pocos De Caldas, Brazil ..... 7,000 mrem/year

Buildings

Many building materials, especially granite, contain naturally radioactive elements.

U.S. Capitol Building ..... 85 mrem/year
Base of Statue of Liberty ..... 325 mrem/year
Grand Central Station ..... 525 mrem/year
The Vatican ..... 800 mrem/year

Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.

Average Indoor Radon Level ..... 1.5 pCi/liter
Occupational Working Limit ..... 200.0 pCi/liter

Food

Food contributes an average of 20 mrem/year, mostly from potassium-40, carbon-14, hydrogen-3, radium-226, and thorium-232.

Beer ..... 390 pCi/liter
Tap Water ..... 20 pCi/liter
Milk ..... 1,400 pCi/liter
Salad Oil ..... 4,900 pCi/liter
Whiskey ..... 1,200 pCi/liter
Brazil Nuts ..... 14 pCi/g
Bananas ..... 3 pCi/g
Flour ..... 0.14 pCi/g
Peanuts & Peanut Butter ..... 0.12 pCi/g
Tea ..... 0.40 pCi/g

Medical Treatment

The exposures from medical diagnosis vary widely according to the required procedure, the equipment and film used for x rays, and the skill of the operator.

Chest X Ray ..... 10 mrem
Dental X Ray,Each ..... 100 mrem

Consumer Goods

Cigarettes-two packs/day (polonium-210) ..... 8,000 mrem/year
Color Television ..... <1 mrem/year
Gas Lantern Mantle (thorium-232) ..... 2 mrem/year
Highway Construction ..... 4 mrem/year
Airplane Travel at 39,000 feet (cosmic) ..... 0.5 mrem/hour
Natural Gas Heating and Cooking (radon-222) ..... 2 mrem/year
Phosphate Fertilizers ..... 4 mrem/year

Natural Radioactivity in Florida Phosphate Fertilizers (in pCi/gram)

	Normal Superphosphate	Concentrated Superphosphate	Gypsum
Ra-226	21.3	21.0	33.0
U-238	20.1	58.0	6.0
Th-230	18.9	48.0	13.0
Th-232	0.6	1.3	0.3

Porcelain Dentures (uranium) ..... 1,500 mrem/year
Radioluminescent Clock (promethium-147) ..... <1 mrem/year
Smoke Detector (americium-241) ..... 0.01 mrem/year

International Nuclear Weapons Test Fallout from pre-1980 atmospheric tests

(average for a U.S. citizen) ..... 1 mrem/year

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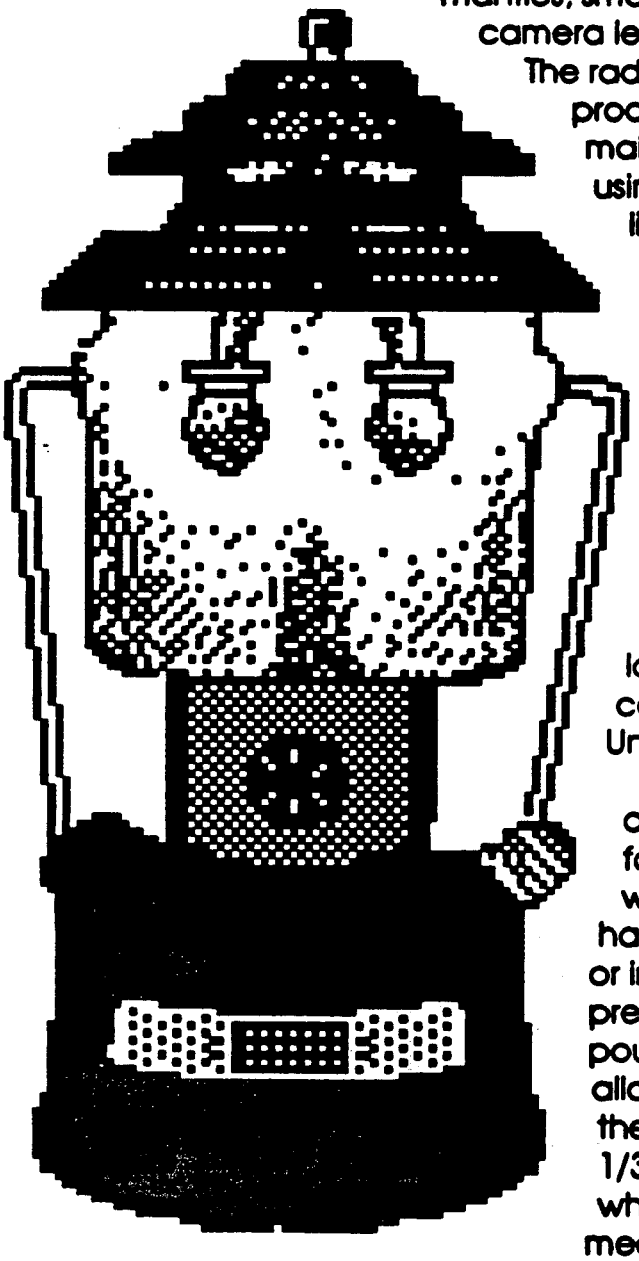
PERSPECTIVE: Radioactivity in Gas Lantern Mantles

Around the House

Many household products contain a small amount of radioactivity. Examples include gas lantern mantles, smoke detectors, dentures, camera lenses, and anti-static brushes. The radioactivity is added to the products either specifically to make them work, or as a result of using compounds of elements like thorium and uranium in producing them. The amount of radiation the products gives off is not considered significant. But with today's sensitive equipment, it can be detected.



Lanterns: In a New Light

About 20 million gas lantern mantles are used by campers each year in the United States.

Under today's standards, the amount of natural radioactivity found in a lantern mantle would require precautions in handling it at many Government or industry sites. The radioactivity present would contaminate 15 pounds of dirt to above allowable levels. This is because the average mantle contains 1/3 of a gram of thorium oxide, which has a specific activity (a measure of radioactivity) of approximately 100,000 picocuries per gram. The approximately 35,000 picocuries of radioactivity in the mantle would, if thrown onto the ground, be considered low-level radioactive contamination.

From information provided by W.L. Beck, Bechtel National, Inc.

PERSPECTIVE: How Big is a Picocurie?

The *curie* is a standard measure for the intensity of radioactivity contained in a sample of radioactive material. It was named after French scientists Marie and Pierre Curie for their landmark research into the nature of radioactivity.

The basis for the curie is the radioactivity of one gram of radium. Radium decays at a rate of about 2.2 trillion disintegrations ($2.2X10^{12}$) per minute. A *picocurie* is one trillionth of a curie. Thus, a picocurie represents 2.2 disintegrations per minute.

To put the relative size of one *trillionth* into perspective, consider that if the Earth were reduced to one trillionth of its diameter, the "pico earth" would be smaller in diameter than a speck of dust. In fact, it would be six times smaller than the thickness of a human hair.

The difference between the curie and the picocurie is so vast that other metric units are used between them. These are as follows:

Millicurie = $\frac{1}{1{,}000}$ **(one thousandth) of a curie**

Microcurie = $\frac{1}{1{,}000{,}000}$ **(one millionth) of a curie**

Nanocurie = $\frac{1}{1{,}000{,}000{,}000}$ **(one billionth) of a curie**

Picocurie = $\frac{1}{1{,}000{,}000{,}000{,}000}$ **(one trillionth) of a curie**

The following chart shows the relative differences between the units and gives analogies in dollars. It also gives examples of where these various amounts of radioactivity could typically be found. The number of disintegrations per minute has been rounded off for the chart.

UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	Amount Used for a Brain or Liver Scan
1 Microcurie	µCi	$2x10^{6}$ or 2 Million	All-Star Baseball Player's Salary	Amount Used in Thyroid Tests
1 Nanocurie	nCi	$2x10^{3}$ or 2 Thousand	Annual Home Energy Costs	Consumer Products
1 Picocurie	pCi	2	Cost of a Hamburger and Coke	Background Environmental Levels

Chart provided by W.L. Beck, Bechtel National, Inc.

APPENDIX E

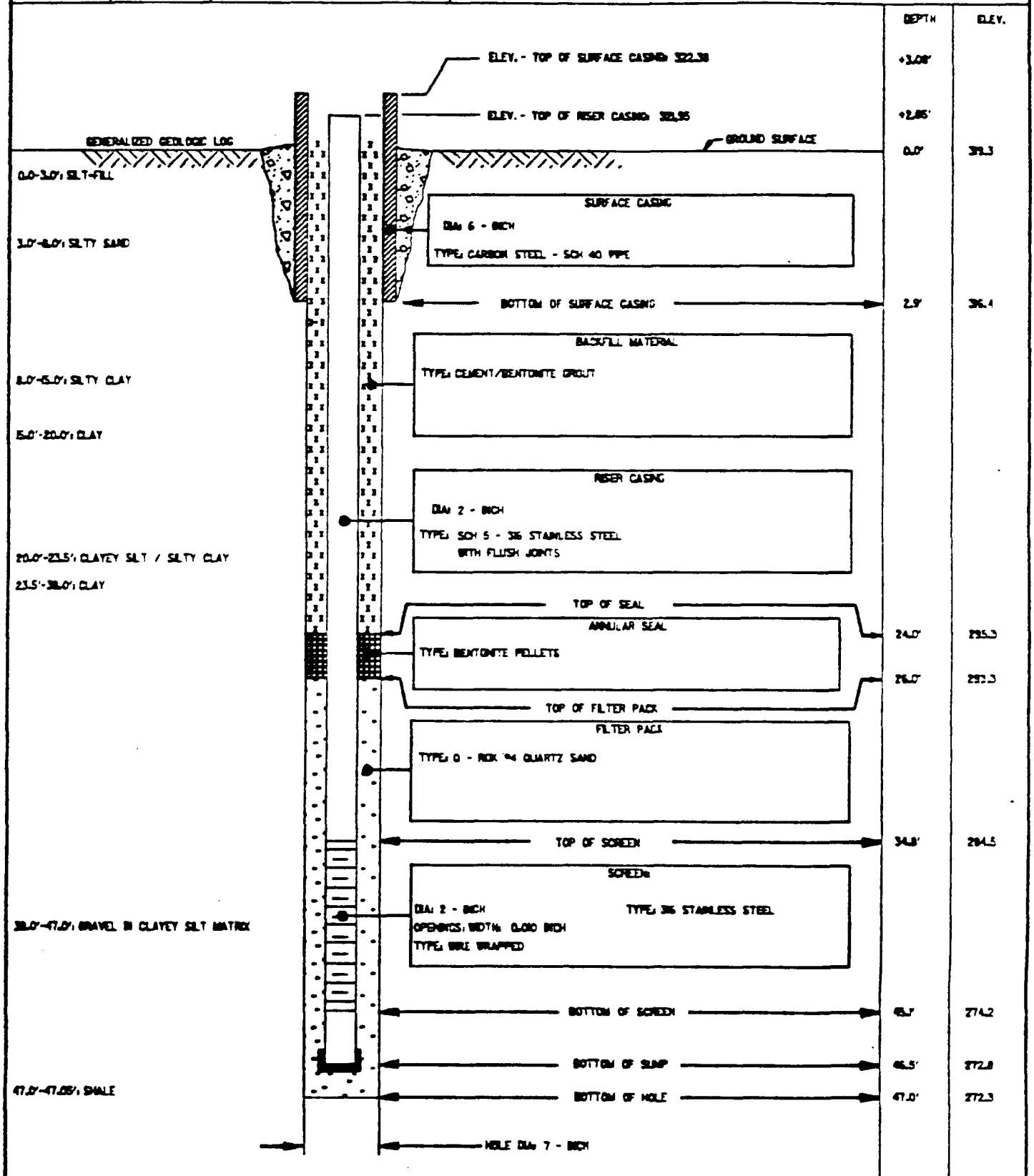
SAMPLE WELL CONSTRUCTION LOGS

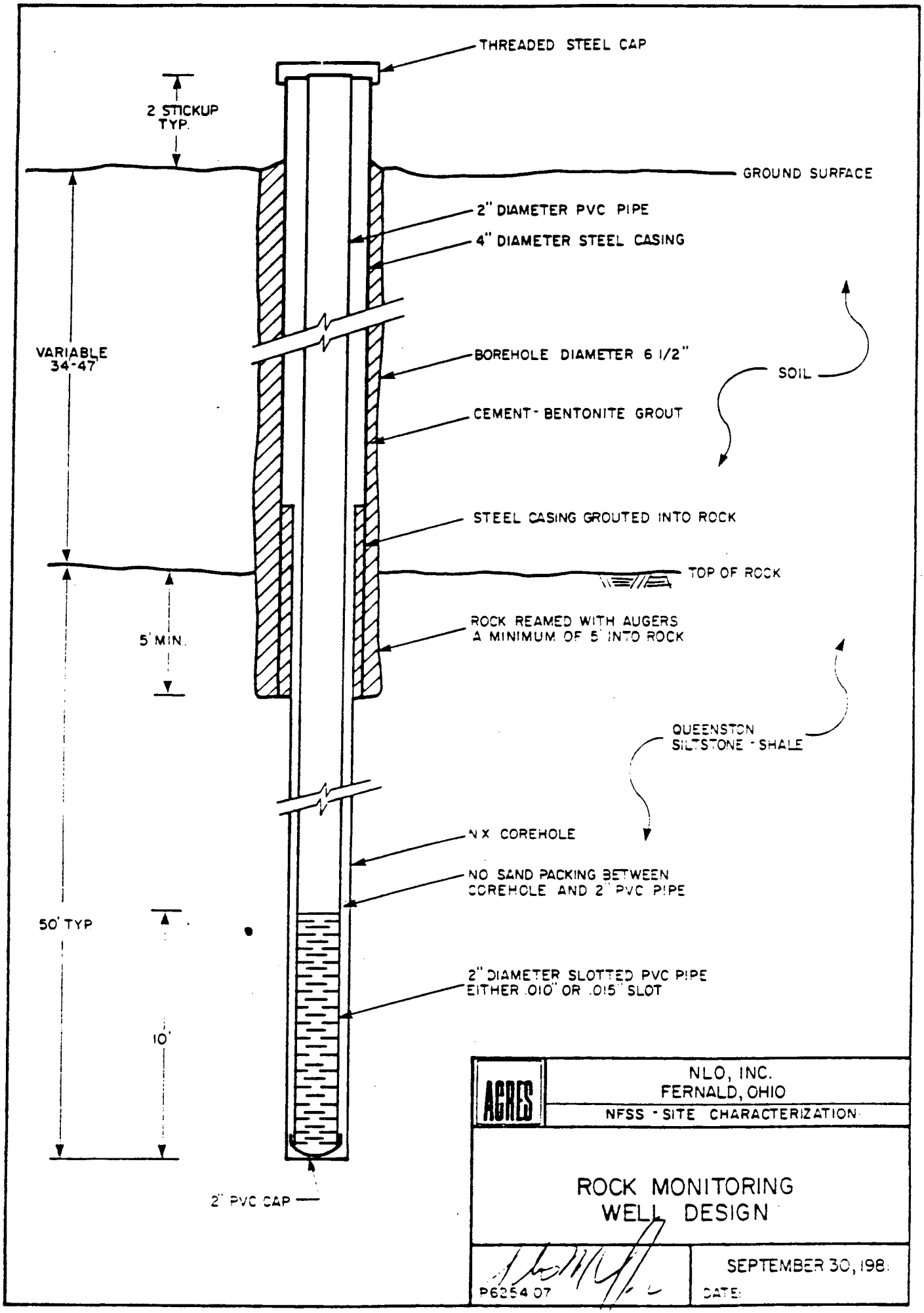
MONITORING WELL

PROJECT	WELL NO.
NIAGARA FALLS STORAGE SITE	OW-1A

JOB NO.	SITE	COORDINATES
14501	WEST OF WASTE CONTAINMENT	S1414 E006

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
9/19/86	10/21/86	A.ATKINSON/D.MIDDLETON	TOP OF STAINLESS STEEL RISER PIPE



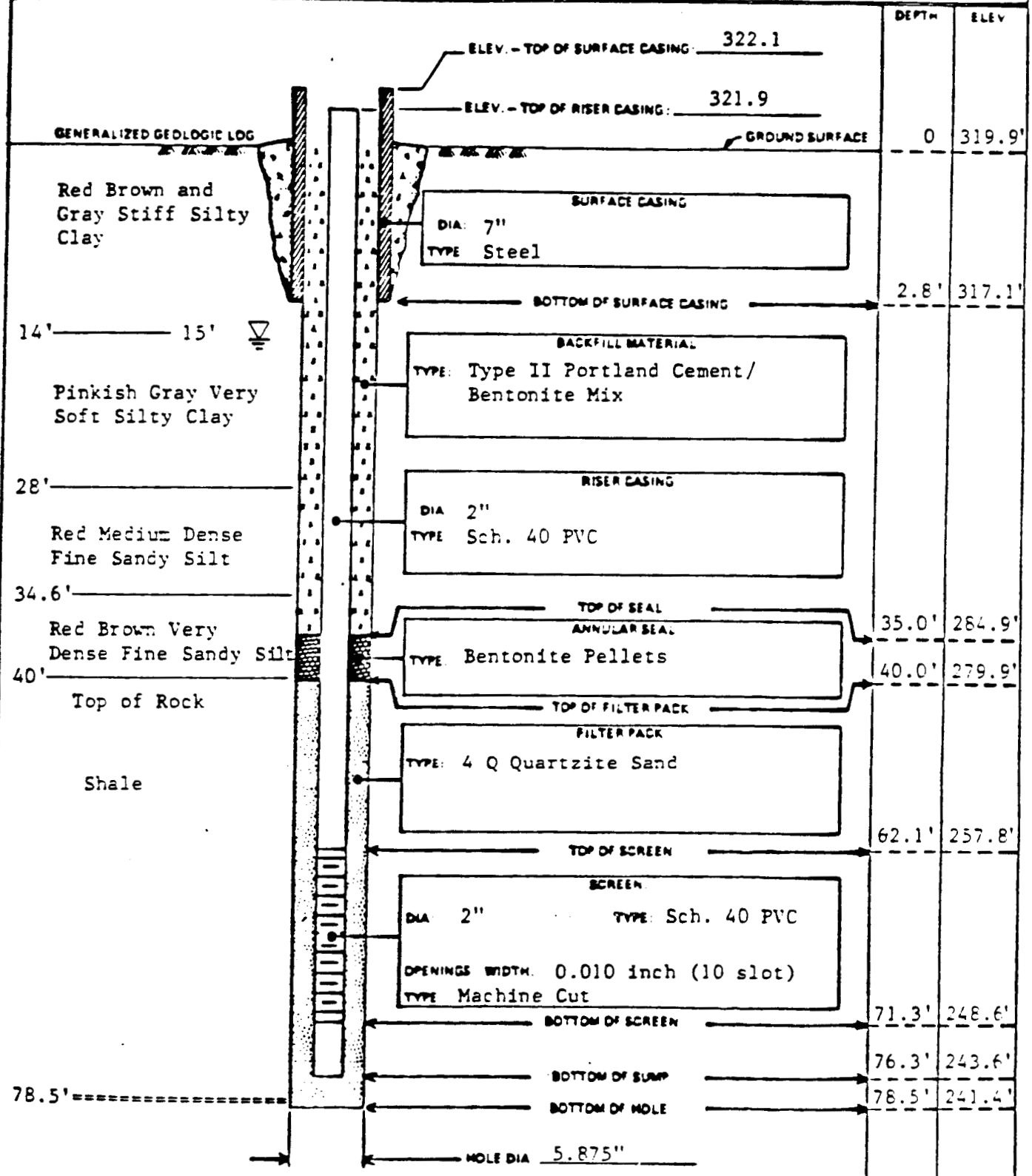

THREADED STEEL CAP
2' STICKUP TYP.
GROUND SURFACE
2" DIAMETER PVC PIPE
4" DIAMETER STEEL CASING
VARIABLE 34'-47'
BOREHOLE DIAMETER 6 1/2"
SOIL
CEMENT - BENTONITE GROUT
STEEL CASING GROUTED INTO ROCK
TOP OF ROCK
5' MIN.
ROCK REAMED WITH AUGERS A MINIMUM OF 5' INTO ROCK
QUEENSTON SILTSTONE - SHALE
NX COREHOLE
NO SAND PACKING BETWEEN COREHOLE AND 2" PVC PIPE
50' TYP
2" DIAMETER SLOTTED PVC PIPE EITHER .010" OR .015" SLOT
10'
2" PVC CAP
ACRES
NLO, INC.
FERNALD, OHIO
NFSS - SITE CHARACTERIZATION
ROCK MONITORING WELL DESIGN
P6254 07
SEPTEMBER 30, 198
DATE

OBSERVATION WELL

PROJECT	WELL NO
FUSRAP/Niagara Falls Storage Site	A-23A

JOB NO	SITE	COORDINATES
14501	NFSS	S 1700.1 E 374.1

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
2/21/83	3/2/83	D. Middleton	Ground Surface



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