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Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for

Niagara Falls Storage Site

200-1e

NFSS_01.06_0766_a

U.S. Department of Energy

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105695

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United States Government

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Oak Ridge Field Office

memorandum

DATE: JUL 01 1993

REPLY TO
ATTN OF: EW-93:Seay

SUBJECT: FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM SITE ENVIRONMENTAL REPORTS

TO: Those on the Attached List

Attached for your information are copies of the 1992 Site Environmental Reports for Hazelwood Interim Storage Site, Colonie Interim Storage Site, Niagara Falls Storage Site, Maywood Interim Storage Site, Wayne Interim Storage Site, and Middlesex Sampling Plant.

The monitoring data and subsequent data analyses have been collected and performed according to controlled operating procedures, and both DOE and operating contractor personnel have reviewed these documents for validity and accuracy. To the best of my knowledge, these reports accurately summarize and present the results of the 1992 environmental monitoring program.

These reports are being distributed to interested local, state, and federal agencies and some members of the public. The media and other agencies and members of the public will receive letters that summarize the reports and provide a toll-free telephone number (800-253-9759) for readers to call if they want a copy of the full report or if they have questions about the report or the site in general.

If you have any questions regarding the contents of these documents, please contact Steven Oldham at (615) 576-7070. If you require additional copies of the documents, please contact Margaret Dyke at (615) 576-4452.

William M. Seay, Acting Director
Former Sites Restoration Division

Attachments

NY/NFSS

DOE/OR/21949-367

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

NIAGARA FALLS STORAGE SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1992

1397 Pletcher Road Lewiston, New York

May 1993

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DOE/OR/21949-367

NIAGARA FALLS STORAGE SITE

ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1992

1397 PLETCHER ROAD

LEWISTON, NEW YORK

MAY 1993

Prepared for

United States Department of Energy

Oak Ridge Operations Office

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

EXECUTIVE SUMMARY

This report describes the environmental surveillance program at the Niagara Falls Storage Site (NFSS) and provides the results for 1992. Located in northwestern New York, the site covers 77 ha (191 acres). From 1944 to the present, the primary use of NFSS has been storage of radioactive residues produced as a by-product of uranium production. All onsite areas of residual radioactivity above guidelines have been remediated. Materials generated during remediation are stored onsite in the 4-ha (10-acre) waste containment structure (WCS). The WCS is a clay-lined, clay-capped, and grass-covered storage pile.

Environmental surveillance at NFSS began in 1981. The site is owned by the U.S. Department of Energy (DOE) and is assigned to DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a program established to identify and decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

The environmental surveillance program at NFSS includes sampling networks for radon concentrations in air; external gamma radiation exposure; and total uranium and radium-226 concentrations in surface water, sediments, and groundwater. Several chemical parameters, including seven metals, are also routinely measured in groundwater. This surveillance program assists in fulfilling the DOE policy of measuring and monitoring effluents from DOE activities and calculating hypothetical doses. Monitoring results are compared with applicable Environmental Protection Agency (EPA) and New York State Department of Environmental Conservation (NYSDEC) standards, DOE derived concentration guides (DCGs), dose limits, and other DOE requirements.

Results of environmental monitoring during 1992 indicate that levels of the parameters measured were in compliance with all but one requirement: Concentrations of iron and manganese in groundwater were above NYSDEC groundwater quality standards. However, these elements occur naturally in the soils and groundwater associated with this region. In 1992 there were no environmental occurrences or reportable quantity releases as defined in

DOE orders and in the Superfund Amendment and Reauthorization Act (SARA) Title III of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The potential radiation dose calculated for a hypothetical maximally exposed individual is 3×10^{-5} mrem/yr (3×10^{-7} mSv/yr), which is less than an individual would receive while traveling in an airplane at 12,000 m (39,000 ft) for one hour. The total population dose is 7.7×10^{-2} person-rem/yr (7.7×10^{-4} person-Sv/yr), which is indistinguishable from background.

During 1992, site activities included the following:

- Routine environmental surveillance of the site
- Resurveying in preparation for releasing 54.7 ha (135 acres) on the eastern portion of the site
- Relocating the western fence to the property line
- Adding a new fence along the proposed eastern boundary
- Constructing a site surveillance and maintenance road adjacent to the new eastern fence and an additional road around the WCS
- Removing and disposing of asbestos-containing materials from four onsite structures
- Monitoring radon flux to comply with National Emission Standards for Hazardous Air Pollutants (NESHAPs).

Except for iron and manganese concentrations that exceed NYSDEC groundwater quality standards, NFSS was in compliance with all applicable DOE requirements and federal and state regulations in 1992.

COMPLIANCE SUMMARY

The primary regulatory guidelines, limits, and DOE requirements for environmental monitoring originate in the following federal acts: the Clean Air Act (CAA); the Clean Water Act (CWA); the Safe Drinking Water Act (SDWA); the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA); the National Environmental Policy Act; and the National Historic Preservation Act (NHPA).

Environmental remediation of NFSS is being conducted in accordance with CERCLA, the protocol for remediating low-level radioactive contamination at FUSRAP sites, and applicable DOE requirements authorized by the Atomic Energy Act. The following summaries identify applicable and relevant requirements as they existed in 1992 and the first quarter of 1993, define the status of compliance with the referenced requirements, and forecast the regulatory changes that could affect the site in the near future.

PRIMARY REGULATORY GUIDELINES

DOE Requirements for Radionuclide Releases

Site releases must comply with specific DOE requirements that establish conservative quantitative limits, DCGs, and dose limits for radiological releases from DOE facilities. A review of environmental monitoring results for calendar year 1992 shows that NFSS was in compliance with all applicable DOE radionuclide release standards. There were no environmental occurrences or unplanned contaminant releases.

Clean Air Act and National Emission Standards for Hazardous Air Pollutants

The primary federal statute governing air emissions is the CAA. The only potential sources of air emissions from NFSS are radon and dust-blown radionuclide emissions from

the WCS. The grass cover on the WCS is routinely inspected, watered, and mowed to control erosion. Although NFSS is a nonoperating DOE facility, Subpart Q ("National Emission Standards for Radon Emissions from Department of Energy Facilities") of NESHAPs is applicable in accordance with 40 CFR Section 61.190. Compliance with the EPA-approved strategy for radon monitoring and reporting was attained and maintained in 1992. Radon flux rates were measured semiannually to demonstrate compliance with the radon emission standard in Subpart Q.

Compliance with the nonradon radionuclide standard in Subpart H ("National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities") of NESHAPs has been determined by evaluating the site using the computer model Clean Air Act Assessment Package-1988 (CAP88) approved by EPA. Results from the model indicate that NFSS is in compliance with Subpart H.

NESHAPs Subpart M contains the "National Asbestos Emission Standards." Subpart M applied to activities associated with the removal and offsite disposal of asbestos-containing floor, ceiling, and siding tiles from Buildings 401A, 402, 416, and 429 during fall 1992. Building 429 was renovated and will be used for storage. The asbestos-containing materials were removed from the other buildings to prepare them for demolition, and waste materials were disposed of in a properly licensed disposal facility.

Clean Water Act

Pollutants discharged to waters of the United States are regulated under the CWA through regulations promulgated and implemented by the State of New York.

On November 16, 1990, EPA issued changes in its stormwater regulation provisions. As a result of these changes, DOE determined that a stormwater discharge permit was required for NFSS. A stormwater discharge permit application was prepared and submitted to EPA before the regulatory deadline of October 1, 1992.

Safe Drinking Water Act

The SDWA was enacted by Congress in 1974 to regulate drinking water systems, require EPA to set national standards for levels of contaminants in drinking water, and provide for protection of aquifers. Under SARA, drinking water standards and goals set under the SDWA became groundwater standards for CERCLA cleanups. However, New York groundwater quality standards, which are applicable requirements under CERCLA, became effective in February 1993. These regulations are designed to protect ambient groundwater quality by establishing both radiological and chemical constituent standards for groundwater pollutant discharges and groundwater cleanups.

Radionuclide releases to groundwater must meet prevailing state SDWA regulations. Chemical data for groundwater monitoring have been evaluated to determine whether cleanup levels are meeting the newly enacted standards. Chemicals and radionuclides discovered in the groundwater at NFSS are at concentrations below applicable SDWA standards. However, concentrations of iron and manganese in groundwater were above NYSDEC groundwater quality standards.

Resource Conservation and Recovery Act

RCRA is the principal federal statute governing the management of hazardous waste. Neither RCRA-regulated wastes nor radioactive wastes containing RCRA-regulated wastes are known to be present at the site. The radioactive residues contained within the WCS are the by-products of mineral processing operations on naturally occurring ores. These ores contain some potentially hazardous elements and naturally decaying radioactive elements. Radioactive by-product materials, as defined by the Atomic Energy Act of 1954 as amended through 1984, are excluded from RCRA hazardous waste regulations. In addition, the 1980 Bevil Amendment to RCRA currently exempts certain solid wastes generated by the "extraction, benification, and processing of ores and minerals" from hazardous waste regulations.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA are polychlorinated biphenyls (PCBs) and asbestos. PCBs have not been identified at NFSS. As noted earlier, asbestos-containing materials were removed from four building at NFSS and disposed of offsite in 1992. TSCA, however, did not apply to this asbestos removal activity.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, as amended by SARA, is the primary source of statutory authority for the remediation of sites contaminated with hazardous substances. However, no additional environmental documentation will be required to support placement of the final cap on the WCS because the National Environmental Policy Act record of decision (ROD) supported these activities in 1986, before SARA made CERCLA applicable to federal facilities.

In response to a request from EPA, a preliminary assessment, which is an evaluation to determine the severity of the threat that hazardous substances at a site pose to human health and the environment, was completed in 1990. A site inspection report, which included Hazard Ranking System (HRS) scoring, was submitted to EPA on July 1, 1992. Two potential sources, the WCS and an undetermined source of hazardous chemicals near Building 401, were evaluated for HRS scoring. The HRS score that causes a site to be included on the National Priorities List is 28.5. The HRS score for the WCS was zero. The HRS score for the area near Building 401 was 0.533 based on the presence of low levels of the volatile organic compounds trichloroethene, tetrachloroethene, and cis-1,2-dichloroethene. These compounds were identified when a soil gas survey was performed in 1990. The need for additional sampling in the area is being evaluated to determine whether remediation is necessary.

If remediation of the areas near Building 401 is determined to be necessary, CERCLA would be the primary statutory authority under which the remediation activities would be managed.

No reports under SARA Title III, Section 313, were required during 1992. FUSRAP sites were not subject to toxic chemical release reporting provisions under 40 CFR 372.22 in 1992. However, FUSRAP evaluates and inventories toxic chemicals used onsite.

National Environmental Policy Act

An environmental impact statement (EIS) was issued in 1986 to evaluate long-term disposition of the WCS. Consistent with the ROD, DOE has chosen long-term, in-place management of the WCS. The WCS was designed to meet the goal of protecting human health and the environment.

Categorical exclusions for ongoing environmental monitoring, surveillance, and maintenance activities were approved in 1992. A categorical exclusion is a category of actions, defined by 40 CFR 1508, that would not normally require an environmental assessment or EIS.

National Historic Preservation Act

NHPA is the primary source of statutory authority related to the preservation of cultural and historical resources.

FUSRAP is committed to managing cultural resources that may be affected by environmental restoration activities. The FUSRAP cultural resource management program ensures that the early stages of project planning provide for a thorough consideration of the potential effects of environmental restoration activities on any cultural resources that may be located on FUSRAP sites. Consultation with state historical preservation officers, Native American groups, and local historians is ongoing to identify cultural resources that may be eligible for nomination to the National Register of Historic Places in accordance with requirements of Section 106 of NHPA.

To date, the FUSRAP cultural resource management program has not identified any historic properties, such as districts, sites, buildings, and structures, at any of the FUSRAP sites that are currently undergoing environmental restoration.

In August 1992 a cultural resource assessment was prepared and submitted to the New York State Division for Historical Preservation. The assessment provided background information on the structures at NFSS that DOE has designated for demolition. This information was requested by the Division for Historical Preservation to assist in determining the appropriateness of the proposed action with respect to the requirements of the NHPA. The assessment indicated that the structures proposed for demolition are not historically significant.

Other Major Environmental Statutes and Executive Orders

In addition to DOE requirements and environmental statutes, several other major environmental statutes are potentially applicable at NFSS. For example, the Federal Insecticide, Fungicide, and Rodenticide Act and the Endangered Species Act have been found to impose no current requirements on NFSS. Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands") and local and state laws, regulations, and ordinances have also been reviewed for applicability. NFSS is in compliance with all applicable environmental statutes, regulations, and executive orders identified in this subsection. These statutes, regulations, and executive orders are reviewed regularly to maintain continual regulatory compliance at NFSS.

APPLICABLE ENVIRONMENTAL PERMITS

A stormwater discharge permit application was submitted pursuant to the National Pollutant Discharge Elimination System regulations by the regulatory deadline of October 1, 1992.

SUMMARY OF REGULATORY COMPLIANCE IN CALENDAR YEAR 1993 (FIRST QUARTER)

NFSS is currently in compliance with all applicable environmental regulations, except for iron and manganese concentrations in the groundwater that exceed NYSDEC standards. However, elevated levels of iron and manganese are a typical characteristic of the soil and the resultant groundwater quality in the region. Groundwater flow velocity in the local area is low [approximately 1 m/yr (3 ft/yr)], and distribution coefficient values for the clay-rich units are high, so contaminant transport velocities are negligible. Self-assessment activities are conducted to identify areas of noncompliance or circumstances that fail to meet best management practices. During the first quarter of 1993, environmental monitoring continued, as did review of potentially applicable regulations for their impact on the site.

CONTENTS

CONTENTS

(continued)

FIGURES

FIGURES

(continued)

TABLES

TABLES

(continued)

ACRONYMS

BNI	Bechtel National, Inc.
CAA	Clean Air Act
CAP88	Clean Air Act Assessment Package - 1988
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DCG	derived concentration guide
DOE	Department of Energy
DQO	data quality objective
EIS	environmental impact statement
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Project
HRS	Hazard Ranking System
KPA	kinetic phosphorescence analysis
LOOW	Lake Ontario Ordnance Works
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFSS	Niagara Falls Storage Site
NOAA	National Oceanic and Atmospheric Administration

ACRONYMS

(continued)

NPDES	National Pollutant Discharge Elimination System
NYCRR	New York Compilation of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	polychlorinated biphenyl
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
RPD	relative percent difference
SARA	Superfund Amendments and Reauthorization Act
SRM	standard reference material
TETLD	tissue-equivalent thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides
TPQ	threshold planning quantity
TSCA	Toxic Substances Control Act
USRADS	ultrasonic ranging and data system
VOC	volatile organic compound
WCS	waste containment structure

UNITS OF MEASURE

Bq	becquerel
Ci	curie
cm	centimeter
cpm	counts per minute
ft	foot
g	gram
h	hour
ha	hectare
in.	inch
km	kilometer
L	liter
m	meter
μCi	microcurie
μg	microgram
mg	milligram
mi	mile
ml	milliliter
mR	milliroentgen
mrem	millirem
mSv	millisievert
pCi	picocurie
ppm	parts per million
rem	roentgen equivalent man
s	second
Sv	sievert
yd	yard
yr	year

1.0 INTRODUCTION

Environmental monitoring of the U.S. Department of Energy's (DOE) Niagara Falls Storage Site (NFSS) began in 1981. This document describes the environmental surveillance program, monitoring results for 1992, and the compliance status of the site.

NFSS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program established to identify and decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy. A concerted effort is made to minimize waste and prevent further pollution.

1.1 SITE DESCRIPTION

NFSS occupies 77 ha (191 acres) in northwestern New York within the township of Lewiston (Niagara County), approximately 13 km (8.0 mi) northeast of Niagara Falls and 6 km (4 mi) south of Lake Ontario (Figure 1-1). The site was resurveyed in 1992 in preparation to release 54.7 ha (135 acres) on the eastern portion of the site. The NFSS property includes a three-story building (Building 401) with three adjacent silos, an office building, a small storage shed, and a storage building (Building 429) (Figure 1-2). The waste containment structure (WCS), a clay-lined, clay-capped, and grass-covered storage pile, encompasses approximately 4 ha (10 acres) (Figure 1-3). The containment cover consists of 1 m (3 ft) of compacted clay covered by 0.5 m (1.5 ft) of topsoil and grass. A turf management program directs the maintenance of the grass cover (fertilizers, herbicides, mulch, pesticides, grass seed, water, erosion control, etc.). The property is fenced to restrict public access.

NFSS originated during World War II, when the Manhattan Engineer District, predecessor to the Atomic Energy Commission, used part of the Army's Lake Ontario Ordnance Works (LOOW) as a transshipment and storage site for radioactive materials. The site was also used for enriching nonradioactive boron-10 (1954 through 1958 and 1964

through 1971). However, the primary use of the site (1944 to present) has been for storage of radioactive residues produced as by-products of uranium production. As a result of storage operations, portions of the former LOOW (other than the present NFSS) became contaminated when some of the stored radioactive materials migrated because of erosion, chiefly through drainage ditches.

NFSS currently consists of 77.4 ha (191 acres) of LOOW's original 3,070 ha (7,570 acres), and preparations are being made to release 54.7 ha (135 acres) on the eastern portion of the site (Figure 1-4). Radiological surveys and characterizations of NFSS were performed in 1979 and 1980 (Battelle 1981), and radiological surveys of vicinity properties were conducted from 1981 to 1985. Remediation of vicinity properties began in 1981 and continued until 1986; remediation at NFSS began in 1982 and continued until 1986. Contaminated materials moved between 1981 and 1986 (including K-65 material resulting from pitchblende processing for uranium extraction) were stored in the WCS. One localized onsite area approximately 100 m^2 (1,100 ft^2), 2 small interim storage piles of radioactively contaminated materials generated during additional remediation of onsite isolated areas in 1989, and 60 drums of radioactively contaminated material were consolidated into the WCS in 1991. All onsite areas of residual radioactivity above guidelines have now been consolidated within the WCS [approximately 195,000 m^3 (255,000 yd^3)]. The NFSS materials in the WCS contain approximately 2,500 Ci. One low-specific-activity box of radiologically contaminated items is stored in front of Building 429.

A chemical characterization of the site was conducted in 1990. A soil gas survey identified volatile organic compounds (VOCs) near Building 401. An investigation will be conducted to determine whether VOCs are also present in the groundwater.

In 1992, asbestos-containing materials were removed from four onsite structures; waste materials were disposed of in a properly licensed disposal facility.

1.2 REGIONAL DEMOGRAPHY

As shown in Figure 1-5, land use in the vicinity of the site is predominantly rural. The site is bordered by a chemical waste disposal facility (CWM Chemical Services, Inc.) to the north, a solid waste disposal facility (Modern Disposal, Inc.) to the east and south, and a Niagara Mohawk Power Corporation right-of-way to the west.

The nearest residential areas are approximately 1.1 km (0.68 mi) southwest of the site and are primarily single-family dwellings. The total population of the area within an 80-km (50-mi) radius of NFSS is in excess of 250,000; according to the 1990 census (Economic Development Board at the Lockport County Court House, County Seat), the population of Niagara County is 220,756.

1.3 HYDROGEOLOGIC SETTING

Hydrogeologic features such as topography, climate, soil characteristics, and depth of the water table influence the migration of contaminants. Except for the WCS and the central and western drainage ditches, the site is essentially flat with a slight slope to the northwest. Trees and shrubs are dense in the eastern and northern areas of the site. The remainder is covered by grass, buildings, and a paved parking lot. The site is in a temperate region with few high-intensity storm events. The soil is predominantly silty clay with variable infiltration, depending on season, and surface runoff is slow. During winter the groundwater is close to the surface, and during summer groundwater depth ranges from 3 to 4.6 m (10 to 15 ft).

1.3.1 Geology

NFSS lies within the Central Lowlands Physiographic Province, which is part of the Erie-Ontario Lowland and is characterized by topography developed on undeformed Paleozoic sedimentary rocks. The rocks occupy a broad basin sloping gently southward from the neighboring crystalline terrains of the Canadian Shield and the Adirondack Dome (Muller 1965). Regionally, a basement of gneiss has been found in wells ranging from

approximately 600 to 900 m (2,000 to 3,000 ft) in depth (USCE 1973). The area was significantly modified by glaciers.

The site stratigraphy includes 10 to 20 m (40 to 50 ft) of unconsolidated deposits overlying a thick sequence of sedimentary rocks. These surficial deposits are glacially derived sediments that include glaciofluvial sands and gravel, dense tills, and glacial lacustrine clays. Lacustrine materials were deposited on the bottoms and along the shores of glacial and postglacial lakes. Beneath these deposits are shales, siltstones, and mudstones of the Ordovician Queenston Formation. Six major geologic units have been identified within the interval from 0 to 30 m (0 to 90 ft) below the ground surface. In order of increasing depth, these units are surficial soils and fill, brown clay, gray clay, sand and gravel, red silt, and bedrock of the Queenston Formation. Geologic profiles of the units are included in Appendix A.

1.3.2 Surface Water

Precipitation drains to the western or central drainage ditches. These ditches are often dry during the summer months. The ditches empty into Fourmile Creek, which discharges into Lake Ontario approximately 6 km (4 mi) north of NFSS (see Figure 1-6). Water collects in ponds in some areas such as the marshy area east of Building 401.

1.3.3 Groundwater

Groundwater production in the soil is limited by the ability of the soils to transmit water (permeability). Soils are predominantly silty clays, which inhibit groundwater flow. The base of the WCS is keyed into the gray clay unit, which is described in more detail in Section 3.3.1. The estimated flow rate for the gray clay is approximately 1 m/yr (3 ft/yr). There are some high permeability sand and gravel lenses within the brown clay unit that occurs directly above the gray clay unit; these lenses have been isolated by the clay cut-off wall around the WCS. Groundwater occurring in the brown clay unit is described as the shallow groundwater system. Groundwater occurring in or below the gray clay unit is described as the deep groundwater systems. Water levels measured in monitoring wells

surrounding the WCS in the shallow and deep groundwater systems indicate seasonal fluctuations up to 3 m (10 ft) within individual wells. The general groundwater flow direction is to the northwest with a dominant influence from dewatering in the central drainage ditch on the shallow groundwater system.

Information from the Niagara County Health Department indicates that groundwater is not a local source of drinking water within 5 km (3 mi) of NFSS. The principal sources of potable water in the NFSS area are Lake Erie (65 percent) and the Niagara River (25 percent). South of the Niagara escarpment, approximately 10 percent of the population in Niagara and Erie Counties use groundwater as a primary drinking water source, usually for small domestic and farm supplies in rural areas. The source of this water, the Lockport dolomite aquifer, is absent north of the Niagara escarpment.

Details of the groundwater well construction and hydrographs dealing with groundwater level fluctuations are included in Appendix A.

1.4 CLIMATE

The climatological data from the National Oceanic and Atmospheric Administration for Buffalo/Niagara Falls vicinity for 1992 show that monthly precipitation ranged from 5.1 to 22.6 cm (2.0 to 8.9 in.) and temperature extremes ranged from -21 to 32°C (-5.8 to 90°F). Average wind speed ranged from 14 to 18.3 km/h (8.4 to 11.4 mph), and the predominant resultant wind direction was from the southwest (NOAA 1992).

FIGURES FOR SECTION 1.0

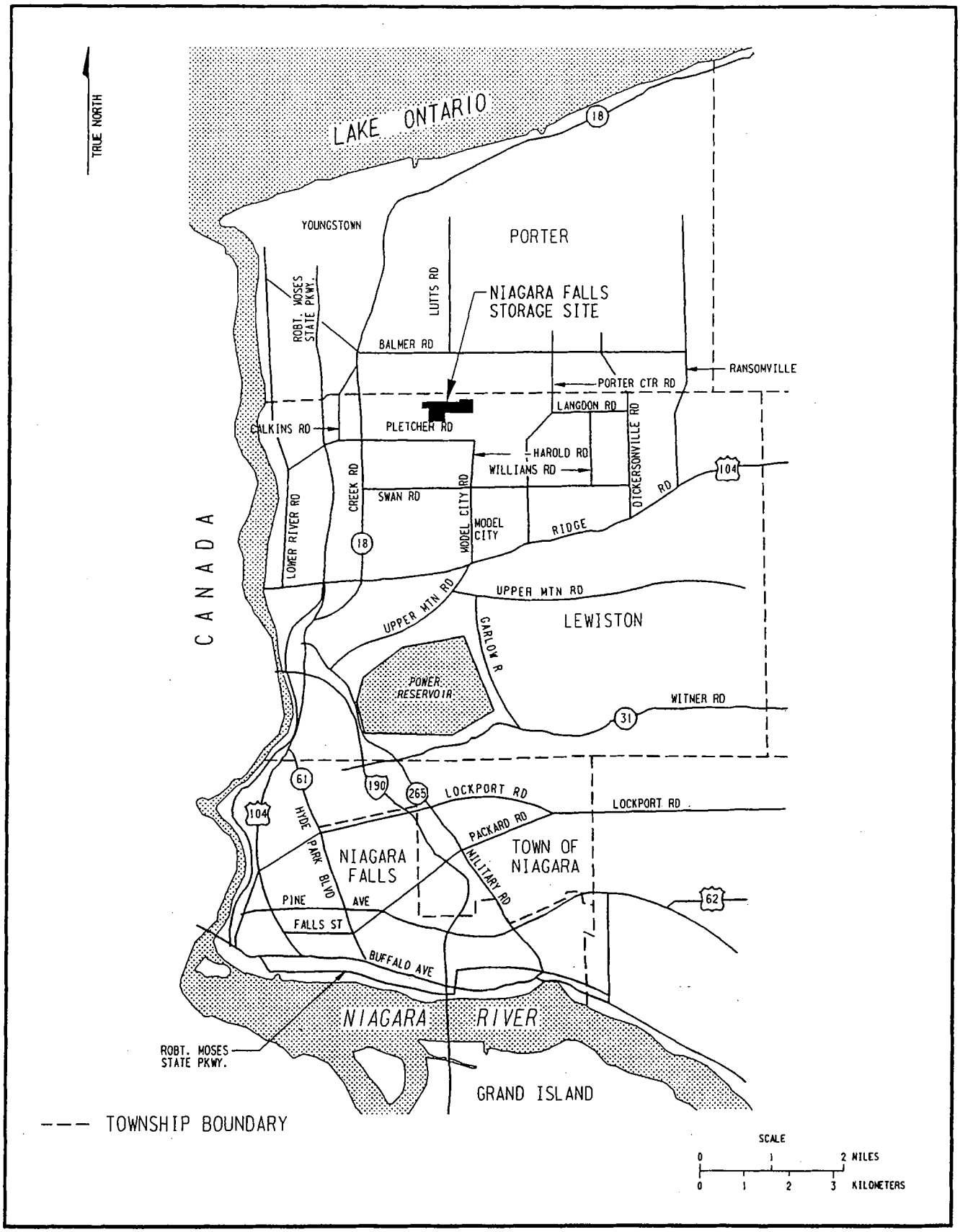

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Figure 1-1
Location of NFSS

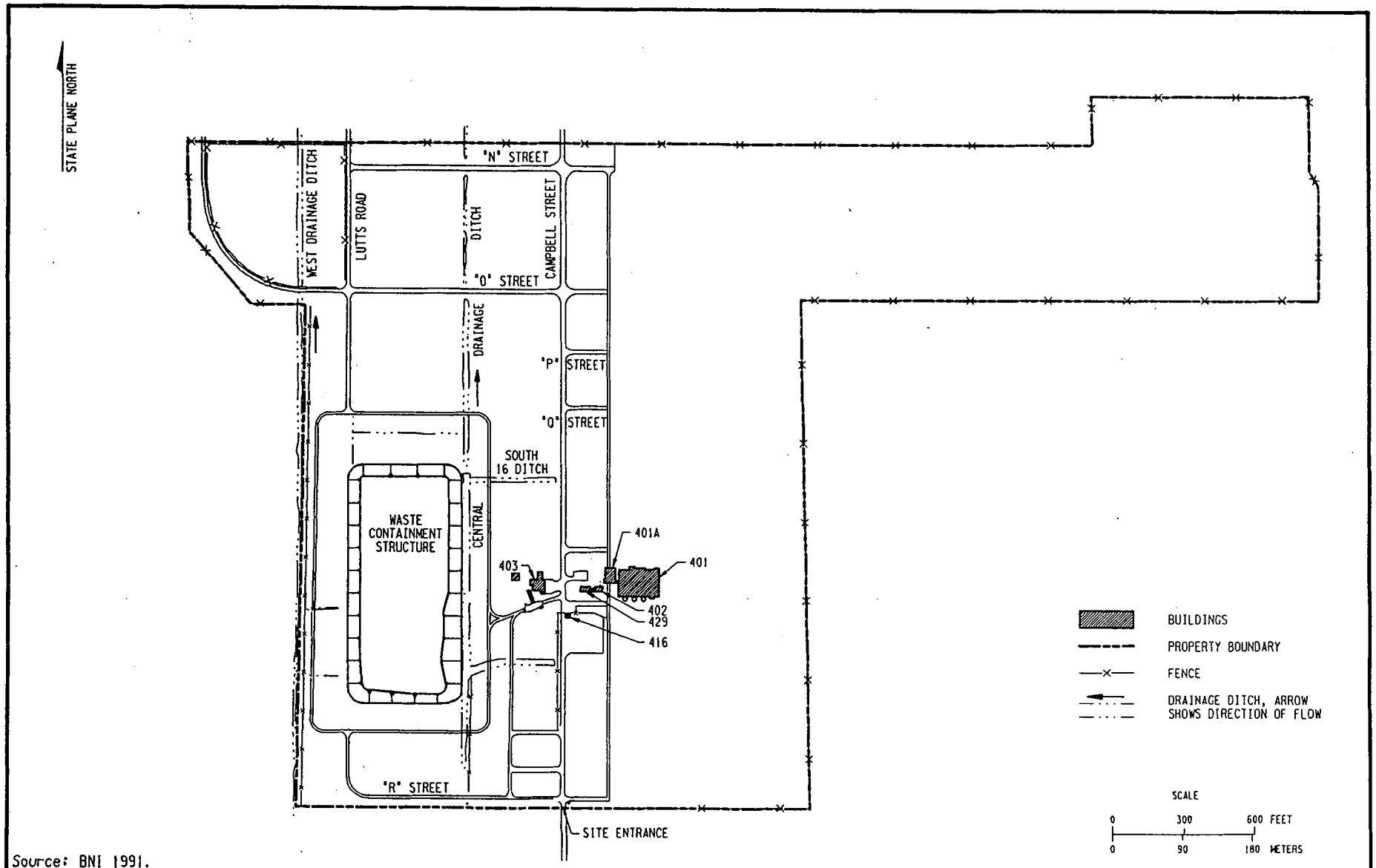

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Figure 1-2
Present Configuration of NFSS

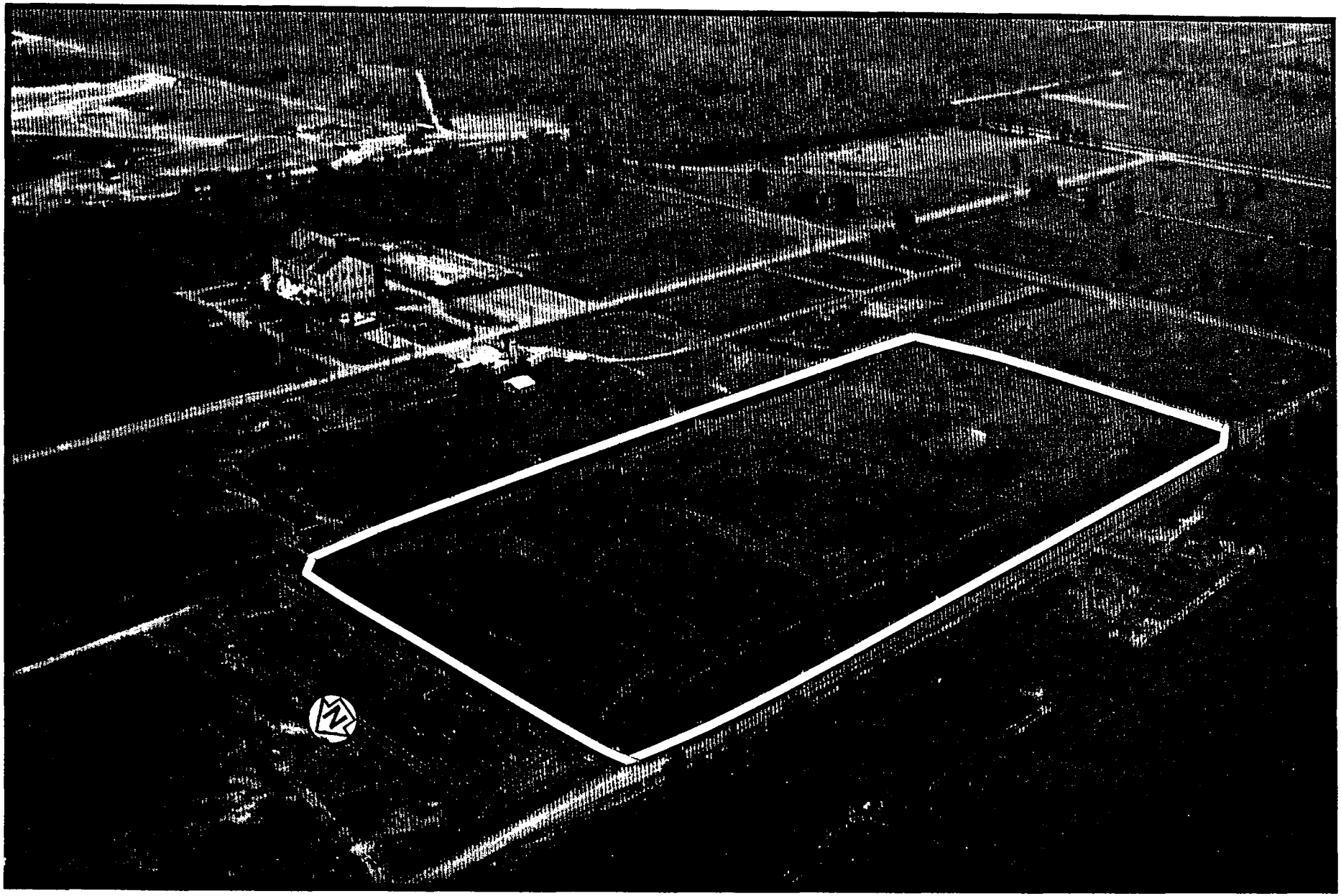

Figure 1-3
Aerial View of the NFSS Waste Containment Structure

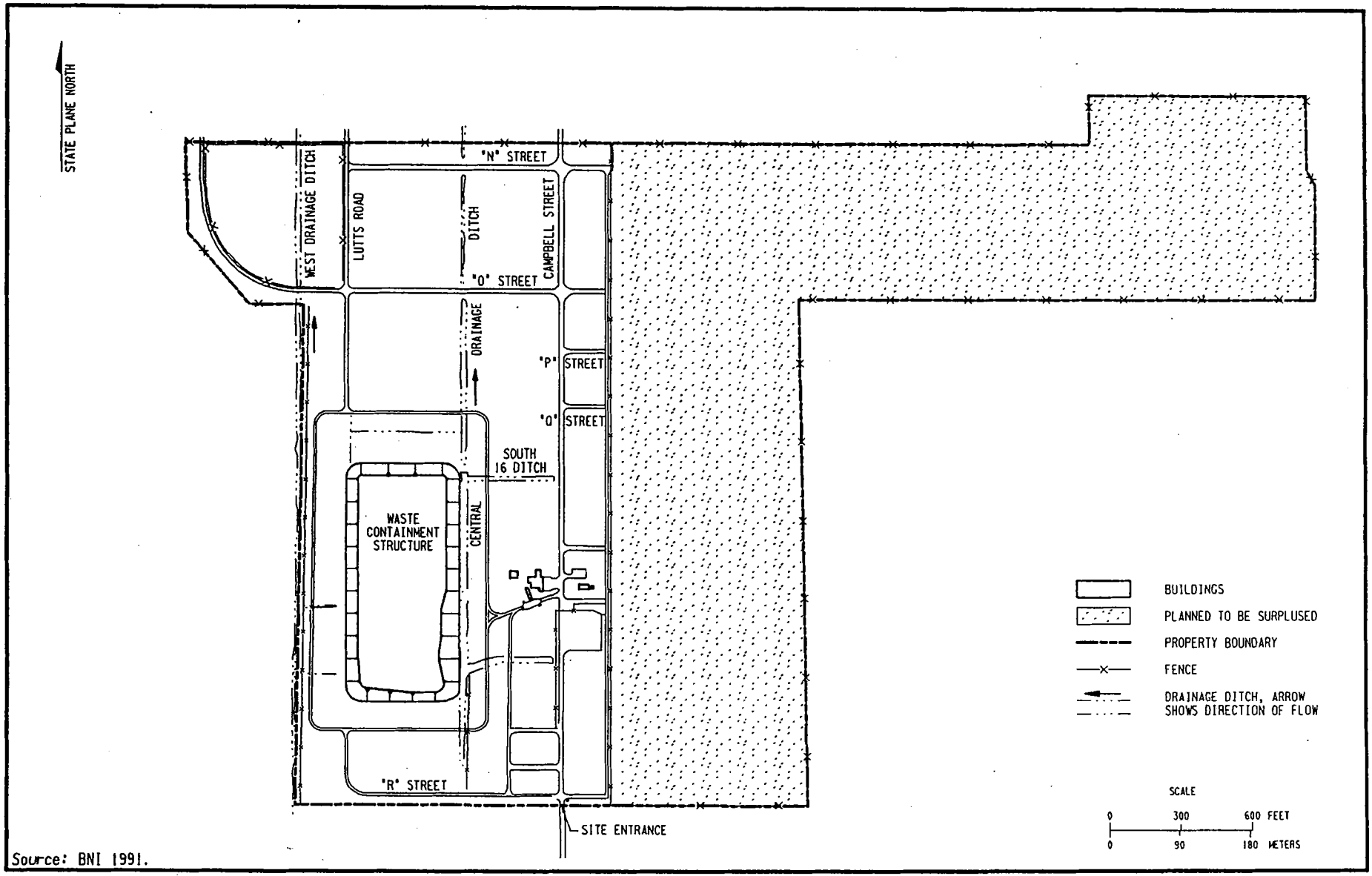

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Figure 1-4
Future Configuration of NFSS

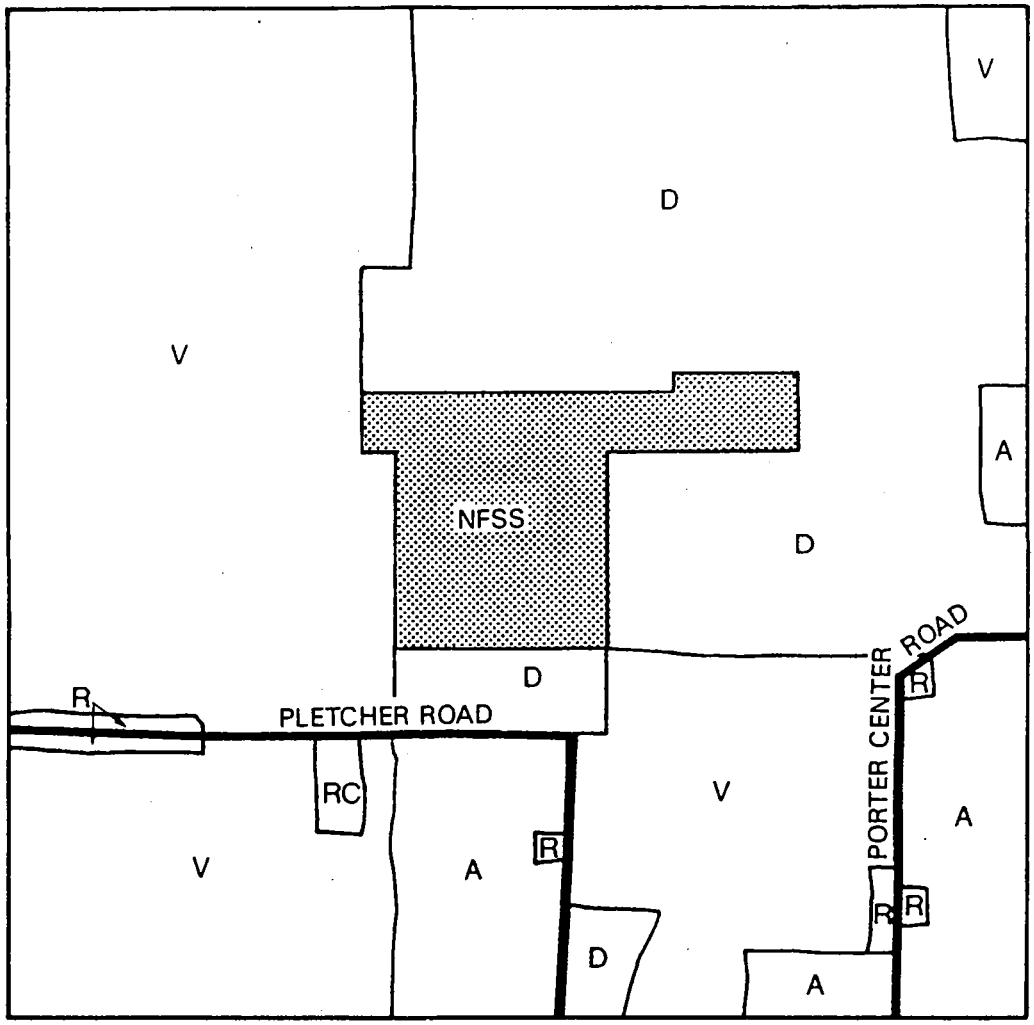

Figure 1-5
Generalized Land Use in the Vicinity of NFSS

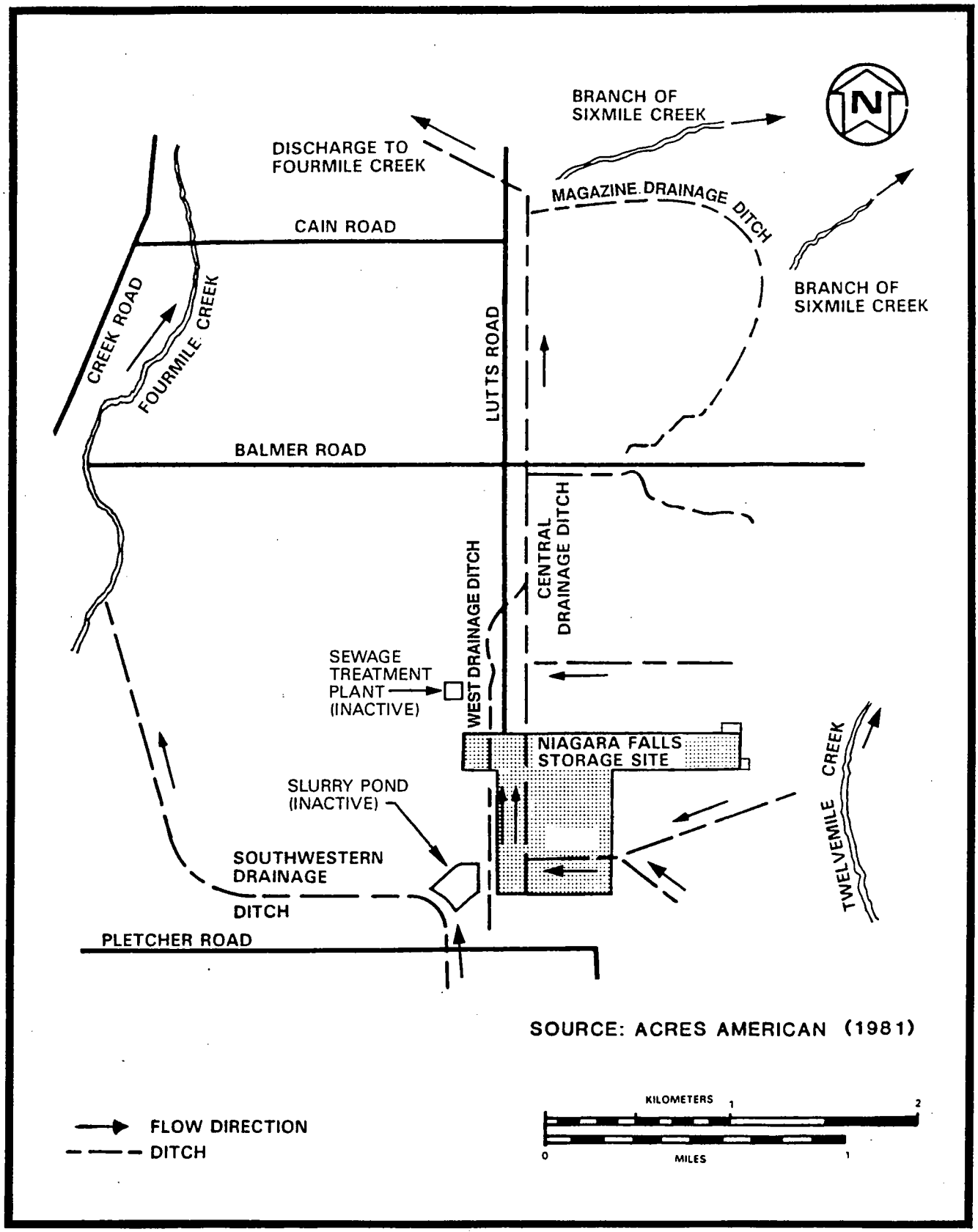

Figure 1-6
Surface Water Drainage Pathways at the NFSS

2.0 ENVIRONMENTAL PROGRAM INFORMATION

2.1 PERMIT ACTIVITIES

An application for a stormwater permit was submitted to the Environmental Protection Agency (EPA) Region II on September 30, 1992. An EPA and New York State Department of Environmental Conservation (NYSDEC) determination of the need for this permit is pending.

2.2 EMISSIONS MONITORING

In addition to routine emission monitoring discussed in Section 3.0, FUSRAP sites monitor unplanned contaminant releases. There were no environmental occurrences or unplanned contaminant releases during 1992.

No reports under SARA (the Emergency Preparedness and Community Right-to-Know Act) Section 313 were required. FUSRAP sites were not subject to toxic chemical release reporting provisions under 40 CFR 372.22 in 1992. To ensure that Section 313 reporting is performed if needed, FUSRAP evaluates and inventories chemicals maintained onsite. Chemicals such as nitric acid are used in small quantities at FUSRAP sites for sampling and other purposes.

2.3 ENVIRONMENTAL DOCUMENTATION

NEPA categorical exclusions were obtained for routine site maintenance and environmental monitoring (DOE 1992a, b).

2.4 SIGNIFICANT ENVIRONMENTAL ACTIVITIES

2.4.1 Special Studies

Gross Beta Results

In 1990, the gross beta result from well OW-15A was 210×10^{-9} μCi/ml. To determine whether the high reading was an anomaly, a groundwater sample from OW-15A was again analyzed for gross beta during 1992. The gross beta result was 61.6×10^{-9} μCi/ml, indicating that the 1990 result was probably an anomaly. A groundwater sample from well OW-15A will also be analyzed for gross beta in 1993.

WCS Elevated Gamma Radiation Levels

As a follow-up to waste consolidation work completed in 1991, a walkover gamma radiation survey of the WCS was performed on February 6, 1992. During this survey, location 2 in Figure 2-1 was identified as having gamma radiation levels of 80,000 cpm, which is above background. Depending on how background measurements were taken, background readings ranged from 7,000 to 10,000 cpm. To determine whether the readings at location 2 were caused by contaminated soil, soil samples were collected from this area and an area representative of background at intervals of 0 to 15 cm (0 to 6 in.) and 15 to 30 cm (6 in. to 1 ft) below ground surface. Soil analyses for radium-226, thorium-232, and uranium-238 showed that the soil contained background levels of these radionuclides.

On the basis of surface soil data indicating no concentrations of uranium and radium above background, it was concluded that the levels were caused by radon-222. To determine radon emanation, three radon canisters were placed on the WCS for 24 h on March 3, 1992. The first one was placed on the surface at location 2, the second was placed about 30 cm (1 ft) deep at that location, and the third was placed about 30 m (100 ft) away to measure background conditions. Results were 0.84 pCi/m^2-s at the surface, 25.65 pCi/m^2-s at 30 cm (1 ft) below the surface, and 0.05 pCi/m^2-s on the surface at the background location. The

National Emission Standards for Hazardous Air Pollutants (NESHAPs) guideline for average radon-222 flux from the surface of a containment structure is 20 pCi/m^2-s.

To locate any areas with readings above background on the WCS, an ultrasonic ranging and data system (USRADS) survey was performed on the WCS in May 1992. USRADS allows gamma radiation rate and positional information to be simultaneously collected, stored, and analyzed. Average readings over 14,000 cpm (twice background) are shown in Figure 2-1.

Results of radon flux measurements, which are taken on the WCS twice a year, were an average of 0.06 pCi/m^2-s in June 1992 from 180 canisters placed in 20-m (50 ft) grids, with a maximum reading of 0.28 pCi/m^2-s, and an average of 0.75 pCi/m^2-s in November 1992 from 179 canisters (one damaged in shipping), with a maximum reading of 2.19 pCi/m^2-s. Flux in natural soils is typically 0.5 to 1 pCi/m^2-s; however, fluxes up to several times these values are not unusual. In conclusion, the WCS is in compliance with NESHAPs guidelines. Walkover gamma radiation surveys will be included in routine monitoring.

2.4.2 Environmental Monitoring Changes

The environmental surveillance programs at FUSRAP sites are periodically evaluated and revised based on the individual site conditions, program objectives, and data results. Revisions consist of the number of sample collection points, frequency of sample collection, and parameters analyzed. This section summarizes changes in the NFSS environmental surveillance program from 1991 to 1992 (BNI 1992a). Monitoring locations are identified in Section 3.0.

Surface Water and Sediment

Based on past sampling results, which showed no unusual findings and no indications of an upward trend, sampling frequency was changed from quarterly to annually.

Groundwater

Based on past sampling results, groundwater modeling, and flow conditions, the number of wells sampled was reduced from 47 to 20, and sampling frequency was changed from quarterly to annually. Except for the background well, sampled wells intersect permeable zones at downgradient locations. The wells sampled are in the expected flow path of potential WCS contaminants. Because groundwater transport is less than 1 m (3 ft) per year, annual sampling should allow adequate response time.

External Gamma Radiations

Because of low exposure rates measured during the past 5 years, the number of monitoring locations was reduced from 46 to 22. Dosimeter locations were selected based on the ability to detect maximum exposure levels from the WCS, accessibility to the public, and previous results. Sampling frequency was changed from quarterly to semiannually. Four dosimeters were placed at each of the 22 stations in January 1992; two were collected and analyzed after 6 months, and the other 2 were collected and analyzed at the end of the year to provide a duplicate measurement for each station. The two dosimeters removed after six months will be used to reveal any changes that may have occurred onsite, and the two dosimeters removed after one year will be used for dose calculations.

Radon Monitoring

Because of the low radon concentrations observed during the past 5 years and the fact that residual radioactivity at the site has been remediated, and because contaminated materials are in a stable storage facility, the number of monitoring locations was reduced from 46 to 23. Sampling frequency did not change.

2.4.3 Response Actions

No removal or remedial actions were conducted during the reporting period; however, the site was resurveyed to establish legal property lines to allow for the release of excess

property. A new security fence was installed, and additional roads were constructed parallel to the security fence and around the WCS. Also, any areas disturbed on the WCS during the 1991 waste consolidation activities were reseeded during spring 1992.

2.5 ENVIRONMENTAL AWARENESS ACTIVITIES

FUSRAP is committed to minimizing the generation of waste at FUSRAP sites and uses methods for waste minimization including source reduction, material substitution, recycling, and controlled disposal of such wastes. The development of waste minimization goals, waste generation information, and a process for continual evaluation of the program are primary elements of this waste minimization philosophy.

Pollution prevention awareness is promoted and various waste minimization techniques are implemented as part of continuing employee training and awareness programs to reduce waste and meet the requirements for quality, safety, and environmental compliance. No hazardous waste minimization certifications or waste reduction reports for waste generators were required during this reporting period.

2.6 TRAINING

Site workers must complete a 40-h hazardous waste training program before beginning work and an 8-h refresher program every year thereafter to comply with OSHA requirements in 29 CFR 1910.120. The first three days onsite, workers also attend site-specific training sessions. Additional training includes but is not limited to fire extinguisher training, respirator training, self-contained breathing apparatus training, and weekly safety meetings.

2.7 SELF-ASSESSMENTS

During 1992, Bechtel National, Inc. (BNI), the project management contractor for FUSRAP, conducted a self-assessment at NFSS. The self-assessment focused on NESHAPs requirements. Eight observations were recorded during this self-assessment, and each was addressed before the annual EPA NESHAPs audit in June 1992.

As part of the self-assessment program, an environmental compliance assessment was conducted at NFSS in September 1992 by the Oak Ridge National Laboratory; four findings were identified. To date, all findings but one have been closed. This finding is expected to be closed in 1993.

FIGURE FOR SECTION 2.0

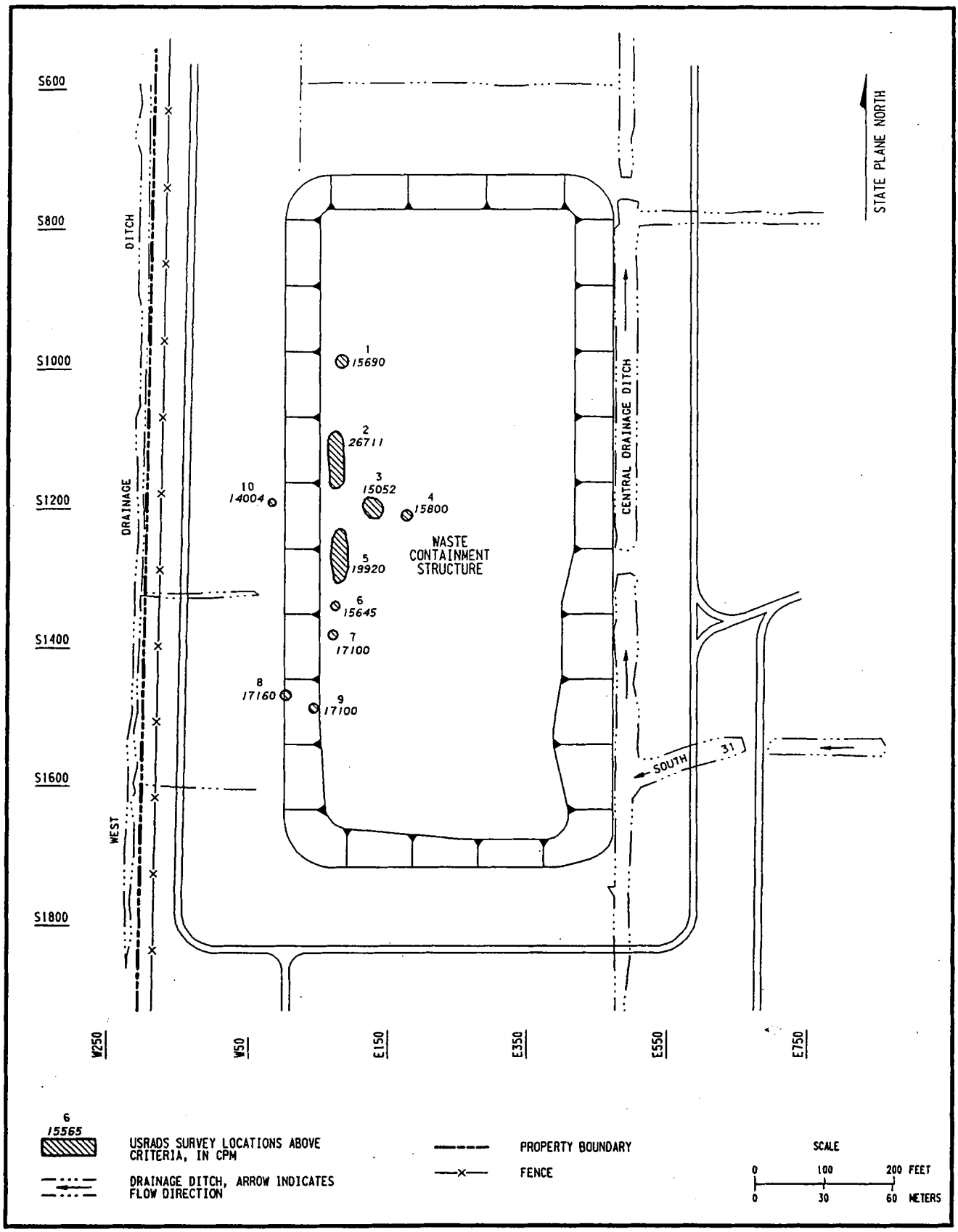

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Figure 2-1
USRADS Survey Results

3.0 MONITORING NETWORKS AND RESULTS

NFSS produces no processing effluents. The only possibility for contamination to be released from the site would be through migration from the WCS. The adequacy of existing monitoring activities is assessed annually, and the results are used to identify changes in the program. These may result from changing site conditions or regulatory requirements or from newly identified data needs to support the remedy selection process for the site. Additionally, as monitoring data are accumulated, decisions may be made to adjust monitoring requirements. Future site environmental reports will reflect these changes.

Based on knowledge of contaminants historically present at NFSS, environmental monitoring in 1992 included sampling for:

- Radon concentrations in air
- External gamma radiation exposure
- Radium-226 and total uranium concentrations in surface water, sediment, and groundwater
- pH, temperature, specific conductivity, total organic carbon, total organic halides, and specific metals in groundwater

> ***Readers not familiar with radiation units may benefit from reviewing Appendix B before proceeding.***

The monitoring systems include onsite, property-line, and offsite sampling locations to provide sufficient information on the potential effects of the site on human health and the environment. The analytical methods performed on each matrix are presented in Appendix C.

This section of the report contains the radiological and chemical data for each sampling point and trend information, where applicable. The methodology for calculating the results is provided in Appendix D. Expected ranges are calculated for each monitoring location using the average result from the previous five years plus or minus 2 standard deviations. The

results are compared with standards listed in Appendix E. Data are reported as received from the laboratory; however, the averages and expected ranges are reported using the smallest number of significant figures from this data (e.g., 3.2 and 32 both have two significant figures). Where appropriate, data are presented using powers of ten (e.g., $0.32 = 3.2 \times 10^{-1}$).

The following subsections discuss the monitoring program, results for 1992, and any possible radioactive contaminant migration indicated by the results. In each monitoring network section, trend tables summarize the analytical results for 1992 and the preceding five years and present the statistical expected range for each monitoring location.

3.1 AIR AND EXPOSURE MONITORING

Routine air monitoring at NFSS consists of nonintrusive, cumulative measurement of radon concentrations and external gamma radiation rates in the air at onsite and offsite locations.

3.1.1 Radon Monitoring Network

At NFSS the major radiation exposure pathway from the uranium-238 series is inhalation of the short-lived radionuclide radon (half-life of 3.8 days) and radon daughter products. Radon is an alpha-particle-emitting gas that is very mobile in air. Radon concentrations are measured using detectors containing alpha-sensitive film. The detectors are placed at breathing level, 1.5 to 1.7 m (5 to 5.5 ft) above the ground. Radon concentration in the air is monitored quarterly at NFSS at the site boundary to demonstrate compliance with environmental regulations; monitoring locations are shown in Figures 3-1 and 3-2. Radon flux measurements at the surface of the pile are made twice a year as part of the NESHAPs compliance program. Radon flux is measured using activated charcoal canisters placed on the surface of the pile at 15-m (50-ft) intervals for an exposure period of 24 h.

No annual average radon concentration was higher than the radon derived concentration guide (DCG) of 3.0×10^{-9} μCi/ml (0.11 Bq/L) above background (Table 3-1). All onsite monitoring locations yielded annual average results that were essentially the same as background. Trends in radon concentrations measured from 1987 through 1992 are presented in Table 3-2. The monitoring stations located on the property line were chosen for the trend analysis because the radon levels measured at these locations best represent the potential levels of exposure to the public. The maximum quarterly concentration for an individual station (station 122) in 1992 was 0.8×10^{-9} μCi/ml (3×10^{-3} Bq/L). As Table 3-2 shows, radon concentrations at these locations are low, have not fluctuated notably during the past five years, and are near background levels for the area.

The radon flux results for the WCS show an average flux rate of 0.4 pCi/m^2-s (0.01 Bq/m^2-s) with minimum and maximum levels of 0.01 and 2.2 pCi/m^2-s (4×10^{-4} and 0.081 Bq/m^2-s), respectively. These results demonstrate that the WCS is in compliance with the limit of 20 pCi/m^2-s (an averaged value) set forth in 40 CFR Part 61, Subpart Q.

3.1.2 External Gamma Radiation

External gamma radiation exposure rates are measured as part of the routine environmental surveillance program to confirm that direct radiation from NFSS is not significantly increasing radiation levels above natural background and to ensure compliance with environmental regulations. Dosimeters are placed 1 m (3 ft) above the ground (approximately at gonad level) to represent exposure to the critical organ nearest the contamination.

Although the tissue-equivalent thermoluminescent dosimeters (TETLDs) used for monitoring are state-of-the-art, the dosimeter accuracy is approximately $\pm$10 percent at exposure rates between 100 and 1,000 mR/yr and $\pm$25 percent at rates between 0 and 100 mR/yr.

The external gamma radiation background value is not constant for a given location or from one location to another, even over a short time, because the value is affected by a combination of both natural terrestrial and cosmic radiation sources and factors such as the location of the dosimeter in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil. Dosimeters are also influenced by site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Eisenbud 1987). Thus, external gamma radiation exposure rates at the boundary could be less than the background rates measured some distance from the site, and rates onsite could be lower than at the boundary.

Monitoring locations are shown in Figures 3-1 and 3-2. Excluding an average background value of 80 mR/yr, the annual average external gamma radiation exposure rate at NFSS in 1992 was 0 mR/yr at the fenceline (Table 3-3) and ranged from 0 to 6 mR/yr onsite. An average of the background levels measured was subtracted from site measurements to provide an estimate of radiation levels resulting from residual materials at the site. Information on public exposure is provided in Section 4.0.

For comparison, Table 3-4 shows the annual average external gamma radiation exposure rates for locations onsite, at the site boundary, and across the nation. Based on these data, the radioactive waste stored at NFSS does not present a threat to the public from external gamma radiation exposure because the rates are so low and access to the material is restricted.

A review of current and previous data reveals that external gamma radiation exposure rates have not changed noticeably over the last five years (Table 3-3).

3.2 SURFACE WATER AND SEDIMENT MONITORING

3.2.1 Monitoring Network

Surface water and sediment samples were collected and analyzed for total uranium and radium-226 in 1992.

Surface water monitoring is conducted to determine whether onsite surface water is contaminated, to determine whether runoff from NFSS contributes to surface water contamination in the area, and to ensure compliance with environmental regulations. Onsite sampling locations for surface water (9, 10, and 11) are shown in Figure 3-3; offsite locations (12 and 20) are shown in Figure 3-2. Location 9 is an upstream, background location established at the south 31 ditch in October 1988. Locations 12 and 20 are 2 and 3 km (1 and 2 mi) downstream, respectively, from the northern boundary of NFSS. Because surface water runoff from the site discharges through the central drainage ditch, all sampling locations except location 9 were placed along that ditch.

Sediment monitoring is conducted to determine whether contaminants are collecting in onsite and/or offsite sediments and to ensure compliance with environmental regulations.

Sediment samples were collected at surface water sampling locations where sediment is present. Onsite sampling locations (9, 10, and 11) are shown in Figure 3-3; downstream, offsite locations (12 and 20) are shown in Figure 3-2.

Currently, there are no DCGs for radionuclides in sediment; therefore, sediment concentrations are compared with FUSRAP soil guidelines (Appendix F).

3.2.2 Surface Water Monitoring Results

Results for analyses of radionuclides of concern in surface water for 1992 are essentially equal to background levels (Table 3-5). A review of data from the past five years shows no unusual findings and no indications of an upward trend. Concentrations of total uranium and radium-226 remain consistent and close to background levels.

3.2.3 Sediment Monitoring Results

A review of 1992 sediment data (Table 3-6) and data from the past five years shows that levels are equal to background conditions. Total uranium concentrations were close to background and below the FUSRAP site-specific soil guideline of 90 pCi/g established for

NFSS (DOE 1988b). Radium-226 levels remained close to background and below the FUSRAP soil guidelines of 5 pCi/g. No upward trends are indicated. FUSRAP site-specific soil guidelines are listed in Appendix F.

3.3 GROUNDWATER MONITORING

Groundwater monitoring is conducted at NFSS to detect migration of contaminants from the WCS. The contaminants stored in the WCS are principally radiological materials; however, chemical constituents suspected to have been used at the site are also evaluated to ensure compliance with environmental regulations.

3.3.1 Groundwater Well Network

There are currently 64 wells in the groundwater well network (see Appendix A). Manual water level measurements are collected from all of these wells. Twenty of these wells are monitored for a specific suite of analytes (Figure 3-4). Except for well 20S, which monitors background conditions, the monitoring wells are on the perimeter of the WCS. Most of the wells surrounding the WCS are labeled with an "OW" prefix and an "A" or"B" suffix. The "A" suffix denotes the lower groundwater system, and "B" denotes the upper groundwater system. The "OW" wells were installed during construction of the WCS. They were strategically spaced 60 m (200 ft) apart to intercept fugitive groundwater contaminants migrating from the WCS. A summary of monitoring well construction and a more detailed discussion are provided in Appendix A.

The principal goal of the groundwater monitoring network is to determine whether contaminants are migrating from the WCS. Analytical data are compared with results of previous sampling events to detect upward trends in concentrations. Before 1992, groundwater samples were collected and analyzed quarterly (BNI 1992b). No significant concentrations of contaminants were detected during the past five years. The low concentration detected during quarterly sampling justified a reduction of sampling frequency to once per year for both radiological and chemical parameters. The parameters are listed in Appendix C.

3.3.2 Results

Groundwater samples were collected in the third quarter of 1992 from monitoring well locations shown in Figure 3-4 and were analyzed for radiological and chemical constituents. Tables 3-7 and 3-8 list concentrations of radium-226 and total uranium in groundwater for 1992 and present a comparison of 1992 data with the previous five years. Concentrations have remained stable. Chemical analysis was conducted for aluminum, copper, iron, lead, mercury, manganese, and vanadium. Total organic carbon (TOC) and total organic halides (TOX) were analyzed as organic carbon indicators. Table 3-9 lists the EPA and NYSDEC (Class GA) drinking water guidelines. Table 3-10 lists the concentrations of chemicals above the laboratory detection limit. Aluminum, iron, and manganese are naturally occurring elements in the native soils, so decreases in concentrations from 1991 to 1992 may be the result of well redevelopment and slower purging methods. Laboratory detection limits are listed in Appendix C. Previous annual reports noted that the groundwater in the vicinity of NFSS is not a satisfactory residential water supply because of naturally occurring high salt content in the deep groundwater system and limited water supply in the shallow groundwater system.

Analytical results indicate that concentrations of total uranium and radium-226 are below their respective DCGs of 600×10^{-9} and 100×10^{-9} μCi/ml above background, respectively; however, wells OW-11B and A-42 have concentrations of uranium above background levels. The five-year trend (Table 3-8) shows values for uranium in wells OW-11B and A-42 consistently above a background of approximately 8×10^{-9} μCi/ml. To determine whether the uranium value in A-42 was dissolved or suspended, a filtered sample was taken. Analytical results indicated no significant difference between the total and dissolved fraction, indicating that the uranium is dissolved. However, analysis results from wells downgradient of well A-42 have not indicated uranium migration.

Iron and manganese concentrations are moderately high and exceed NYSDEC (Class GA) standard concentrations (300 μg/L) (Table 3-10). Concentrations of iron were exceeded in all wells except OW-17B, and concentrations of manganese were exceeded in wells OW-5A, OW-7A, OW-10B, OW-11B, OW-14A, OW-15A, and A-42. Natural waters

in the area are known to contain high total solid concentrations (800 to 5,000 ppm) (LaSala 1968).

Heavy metals such as copper, lead, mercury, and vanadium were all below regulatory levels. Lead does not exceed Safe Drinking Water Act (SDWA) standards but is greater than background, with values ranging from 3.3 to 7.0 μg/L. SDWA standards for lead are 15 μg/L. Other metal concentrations are below SDWA standards.

Rough indicator parameters TOC and TOX were used to determine the presence of organic compounds. These parameters have no regulatory limit and only suggest the presence of organic compounds in the groundwater. To use these indicators, a trend record must be established. If consistently high values are reported, wells are resampled for more specific organic compounds. FUSRAP has determined that additional analyte-specific samples would be taken if TOX exceeds 200 μg/L. To date, no action has been required.

Summary

Evaluation of the groundwater quality parameters indicates that they are not significantly different from the typical groundwater found in the area around NFSS. Iron and manganese are above drinking water standards, but this is a natural characteristic of the groundwater. Wells OW-11B and A-42 are the only wells with uranium concentrations consistently above background (but they are below DOE guidelines).

FIGURES FOR SECTION 3.0

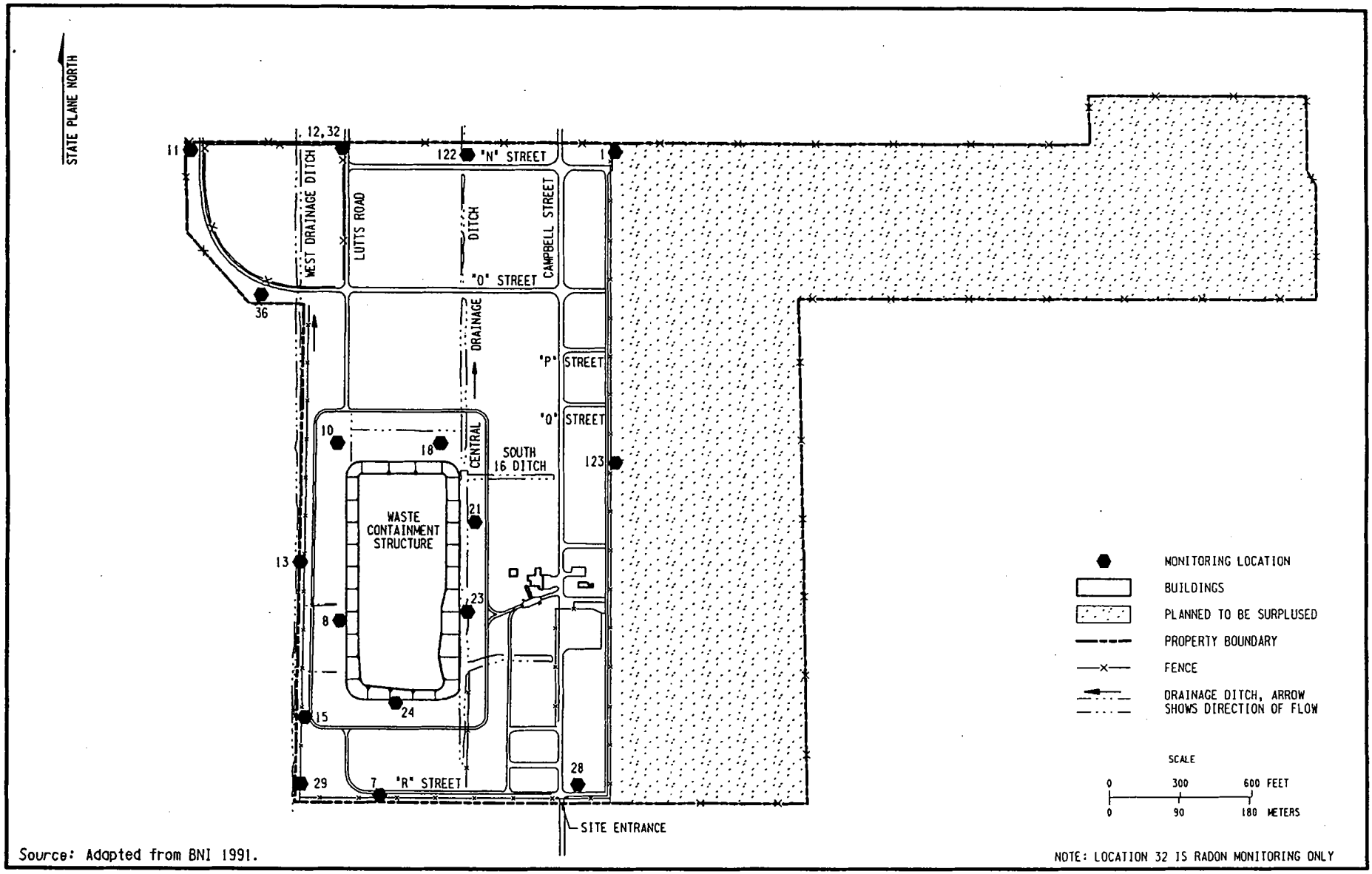

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Figure 3-1
Onsite and Property-Line Radon and External
Gamma Radiation Monitoring Location

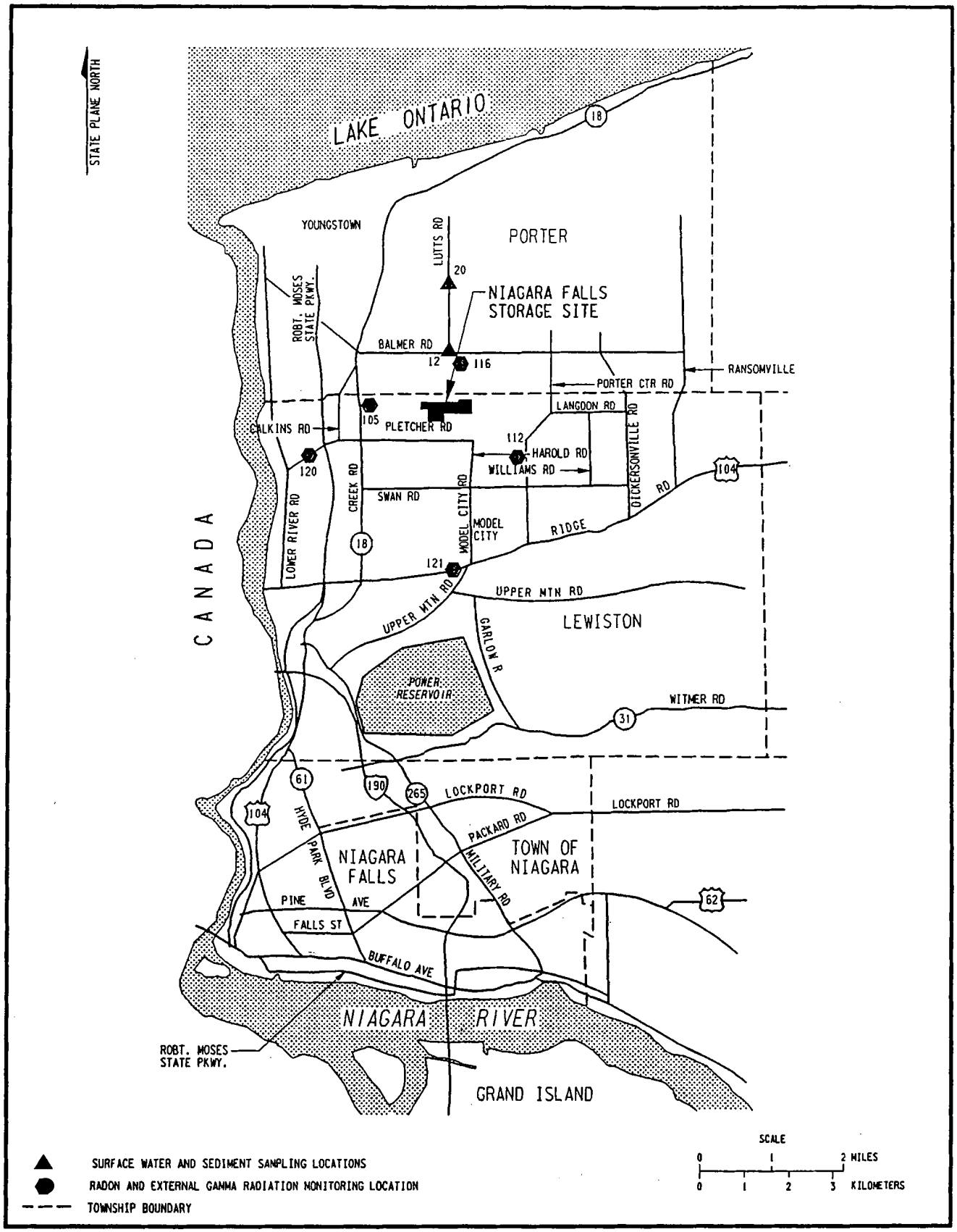

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Figure 3-2
Offsite Radon, External Gamma Radiation, Surface Water, and Sediment Monitoring Locations

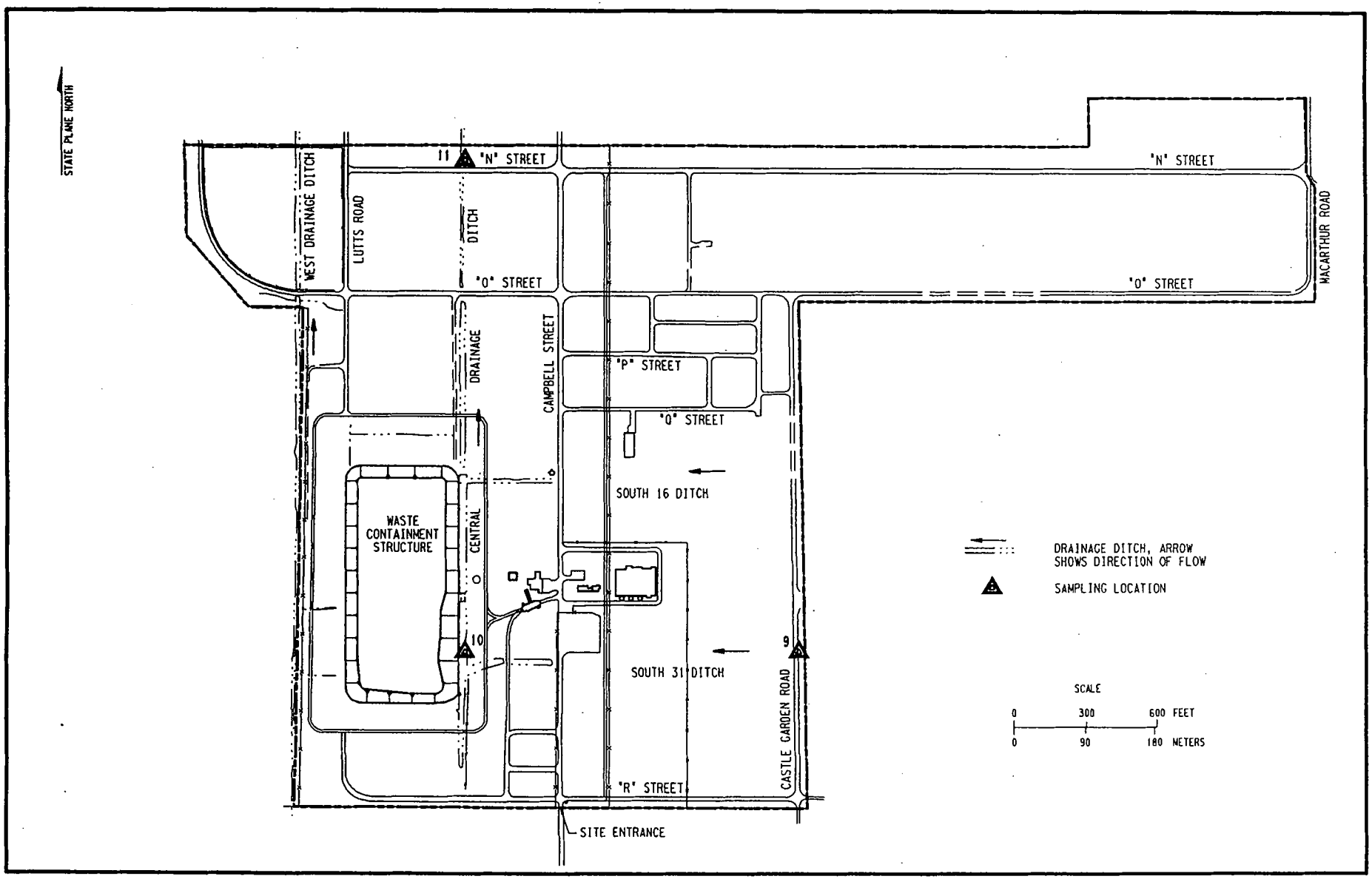

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Figure 3-3
Onsite Surface Water and Sediment Sampling Locations

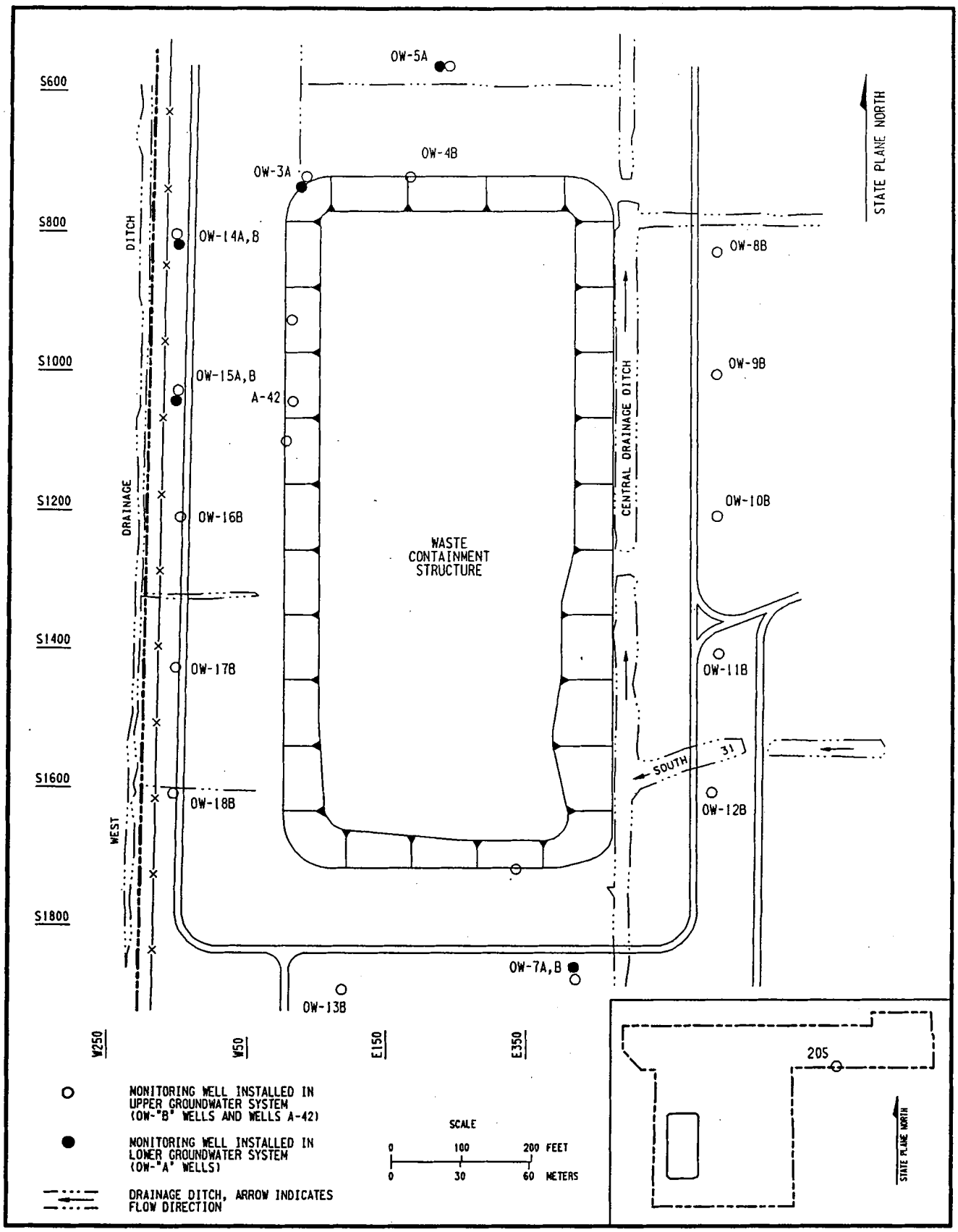

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Figure 3-4
Wells Used for Radiological and Chemical Sampling

TABLES FOR SECTION 3.0

Table 3-1

Average Radon Concentrations at NFSS, 1992[a,b]

Location[c]	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Average
			(Concentrations are in 10^{-9} μCi/ml)		
Property Line					
1	0.5	0.3	<0.3	<0.3	0.4
7	<0.4	0.5	<0.3	<0.3	0.4
11	<0.4	<0.3	<0.3	<0.3	0.3
12	<0.4	0.4	<0.3	<0.3	0.4
13	<0.4	<0.3	<0.3	<0.3	0.3
15	0.6	0.4	<0.3	<0.3	0.4
28	0.4	0.4	<0.3	<0.3	0.4
29	<0.4	0.3	--[d]	<0.3	0.3
36	<0.4	<0.3	<0.3	<0.3	0.3
122	0.8	0.5	<0.3	<0.3	0.5
123	0.4	0.3	<0.3	<0.3	0.3
				Average	0.4
Quality Control					
32[e]	<0.4	<0.3	<0.3	<0.3	0.3
Onsite					
8	<0.4	0.4	<0.3	<0.3	0.4
10	<0.4	0.3	0.4	<0.3	0.4
18	<0.4	<0.3	<0.3	<0.3	0.3
21	<0.4	0.5	<0.3	<0.3	0.4
23	<0.4	<0.3	<0.3	<0.3	0.3
24	<0.4	0.4	<0.3	<0.3	0.4
				Average	0.4
Background					
105	<0.4	0.5	<0.3	<0.3	0.4
112	<0.4	<0.3	<0.3	<0.3	0.3
116	<0.4	<0.3	<0.3	<0.3	0.3
120	<0.4	0.3	<0.3	<0.3	0.3
121	0.4	<0.3	<0.3	<0.3	0.3
				Average	0.3

[a] 1×10^{-9} μCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DOE guideline is 3.0×10^{-9} μCi/ml.

[b] Site background has not been subtracted from the reported values.
Note: Concentrations at some stations were below values at background stations.

[c] Sampling locations are shown in Figures 3-1 and 3-2.

[d] Lost when fence moved (housing attached to fence).

[e] Station 32 is a quality control station for Station 12.

Table 3-2

Trend Analysis for Radon Concentration[a,b]

Sampling Location[c]	Average Annual Concentration 1987	1988	1989	1990	1991	Average Annual Concentration 1992
	(Concentrations are in 10^{-9} μCi/ml)					
1	0.2	0.5	0.4	0.3	0.4	0.4
7	0.3	0.4	0.8	0.3	0.4	0.4
11	0.2	0.2	0.4	0.4	0.6	0.3
12	0.3	0.3	0.5	0.3	0.4	0.4
13	0.1	0.5	0.7	0.3	0.8	0.3
15	0.2	0.3	0.4	0.4	0.5	0.4
28	0.2	0.3	0.5	0.4	0.6	0.4
29	0.3	0.3	0.8	0.7	0.6	0.3
36	0.2	0.3	0.4	0.3	0.5	0.3
122	--[d]	--	--	--	--	0.5
123	--[d]	--	--	--	--	0.3
Quality Control						
32	0.3	0.3	0.6	0.3	0.6	0.3
Background						
105	0.3	0.4	0.4	0.3	0.4	0.4
112	0.2	0.3	0.3	0.4	4	0.3
116	0.3	0.3	0.3	0.3	0.6	0.3
120	--[e]	0.5	0.5	0.3	0.3	0.3
121	--[e]	0.5	0.4	0.3	0.3	0.3

Source for 1987-1991 data: BNI 1992b.

[a]1 $\times$ 10^{-9} μCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DOE guideline is 3.0 $\times$ 10^{-9} μCi/ml.

[b]Measured background has not been subtracted. Note: Concentrations at some stations were below values of background stations.

[c]Sampling locations are shown in Figures 3-1 and 3-2.

[d]Station established in January 1992.

[e]Station established in April 1988.

Table 3-3

Trend Analysis for External Gamma Radiation Exposure Rates[a]

at NFSS, 1987-1992

Sampling Location[b]	Average Annual Rate 1987	1988	1989	1990	1991	Average Annual Rate 1992
	(Rates are in mR/yr)					
Property Line (measured background subtracted)[c]						
1	11	11	0[e]	1	5	0
7	11	7	2	2	6	0
11	2	5	0	0	0	0
12	6	8	0	0	5	0
13	0	6	1	0	3	0
15	6	14	3	2	11	0
28	14	10	2	4	10	0
29	0	10	0	1	3	0
36	16	10	0	1	5	0
122[e]	--	--	--	--	--	0
123[e]	--	--	--	--	--	0
Background						
105	71	64	65	60	67	65
112	79	70	60	61	77	72
116	69	65	64	55	67	70
120[f]	--	--	83	80	89	92
121[f]	--	--	87	83	95	99
					Average	80

Source for 1987-1991 data: BNI 1992b.

[a]The DOE guideline is 100 mrem/yr above background. One mrem is approximately equivalent to 1 mR.

[b]Sampling locations are shown in Figures 3-1 and 3-2.

[c]Average annual measured background has been subtracted from property-line readings.

[d]A zero value indicates that the level was equal to average background at this location.

[e]Station established in January 1992.

[f]Station established in April 1988; data not available.

Table 3-4

External Gamma Radiation Exposure Rates for Comparison

Location	Average Rate (mR/yr) 1991	1992
NFSS boundary	81[a]	80[a]
NFSS onsite	82[a]	81[a]
NFSS vicinity	75	80
U.S. background[b]	103	
Grand Central Station[c]	525	
Statue of Liberty base[c]	325	

[a]Includes background.

[b]Shleien 1989.

[c]Appendix E.

Table 3-5

Trend Analysis for Total Uranium and Radium-226 Concentrations[a,b] in Surface Water at NFSS, 1987-1992

Sampling Location[c]	Average Annual Concentration 1987	1988	1989	1990	1991	Concentration 1992
	(Concentrations are in 10^{-9} μCi/ml)					
	Total Uranium[d]					
9[e]	--	8	9	7	5	6
10	6	7	21	5	8	8
11	14	10	16	9	13	7
12[f]	5	6	10	9	4	0.9
20[f]	6	7	4	8	4	0.9
	Radium-226[g]					
9[e]	--	0.2	1.5	0.5	1	0.3
10	0.2	0.2	0.6	0.5	0.7	1
11	0.3	1	2.5	0.4	2	0.5
12[f]	0.3	0.3	0.6	0.9	0.6	1.6
20[f]	0.4	1	0.5	0.7	0.4	0.7

Source for 1987-1991 data: BNI 1992b.

[a]1 $\times$ 10^{-9} μCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DCGs for total uranium and radium-226 are 600 $\times$ 10^{-9} and 100 $\times$ 10^{-9} μCi/ml, respectively. See Appendix E for information on half-life.

[b]Measured background has not been subtracted.

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

[d]Total uranium concentrations were determined by using fluorometric analysis during 1987 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis (KPA) during the fourth quarter of 1991 and during 1992. KPA is a much more sensitive method of analysis.

[e]Background, upstream sampling location established in October 1988 at the south 31 ditch; thus, data for 1988 represent one quarter's results, not average annual results.

[f]Offsite, downstream sampling location.

[g]Radium-226 concentrations were determined by emanation during 1987 through 1990 and the first three quarters of 1991 and by alpha spectroscopy during the fourth quarter of 1991 and 1992.

Table 3-6

Trend Analysis for Total Uranium and Radium-226

Concentrations[a,b] in Sediments at NFSS, 1987-1992

Sampling Location[c]	Average Annual Concentration 1987	1988	1989	1990	1991	Concentration 1992
	(Concentrations are in pCi/g)					
	Total Uranium					
9[d]	--	2	2.6	3.7	7	7
10	1.8	2.7	8.8	1.8	4	4
11	2	1.5	2.1	2.5	4	4
12[e]	1.3	1.9	1.4	1.7	3	3
20[e]	1.5	1.8	1.5	1.6	3	4
	Radium-226					
9[d]	--	1.3	1	1	2	2
10	0.8	0.8	1.8	0.8	0.8	1
11	1.3	1	1.7	1	1	0.7
12[e]	0.5	1.3	0.8	0.8	0.7	0.6
20[e]	0.8	0.9	0.8	1	1	0.9

Source for 1987-1991 data: BNI 1992b.

[a]One pCi/g is equivalent to 0.037 Bq/g. The FUSRAP NFSS site-specific soil guideline for total uranium is 90 pCi/g, and for radium-226 is 5 pCi/g above background (DOE 1988b). See Appendix E for information on half-life.

[b]Measured background has not been subtracted.

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

[d]Background, upstream sampling location established in October 1988 at the south 31 ditch; thus, data for 1988 represent one quarter's results, not average annual results.

[e]Offsite, downstream sampling location.

Table 3-7

Trend Analysis for Radium-226 Concentrations[a,b]

in Groundwater at NFSS, 1987-1992

Sampling Location[c]	Average Annual Concentration[d] 1987	1988	1989	1990	1991	Concentration[d] 1992
	(Concentrations are in 10^{-9} μCi/ml)					
	Upper Groundwater System					
OW-4B	0.2	0.3	0.5	0.3	1	0.2
OW-7B	0.2	0.4	0.5	0.3	0.3	0.9
OW-8B	0.2	0.8	0.6	0.3	0.2	0.3
OW-9B	0.2	0.7	0.9	0.3	0.2	0.2
OW-10B	0.2	0.3	0.3	0.3	0.7	0.4
OW-11B	0.1	0.5	0.4	0.3	0.2	0.3
OW-12B	0.2	0.6	0.5	0.4	0.3	0.1
OW-13B	0.2	0.7	0.7	0.8	0.5	0.5
OW-14B	0.5	0.8	1	0.5	0.8	0.2
OW-15B	0.2	0.6	0.8	0.4	0.3	0.4
OW-16B	0.2	0.8	0.7	0.6	1	1.6
OW-17B	0.2	0.3	0.4	0.4	0.3	0.2
OW-18B	0.4	0.4	0.8	0.4	0.6	0.5
A-42	0.2	0.5	0.6	0.9	0.5	0.7
20S[e]	--[f]	--[f]	--[f]	0.4	0.4	0.3
	Lower Groundwater System					
OW-3A	0.1	0.4	0.5	0.3	0.4	0.2
OW-5A	0.2	0.4	0.4	0.6	0.5	0.3
OW-7A	0.2	0.5	1	0.4	0.7	0.5
OW-14A	0.2	0.5	0.3	0.2	0.4	0.6
OW-15A	0.3	0.5	0.4	0.5	0.7	1

Source for 1987-1991 data: BNI 1992b.

[a]1 $\times$ 10^{-9} μCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DCG is 100 $\times$ 10^{-9} μCi/ml. See Appendix E for information on half-life.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 3-4. Sampling locations that no longer exist because of adjustments in the monitoring program or changes resulting from remedial actions are not reported in trend tables. Data from these locations would not be valid for comparison or trends.

Table 3-7

(continued)

[d]Radium-226 concentrations were determined by emanation during 1986 through 1990 and the first three quarters of 1991 and by alpha spectroscopy during the fourth quarter of 1991 and during 1992.

[e]Background well.

[f](--) indicates that a well was not established and sampled until fourth quarter 1990.

Table 3-8

Trend Analysis for Total Uranium Concentrations[a,b]

in Groundwater at NFSS, 1987-1992

Sampling Location[c]	Average Annual Concentration[d] 1987	1988	1989	1990	1991	Concentration[d] 1992
	(Concentrations are in 10^{-9} μCi/ml)					
	Upper Groundwater System					
OW-4B	6	7	7	6	6	18
OW-7B	3	5	3	9	12	2
OW-8B	17	20	20	14	10	18
OW-9B	14	20	20	10	20	25
OW-10B	3	6	7	7	10	11
OW-11B	36	28	32	31	23	32
OW-12B	15	14	10	10	13	18
OW-13B	14	17	17	19	18	19
OW-14B	5	7	6	4	7	5
OW-15B	6	7	14	7	17	9
OW-16B	6	7	11	5	7	5
OW-17B	7	8	8	6	6	7
OW-18B	14	18	19	19	14	22
A-42	78	55	67	76	57	76
20S[e]	--[f]	--[f]	--[f]	9	6	8
	Lower Groundwater System					
OW-3A	3	4	8	5	5	7
OW-5A	3	4	4	4	4	2
OW-7A	8	10	10	3	4	2
OW-14A	4	4	3	3	2	1
OW-15A	3	4	3	3	3	2

Source for 1987-1991 data: BNI 1992b.

[a]1 $\times$ 10^{-9} μCi/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DCG is 600 $\times$ 10^{-9} μCi/ml. See Appendix E for information on half-life.

[b]Measured background has not been subtracted.

Table 3-8

(continued)

[c]Sampling locations are shown in Figure 3-11. Sampling locations that no longer exist because of adjustments in the monitoring program or changes resulting from remedial actions are not reported in trend tables. Data from these locations would not be valid for comparison or trends.

[d]Total uranium concentrations were determined by using fluorometric analysis during 1986 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis during the fourth quarter of 1991 and 1992.

[e]Background well.

[f](--) indicates that well was not established and sampled until 1990.

Table 3-9

EPA and NYSDEC Guidelines as Action Levels for Water Media

Constituent	EPA[a] Concentration (μg/L)	NYSDEC[b] (Class GA) Standard Concentration (μg/L)
Aluminum	--[c]	--[c]
Copper	1,300[d]	2,000
Iron	--[c]	300[e]
Lead	15[d]	25
Manganese	--[c]	300[e]
Mercury	2[f]	2
Vanadium	--[c]	--[c]

[a]EPA 1990.

[b]NYSDEC 1991.

[c]No standards available.

[d]EPA 1991.

[e]Combined concentration standard for iron and manganese is 500 μg/L.

[f]Maximum contaminant level.

Table 3-10

Concentrations of Chemicals in Groundwater[a]

Above Detection Limits at NFSS, 1991 and 1992

Sampling Location[b]	Concentration 1991[c]	Concentration 1992[d]	Detection Limits[e]
	(Concentrations are in µg/L)[f]		
OW-3A			
TOC[g]	5	2.6	0.5
Aluminum	3,870	2,080	200
Iron	7,380	3,800	100
Manganese	435	185	15
OW-4B			
TOC[g]	1.8	2.5	0.5
TOX	60	11.4	5.0
Aluminum	6,120	692	200
Iron	10,300	1,410	100
Manganese	342	162	15
OW-5A			
TOC[g]	3	1.9	0.5
Aluminum	4,840	4,720	200
Iron	9,040	9,320	100
Manganese	474	695	15
OW-7A			
TOC[g]	1.8	1.3	0.5
Aluminum	6,100	3,780	200
Iron	10,800	6,960	100
Manganese	715	446	15
Vanadium	50	50	50
OW-7B			
TOC[g]	2	0.94	0.5
Aluminum	6,700	858	200
Iron	12,000	1,670	100
Manganese	412	74.6	15

Table 3-10

(continued)

Sampling Location[b]	Concentration 1991[c]	Concentration 1992[d]	Detection Limits[e]
	(Concentrations are in µg/L)[f]		
OW-8B			
TOC[g]	2.8	2.3	0.5
Iron	4,870	4,210	100
Manganese	150	123	15
Lead	<90	5.2	3.0
Vanadium	<50	50.6	50
OW-9B			
TOC[g]	2.2	1.7	0.5
Aluminum	7,020	515	200
Iron	11,600	1,130	100
Manganese	294	62.2	15
Vanadium	<50	54.9	50
OW-10B			
TOC[g]	3	2	0.5
Aluminum	13,800	15,900	200
Copper	63	67.1	25
Iron	26,400	31,800	100
Manganese	1,750	1,990	15
Lead	<90	7.0	3.0
Vanadium	70	64.5	50
OW-11B			
TOC[g]	1.5	2.5	0.5
Aluminum	4,740	5,280	200
Copper	30	40.6	25
Iron	9,130	10,000	100
Manganese	509	430	15
Lead	<90	3.4	3.0

Table 3-10

(continued)

Sampling Location[b]	Concentration 1991[c]	Concentration 1992[d]	Detection Limits[e]
	(Concentrations are in µg/L)[f]		
OW-12B			
TOC[g]	2.7	1.5	0.5
Aluminum	7,810	484	200
Iron	12,100	1,010	100
Manganese	292	62.3	15
OW-13B			
TOC[g]	9	3.1	0.5
Aluminum	15,100	1,140	200
Iron	26,600	2,400	100
Manganese	800	99.1	15
OW-14A			
TOC[g]	1.7	1.3	0.5
Aluminum	1,590	4,850	200
Iron	3,080	8,530	100
Manganese	325	615	15
Lead	<90	3.3	3
OW-14B			
TOC[g]	5.5	1.3	0.5
TOX	20	6.6	5.0
Aluminum	10,100	606	200
Iron	16,600	1,420	100
Manganese	450	128	15
OW-15A			
TOC[g]	3	1.8	0.5
Aluminum	7,880	8,450	200
Copper	27	31.5	25
Iron	14,500	17,300	100
Manganese	725	1,310	15

Table 3-10

(continued)

Sampling Location[b]	Concentration 1991[c]	Concentration 1992[d]	Detection Limits[e]
	(Concentrations are in µg/L)[f]		
OW-15B			
TOC[g]	2.2	2.3	0.5
TOX	<20	12.2	5.0
Aluminum	8,760	2,680	200
Iron	14,700	4,720	100
Manganese	386	132	15
Lead	<90	4.1	3.0
OW-16B			
TOC[g]	1.6	1.2	0.5
Iron	29,800	319	100
Manganese	1,170	111	15
OW-17B			
TOC[g]	1.9	2.2	0.5
Iron	3,440	157	100
Manganese	91	20.4	15
OW-18B			
TOC[g]	3.2	2.9	0.5
Aluminum	11,000	1,430	200
Iron	18,800	3,040	100
Manganese	650	110	15
Vanadium	70	60.5	50
A-42			
TOC[g]	2.7	4.1	0.5
Aluminum	200	2,010	200
Iron	301	3,490	100
Manganese	698	673	15
Lead	<90	3.6	3.0

Table 3-10

(continued)

Sampling Location[b]	Concentration 1991[c]	Concentration 1992[d]	Detection Limits[e]
(Concentrations are in µg/L)[f]			
20S Background Well			
TOC[g]	2.2	2.6	0.5
TOX	30	12.5	5.0
Iron	7,150	316	100
Manganese	250	41.6	15

[a]Groundwater samples were not filtered before analysis.

[b]Sampling locations are shown in Figure 3-4.

[c]Annual average.

[d]Sampled July 14, 1992.

[e]Detection limits can vary.

[f]µg/L = ppb.

[g]TOC concentrations are in mg/L (ppm).

4.0 ESTIMATED DOSE

The information in Section 3.0 was evaluated as described in Appendix E to estimate the potential radiation doses to the general public and to a hypothetical maximally exposed individual from the radioactive material stored in the WCS at NFSS. As expected for a stable site such as NFSS, all calculated doses were well below the DOE guideline.

Doses can come from either external or internal exposures. Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides deposited inside the body are called internal exposures. The distinction is important because external exposures occur only when a person is near the external radionuclides, but internal exposures continue as long as the radionuclides reside in the body.

To assess the potential health effects from the materials stored at NFSS, radiological exposure pathways were evaluated, and radiation doses were calculated for a hypothetical maximally exposed individual and for the population within 80 km (50 mi) of the site. The combined effects from all pathways (surface water, groundwater, air, and direct gamma radiation) from all DOE sources were considered and then compared with the DOE guidelines. All doses presented in this section are estimated and do not represent actual doses, but they are a small fraction of the applicable guidelines. A summary is provided in Table 4-1.

4.1 HYPOTHETICAL MAXIMALLY EXPOSED INDIVIDUAL

The hypothetical maximally exposed individual for NFSS is assumed to be a worker at the nearby Modern Disposal Landfill east of the site at an average distance of 10 m (30 ft). The worker is considered to occupy this location 8 h/day for 5 days/week for 50 weeks/yr.

4.1.1 Direct Gamma Radiation Pathway

Monitoring data show the external gamma radiation levels at the site boundary to be at background levels. Therefore, there is no realistic scenario in which a hypothetical individual would receive a gamma radiation exposure attributable to NFSS.

4.1.2 Drinking Water Pathway

Only one water pathway, either groundwater or surface water, is used to determine the committed dose to the hypothetical maximally exposed individual. This individual would obtain 100 percent of his or her drinking water from either surface water or groundwater in the vicinity. Because of the low radionuclide concentrations (near or below background) found in groundwater monitoring wells in the vicinity of the site and because no known drinking water wells are located within a 2-km (1-mi) radius of NFSS, the dose commitment to a hypothetical maximally exposed individual would be negligible and was not calculated. The dose from surface water to this individual was also not calculated because of the very low concentrations of radionuclides in the surface water.

4.1.3 Air Pathway (Ingestion, Air Immersion, Inhalation)

The effective dose equivalent to the hypothetical maximally exposed individual, determined using EPA's Clean Air Act Assessment Package-1988 (CAP88) PC computer model, Version 1.0, is negligible (3.0×10^{-5} mrem/yr).

4.1.4 Total Dose

The total dose for the hypothetical maximally exposed individual is the sum of the 50-yr committed effective dose equivalent and the external effective dose equivalent based on the total from all pathways. When these doses are added together, the total effective dose equivalent for the hypothetical maximally exposed individual would not be significantly different from zero.

4.2 GENERAL POPULATION

The collective dose to the general population living within 80 km (50 mi) of the site was calculated using the following input and criteria.

4.2.1 Direct Gamma Radiation Pathway

Monitoring data for external gamma radiation at the site boundary reflected background levels. In addition, distance from the site to the nearest residential areas and the presence of intervening structures reduce direct gamma exposure from NFSS. Because of this additional shielding and the fact that the hypothetical maximally exposed individual does not receive a gamma radiation dose from NFSS, it is reasonable to assume that there is no detectable gamma exposure to the general public above variations in normal background levels.

4.2.2 Drinking Water Pathway

No realistic exposure pathway was identified. No drinking water wells exist within 4.8 km (3 mi) of NFSS.

4.2.3 Air Pathway (Ingestion, Air Immersion, Inhalation)

The EPA CAP88-PC model is used to estimate an effective dose equivalent for contaminants transported through the atmospheric pathway at different distances from the site. The collective dose for the general population within 80 km (50 mi) of NFSS was calculated using these effective dose equivalents and the population density.

The calculated dose to the general public within an 80-km (50-mi) radius of the site was 7.7×10^{-2} person-rem/yr (7.7×10^{-4} person-Sv/yr).

The total population dose is the sum of the doses from all exposure pathways; however, the collective population dose is extremely small [7.7×10^{-2} person-rem/yr (7.7×10^{-4} person-Sv/yr)] when compared with the collective population dose from natural background gamma radiation in the area [2×10^{4} person-rem/yr (2×10^{2} person-Sv/yr)].

TABLE FOR SECTION 4.0

Table 4-1

Summary of Calculated Doses[a] for NFSS, 1992

Exposure Pathway	Dose to Hypothetical Maximally Exposed Individual[b] (mrem/yr)[c]	Collective Dose for Population Within 80 km of Site (person-rem/yr)[c]
Direct gamma radiation[d]	0	0
Drinking Water	--[e]	--[e]
Ingestion	--[e]	--[e]
Air immersion	--[e]	--[e]
Inhalation	3.0×10^{-5}	7.7×10^{-2}
Total[f]	3.0×10^{-5}	7.7×10^{-2}
Background[g]	80	2×10^{4}[h]

[a]Does not include radon.

[b]A Modern Disposal Landfill worker 10 m from the eastern fenceline.

[c]1 mrem/yr = 0.01 mSv/yr; 1 person-rem/yr = 0.01 person-Sv/yr.

[d]Does not include contribution from background.

[e]No realistic pathway.

[f]The DOE guideline for total exposure to an individual is 100 mrem/yr above background (DOE 1990b).

[g]Direct gamma radiation exposure only.

[h]Calculated by the following: (80 mrem/yr) (2.5×10^5 persons).

5.0 QUALITY ASSURANCE

5.1 INTRODUCTION

This section summarizes the quality assurance (QA) assessment of environmental activities at the site, which were conducted to ensure that onsite contamination does not pose a threat to human health or the environment. Using this criterion, the overall project data quality objective (DQO) requirement for the environmental surveillance program is to provide data of sufficient quality to allow reliable detection and quantitation of potential release of contaminated material from the site. The DQO requirements are assessed annually during review of the environmental monitoring plan and are updated based on historical information, trends identified, and changes in environmental regulations.

5.2 PROCEDURES

The *Quality Assurance Program Plan for the U.S. DOE FUSRAP* (QAPmP) (BNI 1992c) addresses the quality requirements for work being performed under this project. This plan requires all subcontractors to implement a compatible plan for QA or use the DOE plan. This is done to ensure compatibility with all requirements to maintain protection of human health and the environment.

QA procedures are detailed in project procedures and project instructions and are implemented for all field activities. Sampling techniques are derived from several documents, including *A Compendium of Superfund Field Operations Methods* (EPA 1987a) and the EPA Region II QA manual. Laboratory QA procedures have been derived from applicable EPA methods to ensure compatibility of the results. Also, activities such as data reviews, calculation checks, and data evaluations have been incorporated in procedures to monitor results and prevent or identify quality problems.

5.3 QUALITY ASSURANCE SUMMARY

QA/quality control (QC) activities are an integrated part of all environmental surveillance activities at the site. The specific methods, definitions, and formulas used to evaluate the QA/QC program are described in the *Quality Assurance Document for Site Environmental Reports* (BNI 1993). This document also discusses precision, accuracy, representativeness, comparability, and completeness (PARCC). For informational purposes, brief definitions or explanations will be given throughout this chapter for terms and processes used during the QA/QC evaluation.

The QA/QC program satisfies the requirements of DOE Orders 5400.1, 5400.5, and 5700.6C (DOE 1991). The programmatic controls in place for the environmental surveillance program are discussed in the project instruction guides.

5.3.1 Data Usability

To determine data usability, a verification process is used which evaluates items such as holding times and results for method blanks, spike recoveries, and duplicate results. This information is then used to verify whether the data are of sufficient quality to provide a basis for making decisions about the site. During this process, two qualifiers are associated with the data if there is any question concerning data usability:

"J"—the data result is estimated and should be used with discretion.
"R"—the data result is rejected and should not be used.

The data are then evaluated using the PARCC parameters to determine whether enough information is present to make decisions concerning the site. Any major problems encountered are documented as nonconformances and are tracked to ensure correction.

The results of the PARCC evaluation are presented as a percentage that met requirements. The formula used is:

$$\frac{\text{number of results that met EPA requirements}}{\text{total number of results}} \times 100 = \text{percent acceptable}$$

For Tables 5-1 to 5-5, a generic 80 percent has been used as an acceptable level. Representativeness and comparability cannot have a percentage applied; see Subsections 5.3.4 and 5.3.5 for definitions and discussions about the use of these two parameters.

5.3.2 Precision

Precision is defined as a measurement of the agreement of a set of replicate results among themselves without assumption of any prior information as to the true result. Precision is assessed through the use of duplicate results or matrix spike (MS) and matrix spike duplicate (MSD) results. MSs and MSDs are usually used with organic analytes; inorganic analytes are generally run as a true duplicate and a single MS. Field duplicates are also used to assess field precision; results are presented separately from the laboratory duplicate results. Table 5-1 lists the results of the laboratory precision. All results met the requirements for acceptability.

Table 5-2 shows the results for the field duplicates. Metals, radium-226, and total uranium met the acceptable levels. TOC and TOX both failed the requirements. TOC was evaluated with two sets of duplicates. The first set had poor results for the precision calculation; however, the second set met EPA requirements. This could be a result of the matrix, poor sampling technique, or poor lab technique. For TOX, only one set of field duplicates was analyzed. The resulting calculation was 43 percent reproducibility. As with the TOC analysis, matrix, sampling technique, or lab technique could be the cause. During data verification, sample results associated with these duplicates were evaluated.

Table 5-3 lists the results for the laboratory radiochemical duplicates. Radium-226 and total uranium both met the acceptable limits. The use of 20 percent relative percent difference (RPD) for radiochemical duplicates was derived from *Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1988).

5.3.3 Accuracy

Accuracy is defined as the nearness of a result or the mean of a set of results to the true, known, or reference value. The assessment of accuracy may be determined through standard reference materials, MSs, laboratory control samples, and surrogate spikes.

Table 5-4 gives the results for the chemical spikes; all categories were above the 80 percent level. Results for radiological spikes, listed in Table 5-5, were all acceptable. The use of recovery windows of 75 to 125 percent for radiological spikes was derived from *Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1988).

5.3.4 Representativeness

Field sampling and laboratory analytical representativeness expresses the degree to which the data accurately and precisely represent the matrix from which the samples were obtained. Representativeness generally expresses the extent to which the data generated define an environmental condition.

To ensure field sampling representativeness, several controls were used during sampling, including the use of rinse blanks, dedicated well pumps, and field duplicates. Rinse blanks were collected to determine whether site conditions, sample containers, or preservatives were producing false-positive sample results and to assess the adequacy of sampling equipment decontamination procedures. Field duplicates have been discussed in Section 5.3.2. Dedicated well pumps were installed on all monitoring wells except for well 20S, so that possible cross-contamination between wells is eliminated. The rinse blank presented in Table 5-6 is only applicable to well 20S.

To ensure representativeness in the laboratory, constraints are placed on analytical methodology. Method blanks are prepared for each parameter analyzed, with an associated frequency of 1 per batch of no more than 20 samples. A method or preparation blank is used to determine whether contaminants are present in the laboratory that could have an impact on the samples associated with that method blank. The presence of contaminants can indicate the possibility of false positive results.

False negative results can also be reduced through the use of sample preservatives and holding times. All samples were preserved at the time of sampling by the addition of required chemicals, through refrigeration, or both. The use of preservation limits biological and chemical degradation that would bias sample results.

Table 5-7 lists the contaminants and their concentrations for method blanks. The method blanks were contaminated with iron and total uranium. During the evaluation and verification of data, this contamination was assessed to determine its impact on the data.

5.3.5 Comparability

Comparability expresses the confidence with which data are compared with each other. Comparability also takes into account the use of equivalent instrumentation and methodology. The laboratories follow approved procedures that are consistent with industry-accepted practices, and comparability is maintained.

5.3.6 Completeness

Completeness measures the amount of usable data resulting from the data collection activities compared with the total data possible. For environmental monitoring, all samples were taken as required in the instruction guide for usability. Section 5.3.1 discussed data rejected during the verification process; Table 5-8 summarizes the acceptability rate for all analytes. TOX failed the 80 percent usability rate, at 71 percent.

5.3.7 Interlaboratory Programs

The radiochemistry laboratory participates in the Environmental Measurements Laboratory's Quality Assessment Program, EPA's Cross Check Program, and the Nuclear Fuel Services' Interlab Quality Control Comparison. The chemical laboratory participates in EPA's water supply and water pollution programs and analyzes quarterly single-blind samples submitted by FUSRAP. Results for these programs are submitted to FUSRAP. Repeated failure of an analyte for consecutive periods results in the suspension of that analyte until corrective actions have been taken. Table 5-9 shows the radiochemistry results from the DOE Quality Assessment Program; Table 5-10 shows the results from the EPA Intercomparison Program.

TABLES FOR SECTION 5.0

Table 5-1

Results for Chemical Laboratory Duplicates

Parameters	Percent Acceptable	Meets Established DQOs
Metals	92	Yes
TOX	100	Yes
TOC	100	Yes

Table 5-2

Results for Field Duplicates[a]

Parameters	Percent Acceptable	Meets Established DQOs
Metals	100	Yes
TOC	50	No
TOX	0	No
Radium-226	100	Yes
Total uranium	100	Yes

[a]Acceptability based on a 20 percent RPD.

Table 5-3

Results for Laboratory Radiochemical Duplicates[a]

Parameters	Percent Acceptable	Meets Established DQOs
Radium-226	100	Yes
Total uranium	100	Yes

[a]Acceptability based on a 20 percent RPD.

Table 5-4

Results for Chemical Spike Recoveries

Parameters	Percent Acceptable	Meets Established DQOs
Metals	91	Yes
TOX	100	Yes
TOC	100	Yes

Table 5-5

Results for Radiological Spike Recoveries[a]

Parameters	Percent Acceptable	Meets Established DQOs
Radium-226	100	Yes
Total uranium	100	Yes

[a]Acceptability based on a 75-125 percent recovery.

Table 5-6

Results for Rinse Blanks

Parameters	Matrix	Concentration
Lead	water	3.4 μg/L
TOX	water	16.2 μg/L

Table 5-7

Results for Laboratory Method Blanks

Parameters	Maximum Concentration
Iron	132 μg/L
Total uranium	1.9 μg/g

Table 5-8

Usability Rates for Each Parameter

Parameters	Percent Acceptable	Meets Established DQOs
Metals		
Aluminum	100	Yes
Copper	100	Yes
Iron	100	Yes
Lead	100	Yes
Manganese	100	Yes
Mercury	100	Yes
Vanadium	100	Yes
TOX	71	No
TOC	100	Yes
Radiological		
Radium-226	100	Yes
Total uranium	100	Yes

Table 5-9

Radiochemistry Laboratory Performance on DOE Quality Assessment Program Samples in 1992

Sample Media	Radionuclides	Number of Results Reported	Number Within Control Limits
Air filters	Uranium (mass)	1	1
Soil	Potassium-40 Strontium-90 Cesium-137 Uranium (mass)	4	3
Vegetation	Potassium-40 Strontium-90 Cesium-137	3	3
Water	Tritium Manganese-54 Cobalt-60 Cesium-134 Cesium-137 Cerium-144 Plutonium-238 Plutonium-239 Americium-241 Uranium (mass)	10	9

Table 5-10

Radiochemistry Laboratory Performance on EPA Intercomparison Program Samples in 1992

Sample Media	Radionuclides	Number of Results Reported	Number Within Control Limits
Water	Alpha Beta Zinc-65 Cobalt-60 Ruthenium-106 Cesium-134 Cesium-137 Barium-133	26	24
Water	Radium-226 Radium-228 Plutonium-239 Uranium (natural)	16	16
Water	Strontium-89 Strontium-90	7	6
Water	Tritium	2	2
Air filters	Alpha Beta Strontium-90 Cesium-137	7	5

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APPENDIX A Hydrogeologic Details

HYDROGEOLOGIC DETAILS

This appendix contains a discussion of the hydrogeology at NFSS. Chemical and radiological data from 1991 and 1992 are included to support the discussion in Subsection 3.3. Groundwater is a potential pathway for chemical and radioactive contaminants, but because it cannot be directly observed from the surface, water levels and groundwater samples from monitoring wells provide the best information about migration pathways. The first step in identifying these migration pathways is to evaluate the ground material. At NFSS, groundwater is most mobile in coarse soils and in fractured bedrock. The coarsest soils are close to the surface and at the top of bedrock and are separated by a 7.6- to 15-m (25- to 50-ft) layer of finer clay material that restricts flow of groundwater. Because the groundwater is separated by this clay barrier, two distinct groundwater systems exist, the upper and lower groundwater systems. Water levels from the 64 wells at the 77-ha (191-acre) site were measured every two weeks in 1992. Water levels of selected wells around the WCS were plotted as hydrographs for 1992 and for the past four years to identify groundwater trends. Water levels can be translated to water surface elevations, which are contoured to make potentiometric surface maps.

Hydrogeologic Setting

NFSS lies within the Central Lowland Physiographic Province, which is part of the Erie-Ontario Lowland and is characterized by topography developed on essentially undeformed Paleozoic sedimentary rocks. The rocks occupy a broad basin sloping gently southward from the neighboring crystalline terrains of the Canadian Shield and the Adirondack Dome (Muller 1965). Regionally, a metamorphic basement of gneiss has been found varying from approximately 610 to 914 m (2,000 to 3,000 ft) (USCE 1973). The area was significantly modified by glaciers.

The site stratigraphy includes 12 to 15 m (40 to 50 ft) of unconsolidated deposits overlying a thick sequence of sedimentary rocks. These surficial deposits are glacially derived sediments, which include glaciofluvial sands and gravel, dense tills, and glacial lacustrine clays. Lacustrine materials were deposited on the bottoms and along the shores of

glacial and post-glacial lakes. Beneath these deposits are shales, siltstones, and mudstones of the Queenston Formation. Six major geologic units are identified within the interval from 0 to 27 m (90 ft) below ground surface. In order of increasing depth, these units are surficial soils and fill, brown clay, gray clay, sand and gravel, red silt, and bedrock of the Queenston Formation.

Two groundwater systems identified within the unconsolidated units are described as the upper groundwater system and the lower groundwater system. Bedrock wells are screened in the bedrock groundwater system, which is not included in the groundwater discussion of NFSS. Upper groundwater system wells are screened at depths from 2.4 to 6.7 m (8 to 22 ft) within the brown clay geologic unit and are most likely to intercept contaminants moving in the groundwater. The brown clay contains intermittent lenses of sand, gravel, and silt which transmit groundwater at a higher rate than the surrounding clay material; however, these lenses are seldom in contact with the surface, so they do not receive recharge directly. Lower groundwater system wells are screened at depths between 6.1 to 14.4 m (20 to 47.2 ft) in materials below the brown clay and above the bedrock.

Groundwater Quality and Usage

A well canvass of NFSS conducted in 1987 and 1988 yielded records for seven wells. There were no private wells that provided water for drinking purposes, but one well drilled for irrigation reportedly is a source of water suitable for drinking. No public water supply wells were found within the investigation area, and no new drinking water wells have been drilled in the vicinity since 1988, according to the Department of Health records for Niagara County (1992). Water needs for the area are usually met by treated water from Lake Erie and from the Niagara River.

Groundwater Monitoring

The hydrogeologic interpretations presented here are based on groundwater levels measured in monitoring wells during the 1992 calendar year. Groundwater levels are measured weekly using a water level indicator. The locations of groundwater monitoring

wells are shown in Figure A-1. Examples of well construction details are provided in Figure A-2. Groundwater samples are collected from selected monitoring wells onsite; locations are shown in Figure 3-4. Further information on site geology, hydrogeology, and well installation methods can be found in Muller 1965, USCE 1973, DOE 1986, BNI 1984, BNI 1986, and Acres American, Inc. 1981.

Water level measurements from monitoring wells are used to prepare two types of graphic exhibits (hydrographs and potentiometric surface maps) that show hydrogeological conditions at the site. Hydrographs are line graphs that display changes in water levels for each monitoring well throughout the year. The NFSS hydrographs also include bar graphs of U.S. Weather Service precipitation records for the Niagara Falls area as an aid in evaluating the influence of precipitation on water level behavior.

Potentiometric maps (Figures A-3 through A-6) show lines of equal elevation of the water surface. These lines (or contours) are used to determine the amount of slope (gradient) and flow direction of the NFSS groundwater systems. Potentiometric maps are prepared by plotting water level measurements for selected dates on a base map and producing contours to show the values.

Results and Conclusions

Yearly hydrographs for 1992 and four-year hydrographs including 1989, 1990, 1991, and 1992 are shown in Figures A-7 through A-16. Results of chemical and radiological analyses are provided in Tables A-1 and A-2. The wells selected for discussion are representative of conditions on all sides of the WCS. Hydrogeologic discussion will be limited to the upper and lower groundwater systems because they represent water-bearing zones within the unconsolidated material. The primary area of concern at NFSS is around the WCS; other areas are outside the influence of the potential source of contaminants.

Upper Groundwater System

Separate hydrographs are shown for wells OW-4B, OW-6B, OW-10B, OW-11B, and OW-16B (Figures A-7 through A-16) for 1992 and the previous three years. These shallow wells are plotted beside the lower wells for comparison. The 1992 hydrographs, plotted with 1992 rainfall data, do not indicate a direct response to rainfall. However, rainfall accumulated during the summer months did affect the normally low season. Viewing daily rainfall records without looking at intensities is deceiving because high-intensity rainfalls can produce large volumes of rain, with most of the rainfall draining off and not percolating into the ground. It is likely that a high percentage of the rainfall measured during summer 1992 was slow, soaking rain that percolated into the ground and showed up in the groundwater. The upper groundwater usually fluctuates during the year, but in recent years it has exhibited a distinct peak high and low. The 1992 hydrographs show a peak high during the winter to spring but do not show a distinct low period as in previous years. The drought experienced in 1991 ended rapidly early in 1992 with a rapid increase in the water table from January to February.

Potentiometric contour maps of the upper groundwater system (Figures A-3 and A-4) show a groundwater high on the west side of the WCS with radiating flow dominating toward the east. In periods of low water table (fall 1992) the central drainage ditch influences flow direction. During periods of high water table, the flow gradient is more uniform and less influenced by the drainage system. The flow gradient is generally low (about 0.01), with a steep gradient along the central drainage ditch.

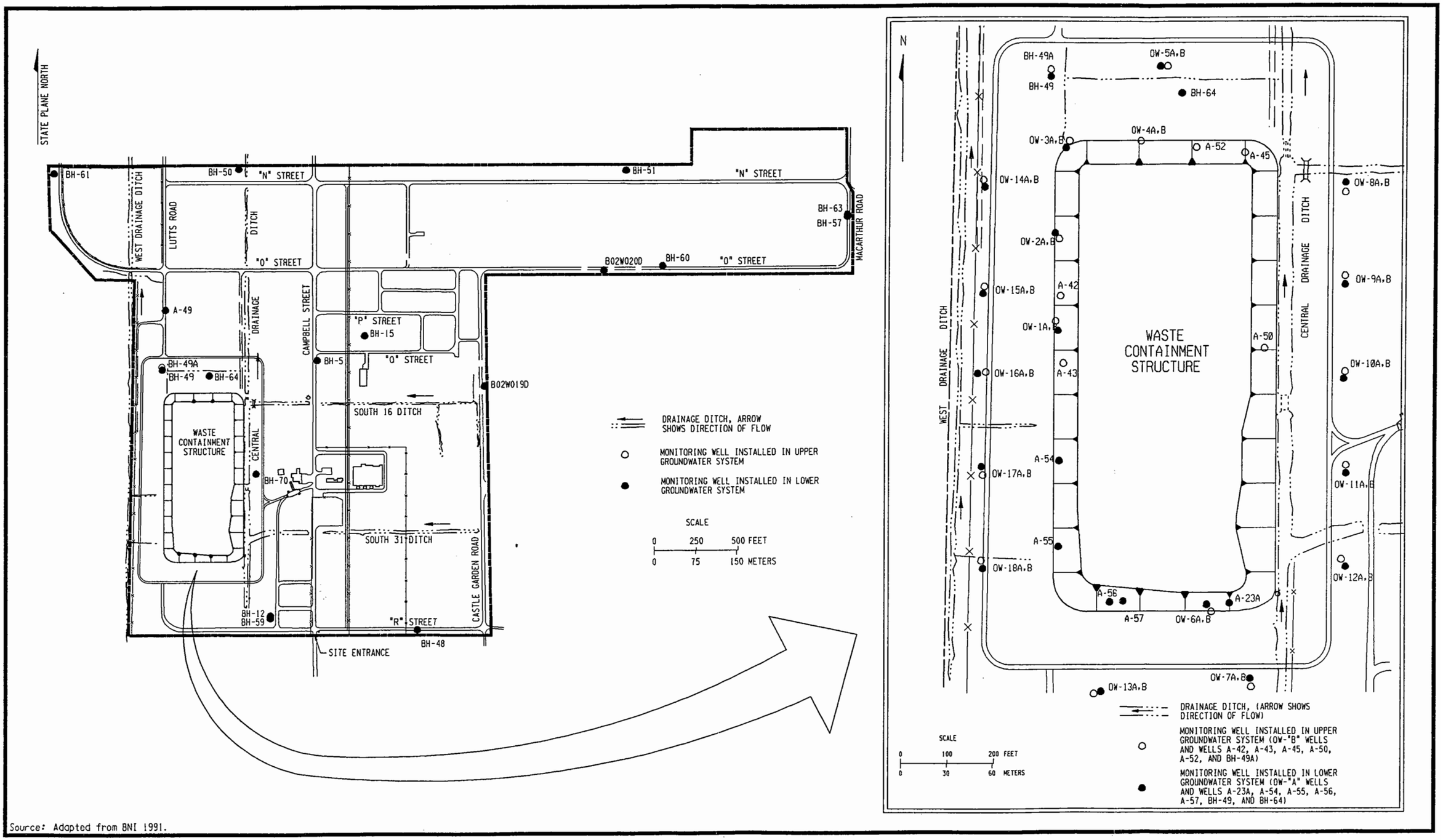
Lower Groundwater System

Hydrographs of wells screened in the lower groundwater system (Figures A-8 and A-9) show a constant rise since December 1991. This rise reflects the recovery of groundwater storage, which was depleted during the 1991 drought. Under normal seasonal conditions, there would be a peak high, usually following winter, and a peak low after summer. The 1991 drought was followed by a summer surplus in 1992, which caused a rise in late summer when water levels usually drop. Hydrographs from wells in the lower system are smooth,

lacking the sawtooth appearance of the upper system wells. This smooth appearance can be attributed to the slow percolation to the lower system. There is typically no direct response to precipitation events. Water levels are expected to level off at the end of 1992 and start decreasing in the spring of 1993.

Potentiometric contour maps of the lower groundwater system (Figures A-5 and A-6) are similar to those reported in 1991. The general flow direction is to the northwest with a ridge running southeast to northwest in the northwest corner of the WCS. There is another ridge that forms a groundwater divide across the southern third of the WCS, where flow direction is to the south. The groundwater flow gradient is low (about 0.001), which is consistent with previous years.

FIGURES FOR APPENDIX A



Source: Adapted from BNI 1991.

R19F007.DGN

Figure A-1
Wells Used for Water Level Measurements

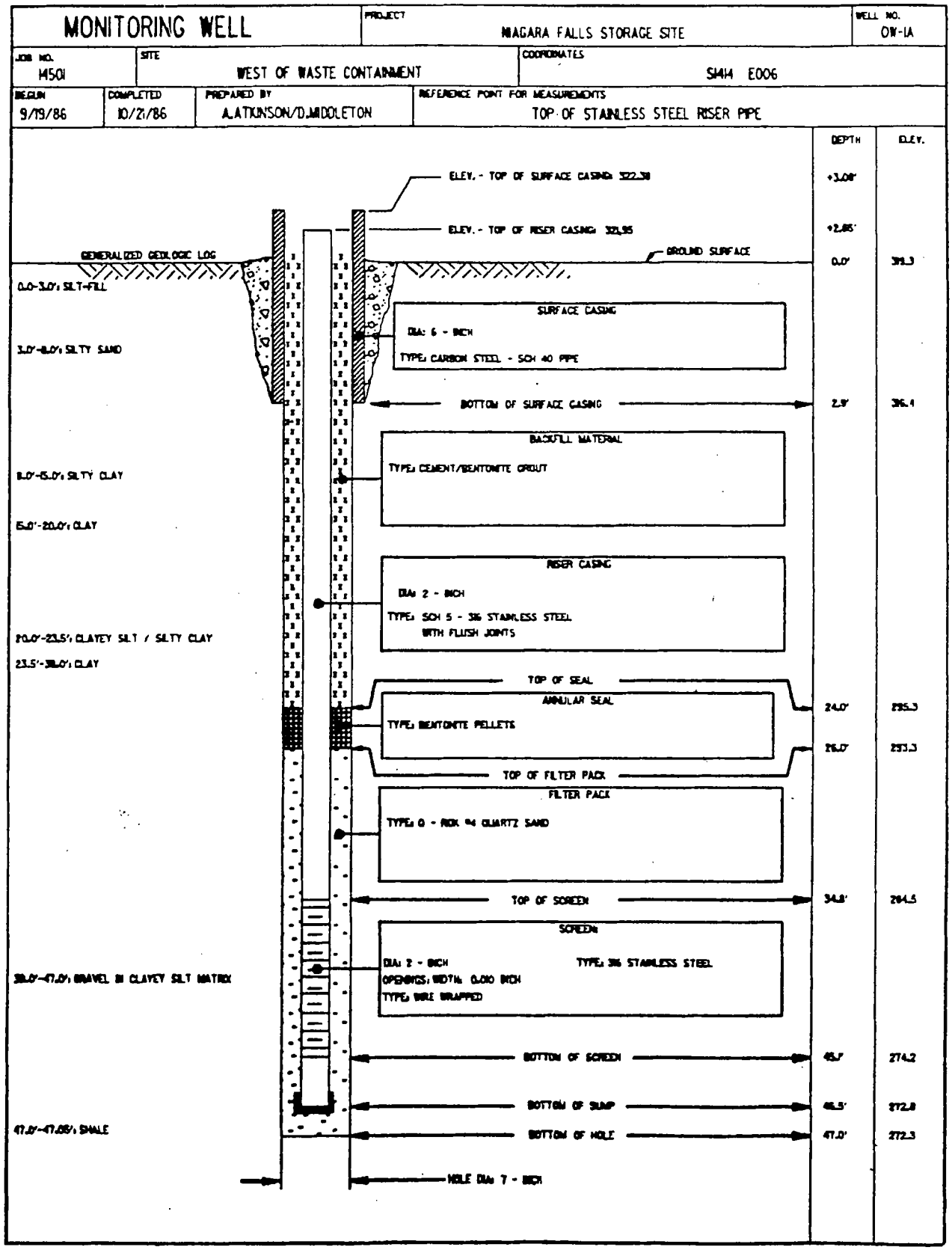
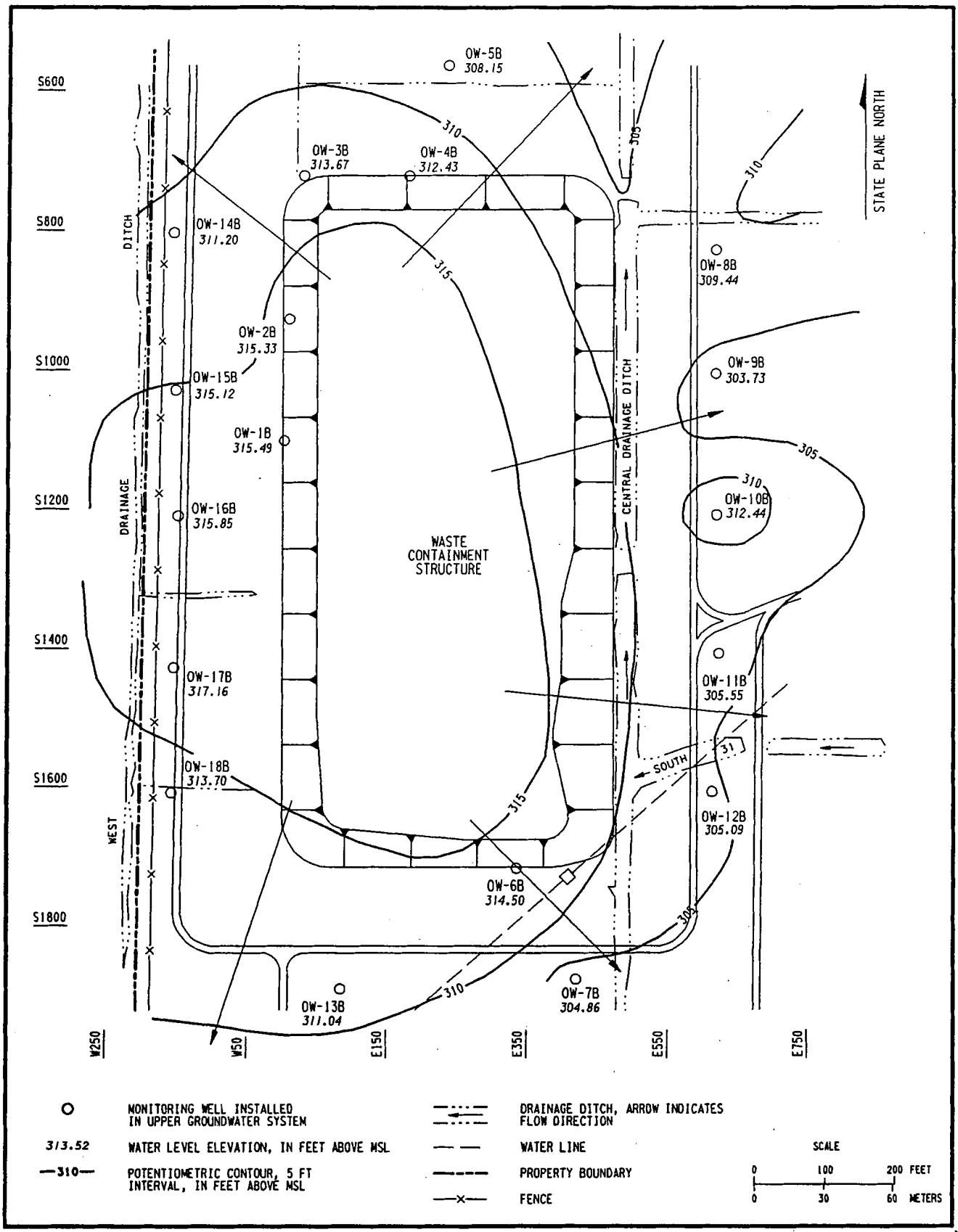
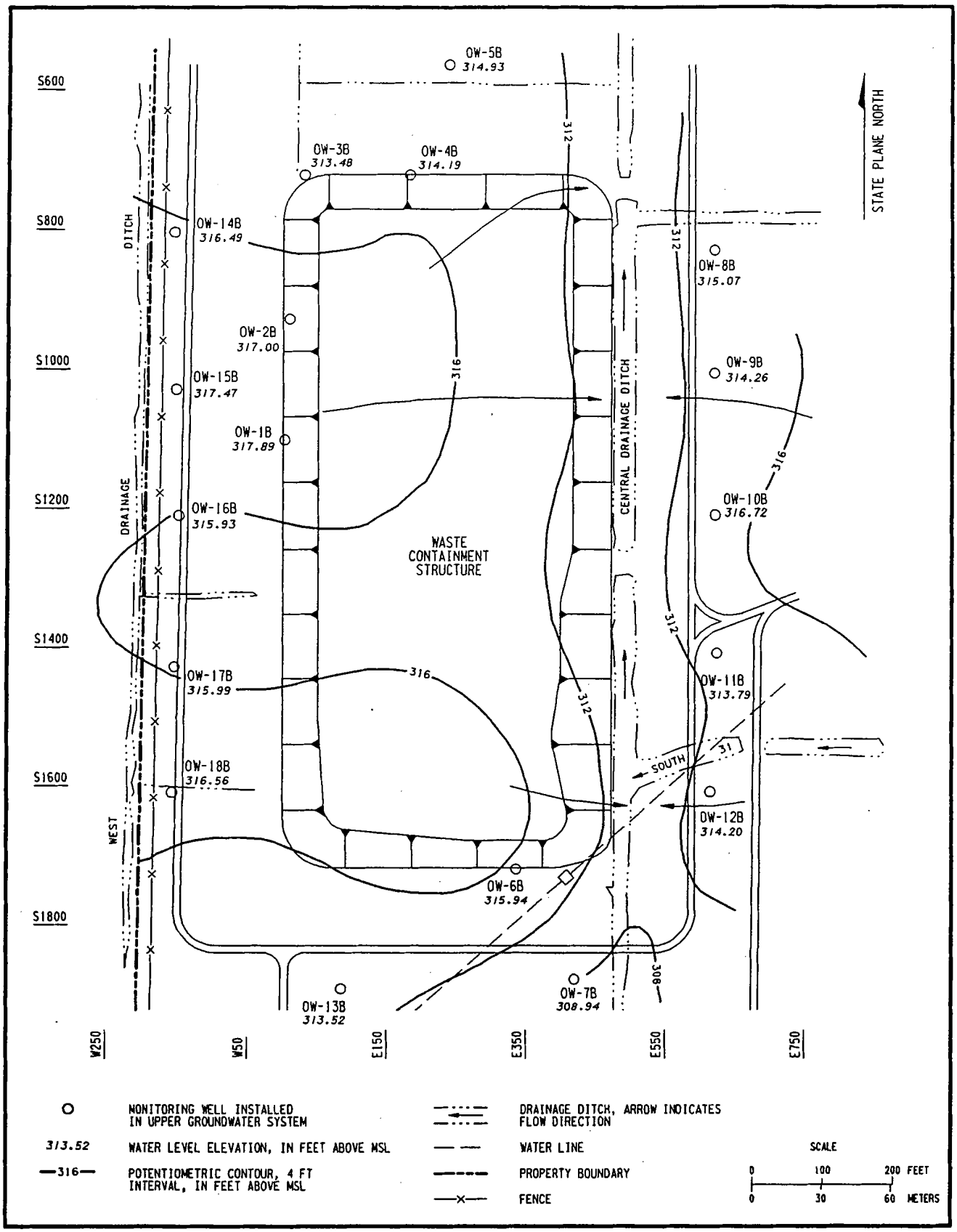


Figure A-2
Example of Monitoring Well Construction



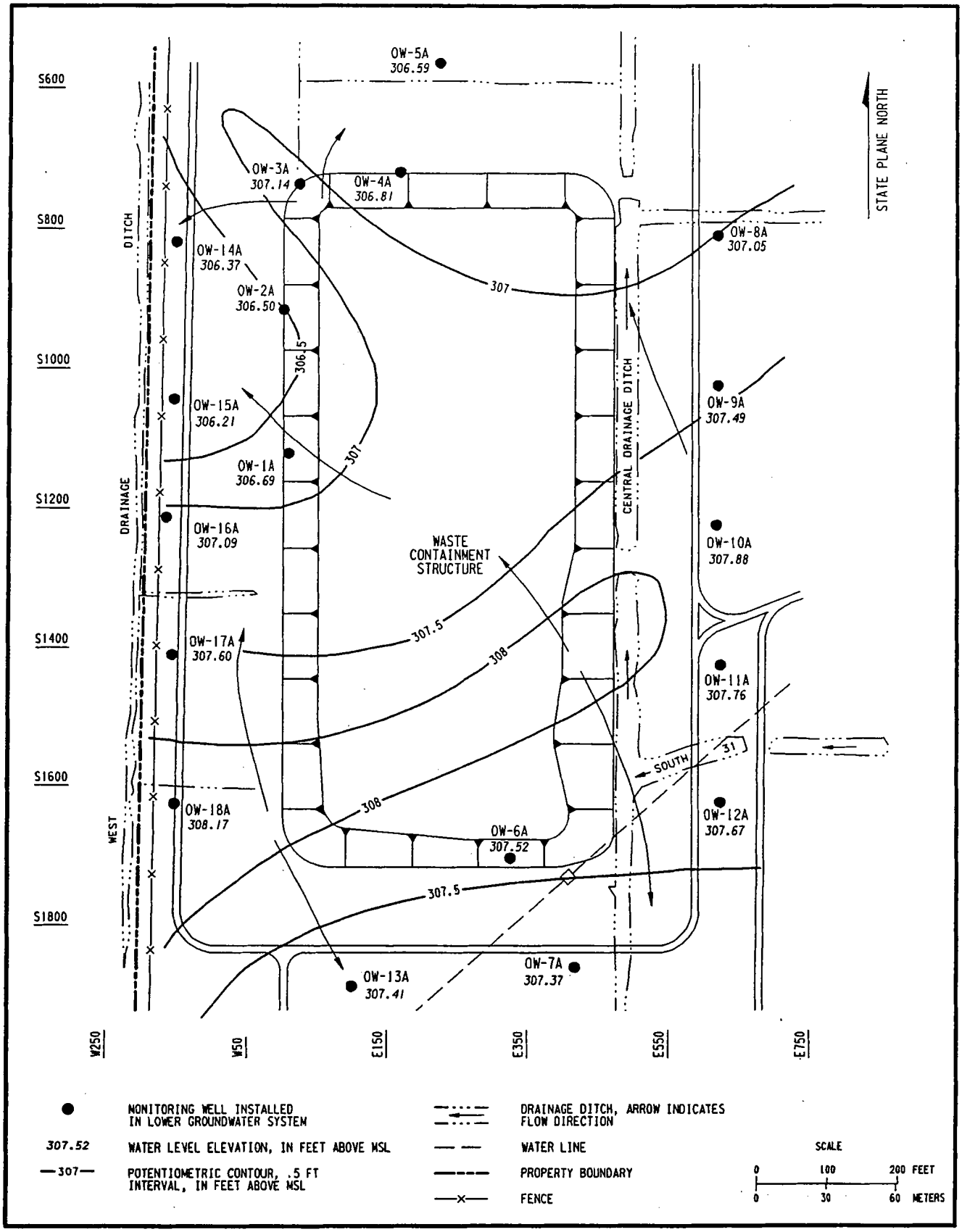
R35 R35F003.DGN

Figure A-3
Potentiometric Map of Upper Groundwater System (1/22/92)



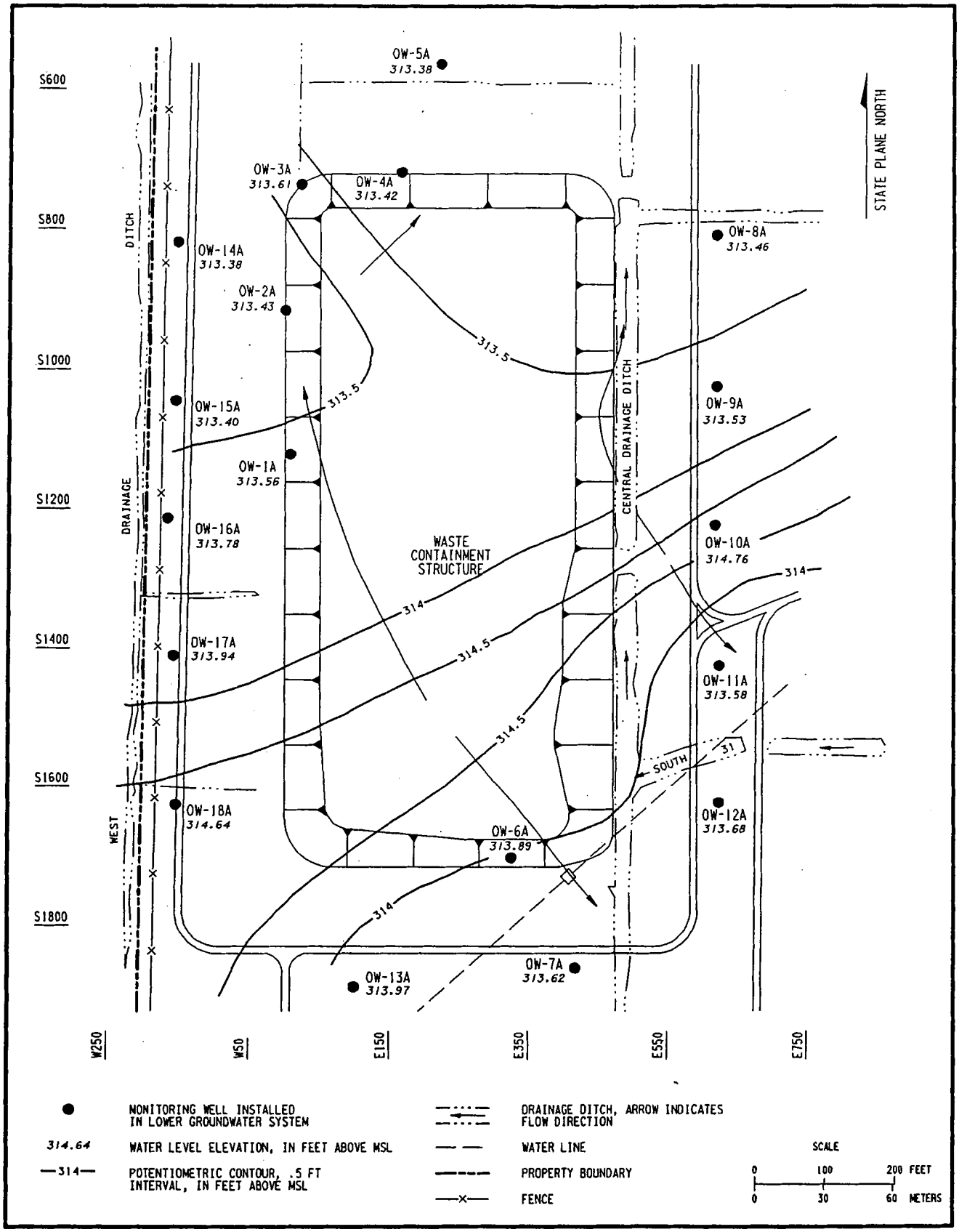
R35 R35F001.DGN

Figure A-4
Potentiometric Map of Upper Groundwater System (11/09/92)



R35 R35F004.DGN

Figure A-5
Potentiometric Map of Lower Groundwater System (1/22/92)



R35 R35F002.DGN

Figure A-6
Potentiometric Map of Lower Groundwater System (11/09/92)

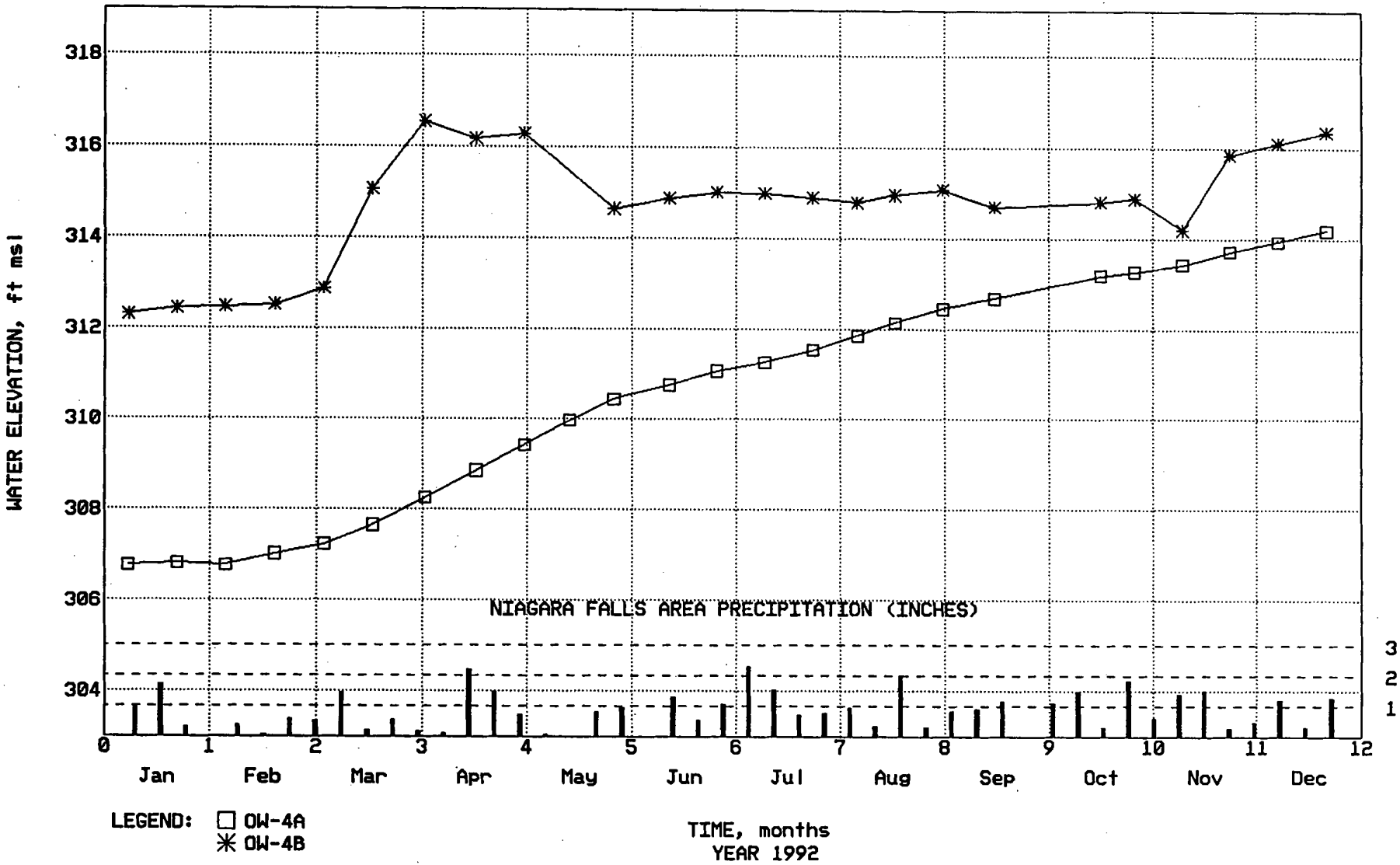


Figure A-7
Hydrograph for Wells OW-4A and OW-4B

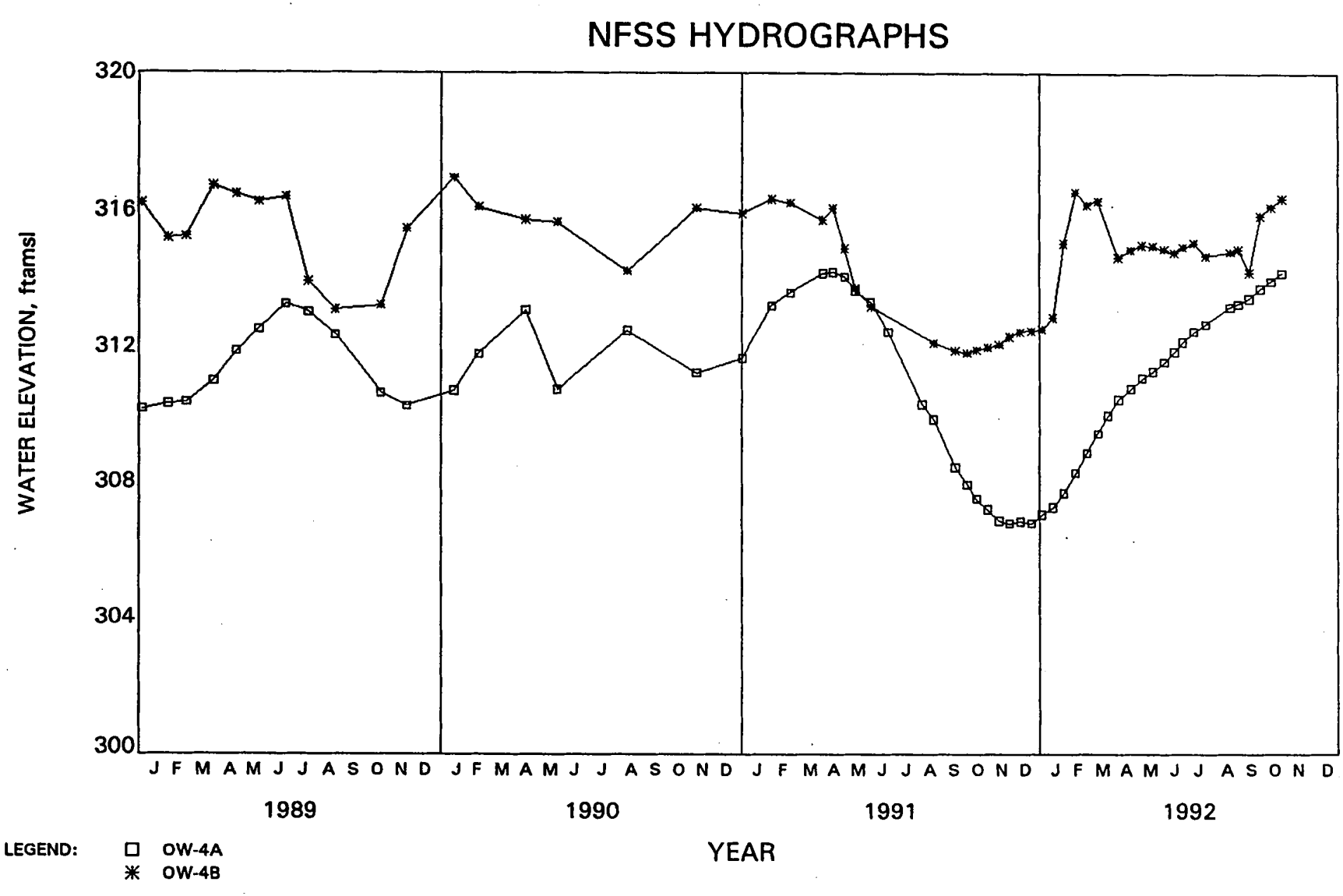


Figure A-8
Four-Year Hydrograph for Wells OW-4A and OW-4B

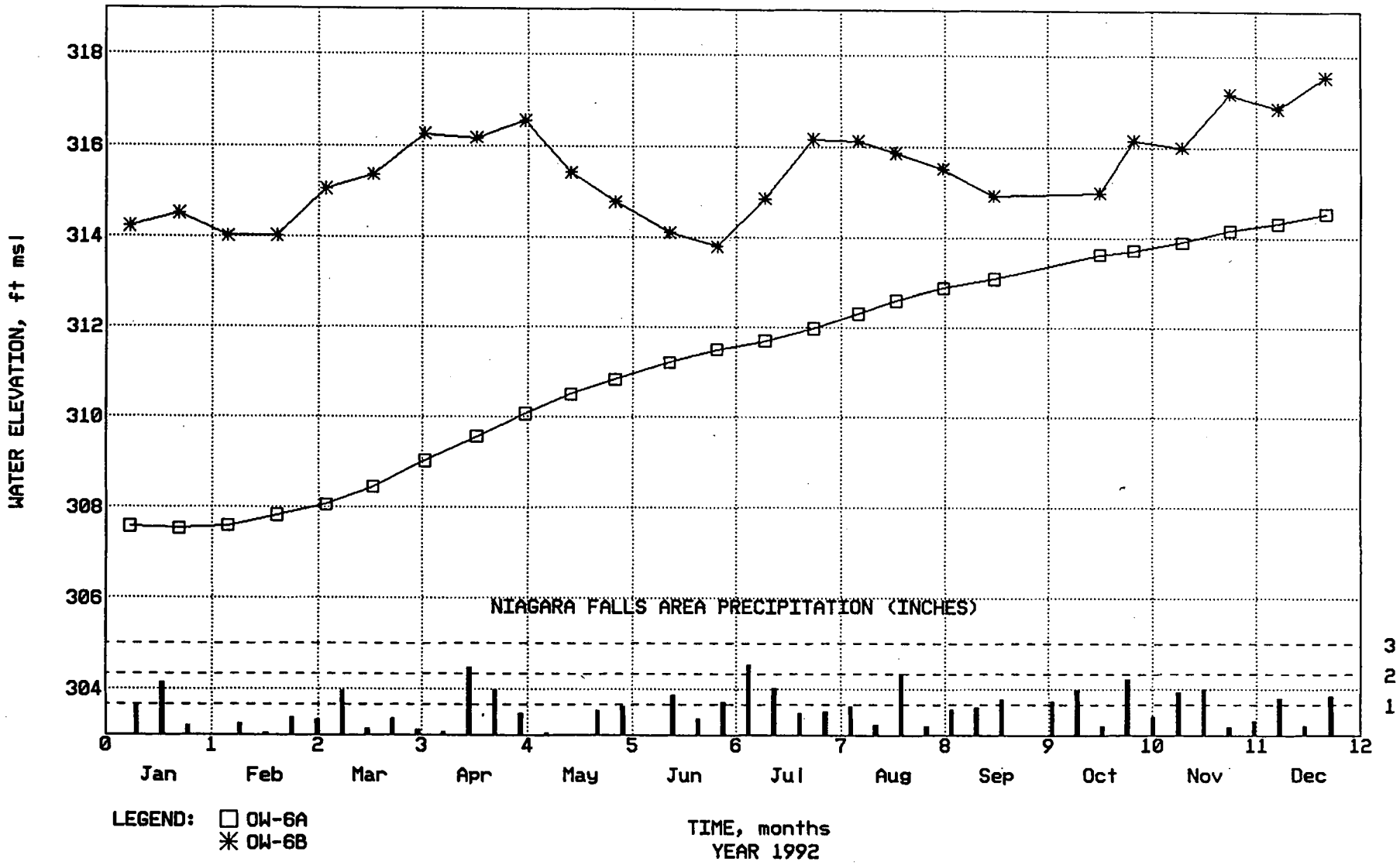


Figure A-9
Hydrograph for Wells OW-6A and OW-6B

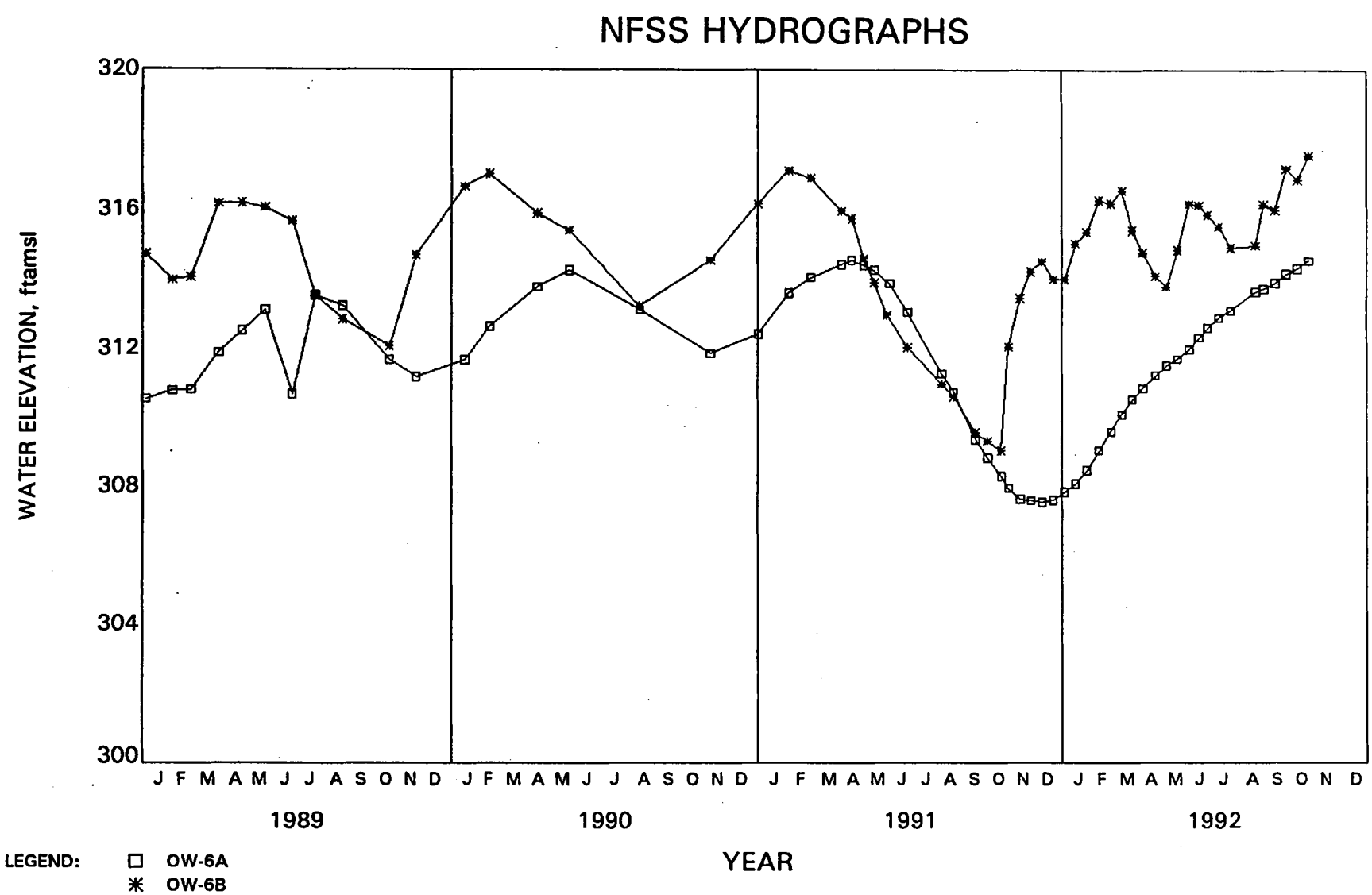


Figure A-10
Four-Year Hydrograph for Wells OW-6A and OW-6B

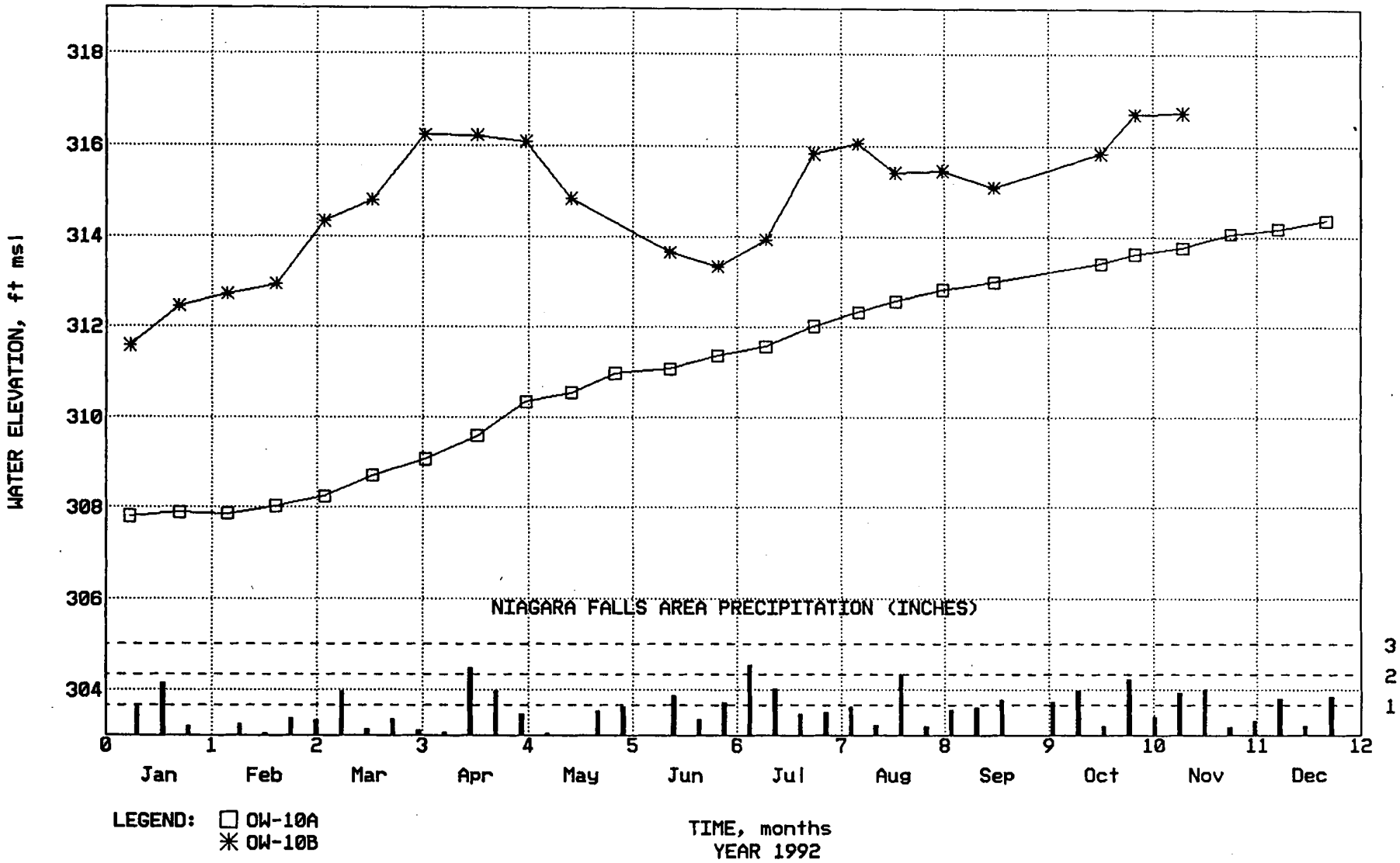


Figure A-11
Hydrograph for Wells OW-10A and OW-10B

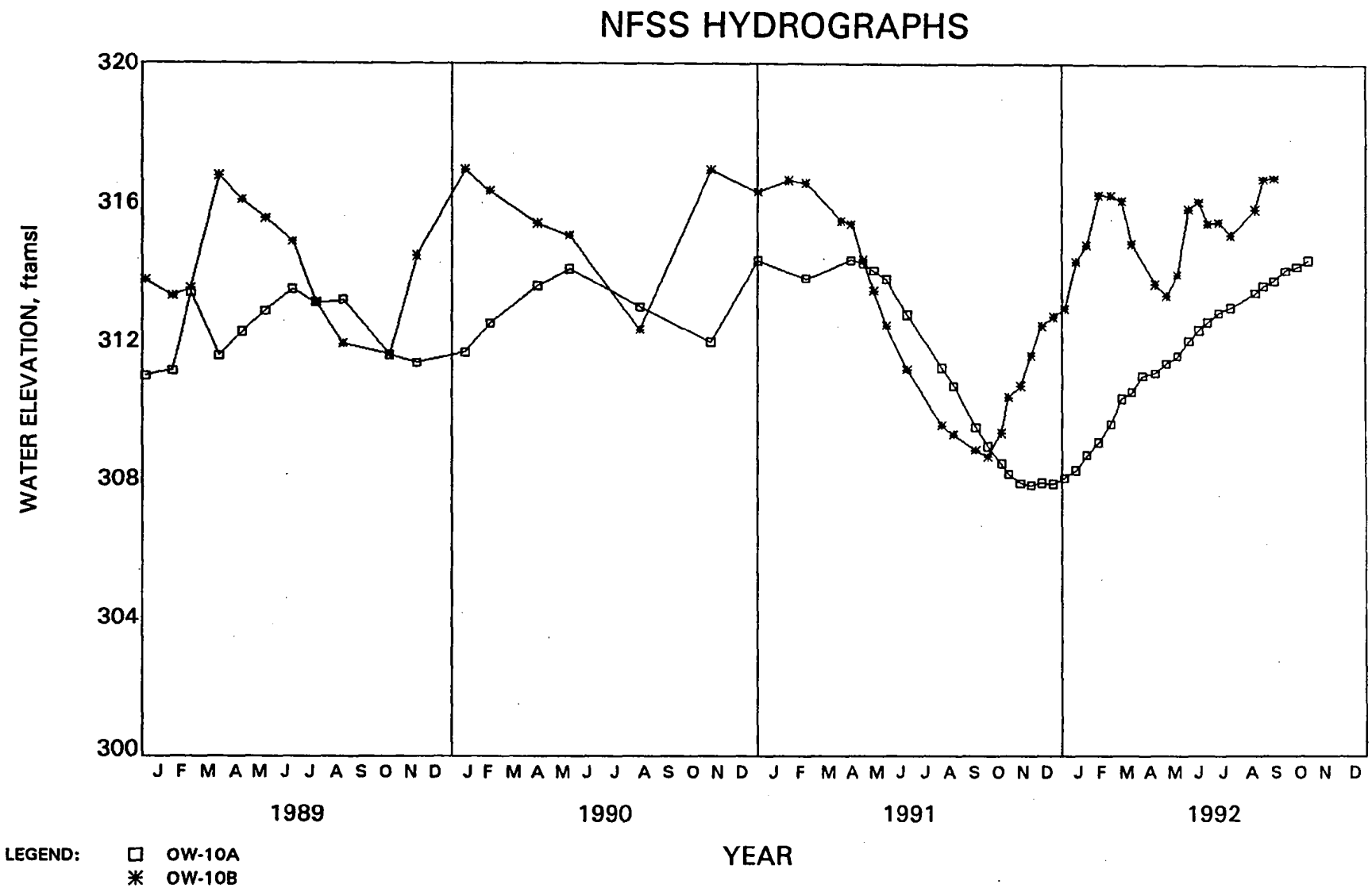


Figure A-12
Four-Year Hydrograph for Wells OW-10A and OW-10B

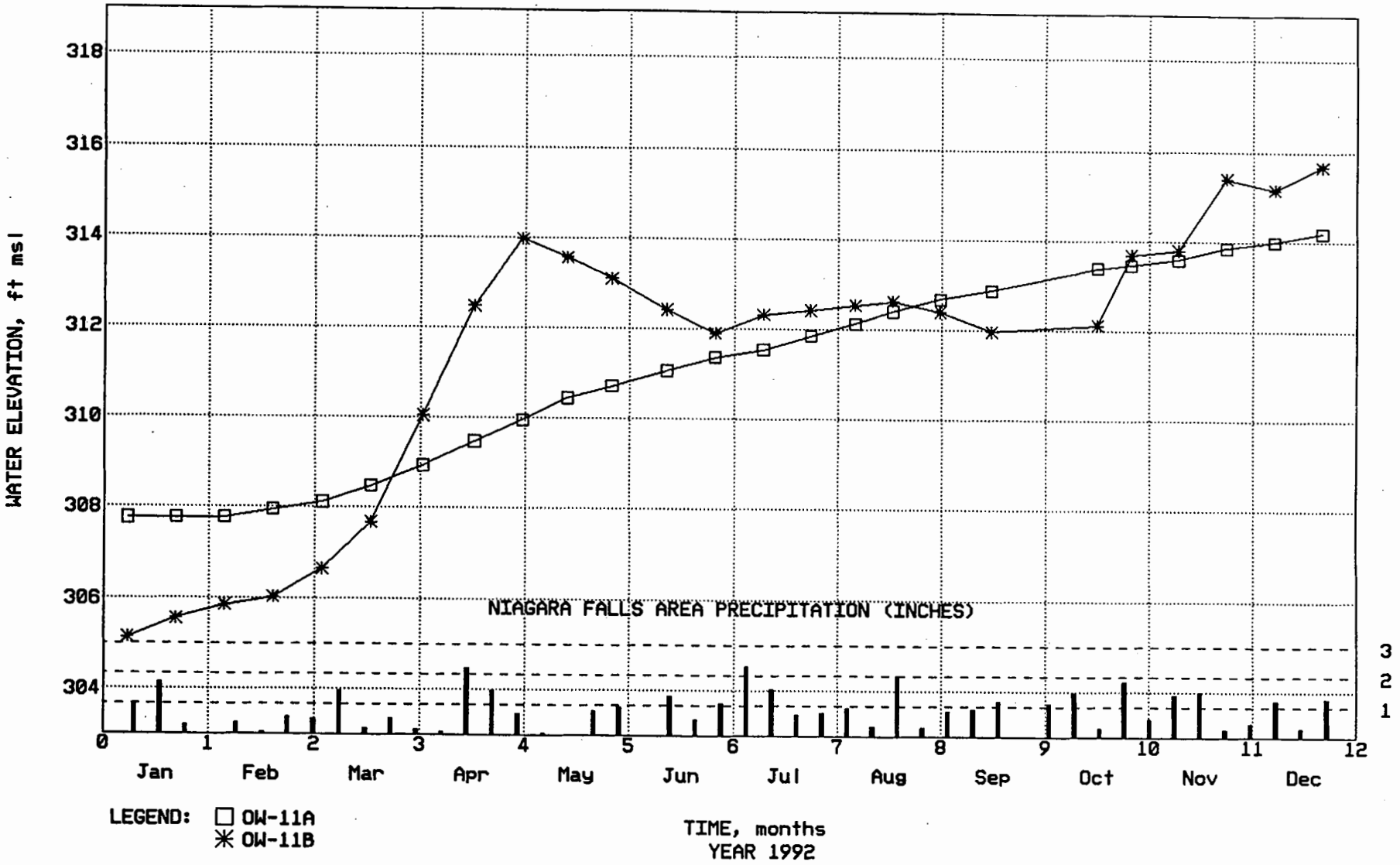


Figure A-13
Hydrograph for Wells OW-11A and OW-11B

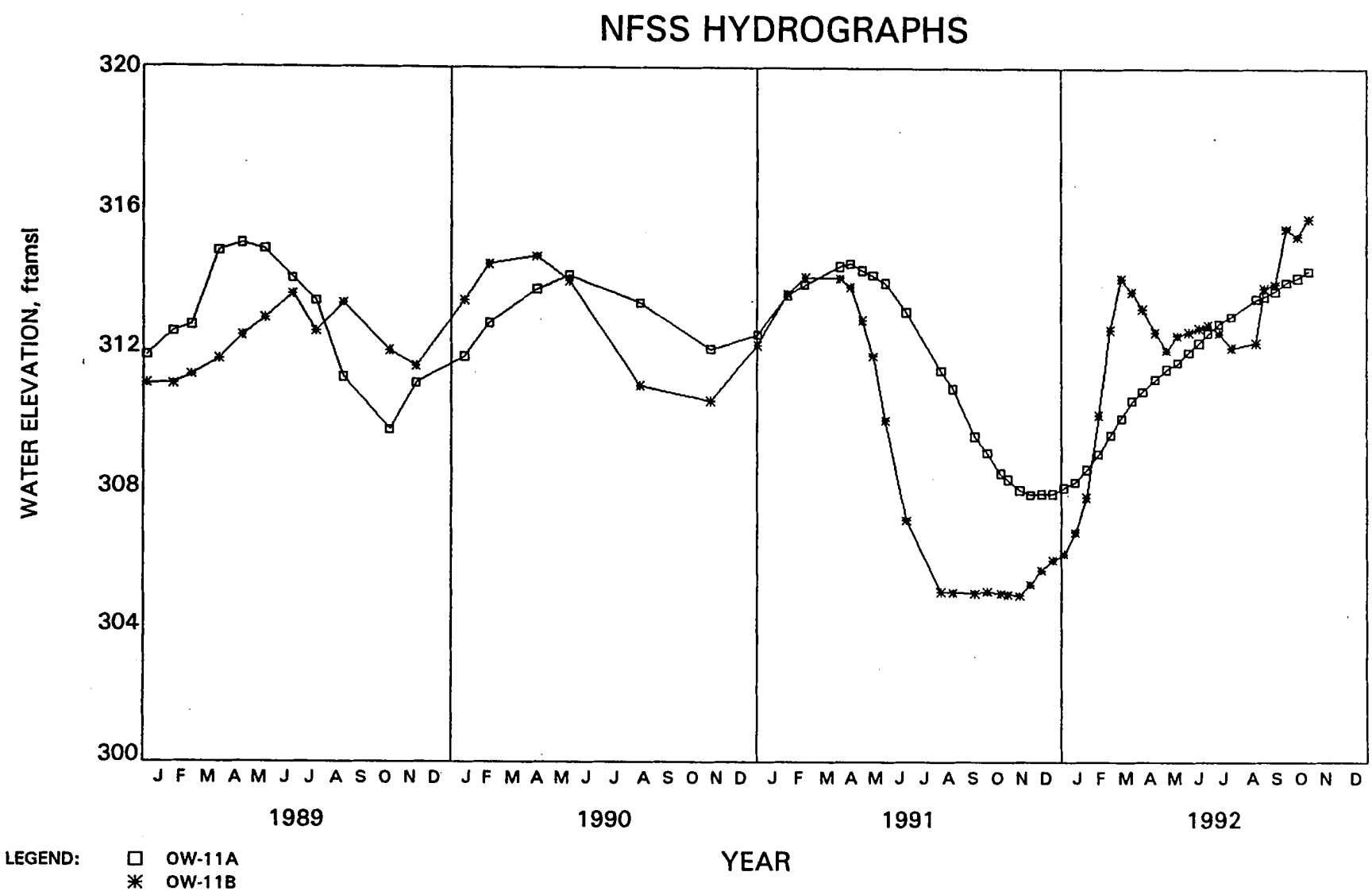


Figure A-14
Four-Year Hydrograph for Wells OW-11A and OW-11B

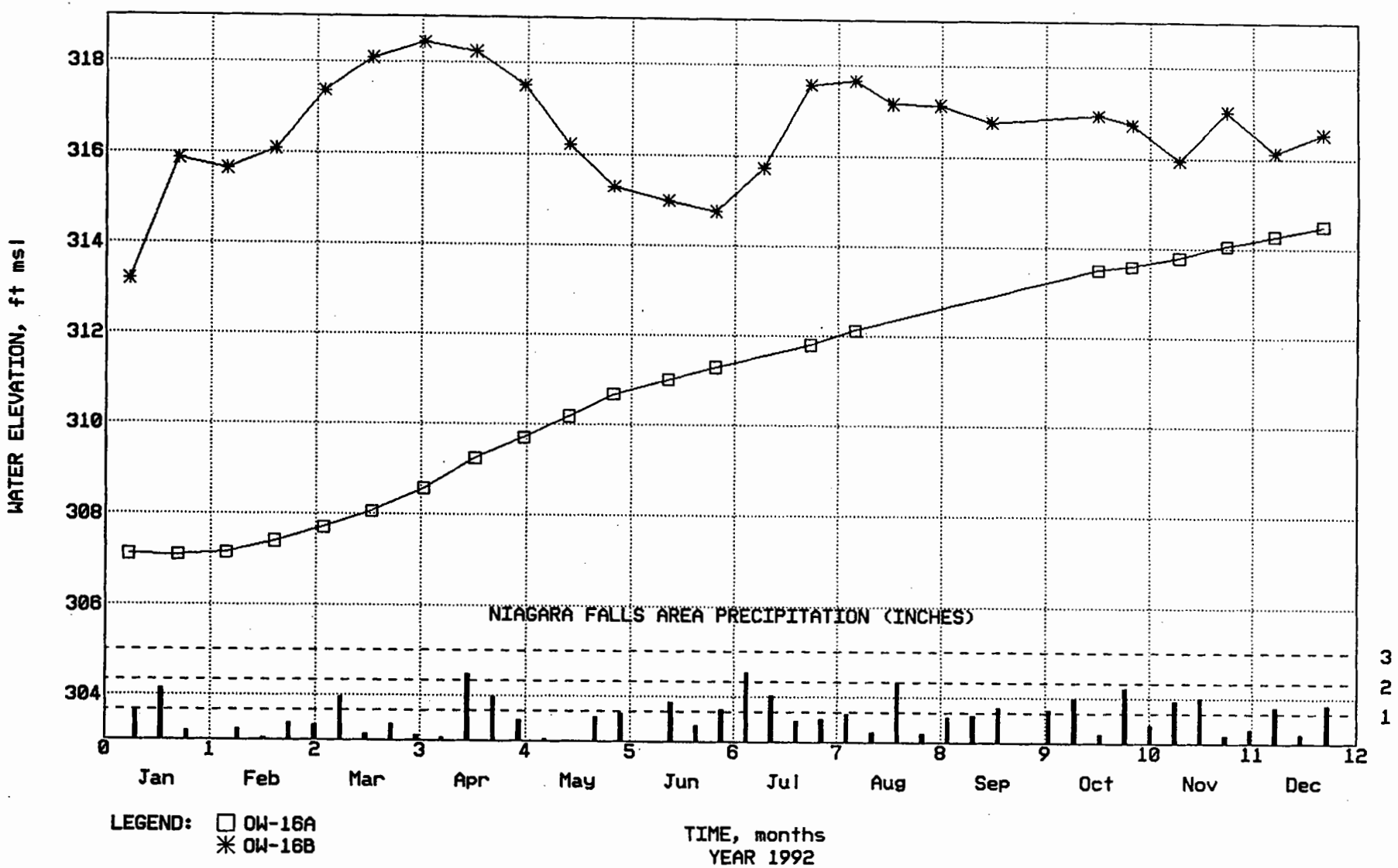


Figure A-15
Hydrograph for Wells OW-16A and OW-16B

TABLES FOR APPENDIX A

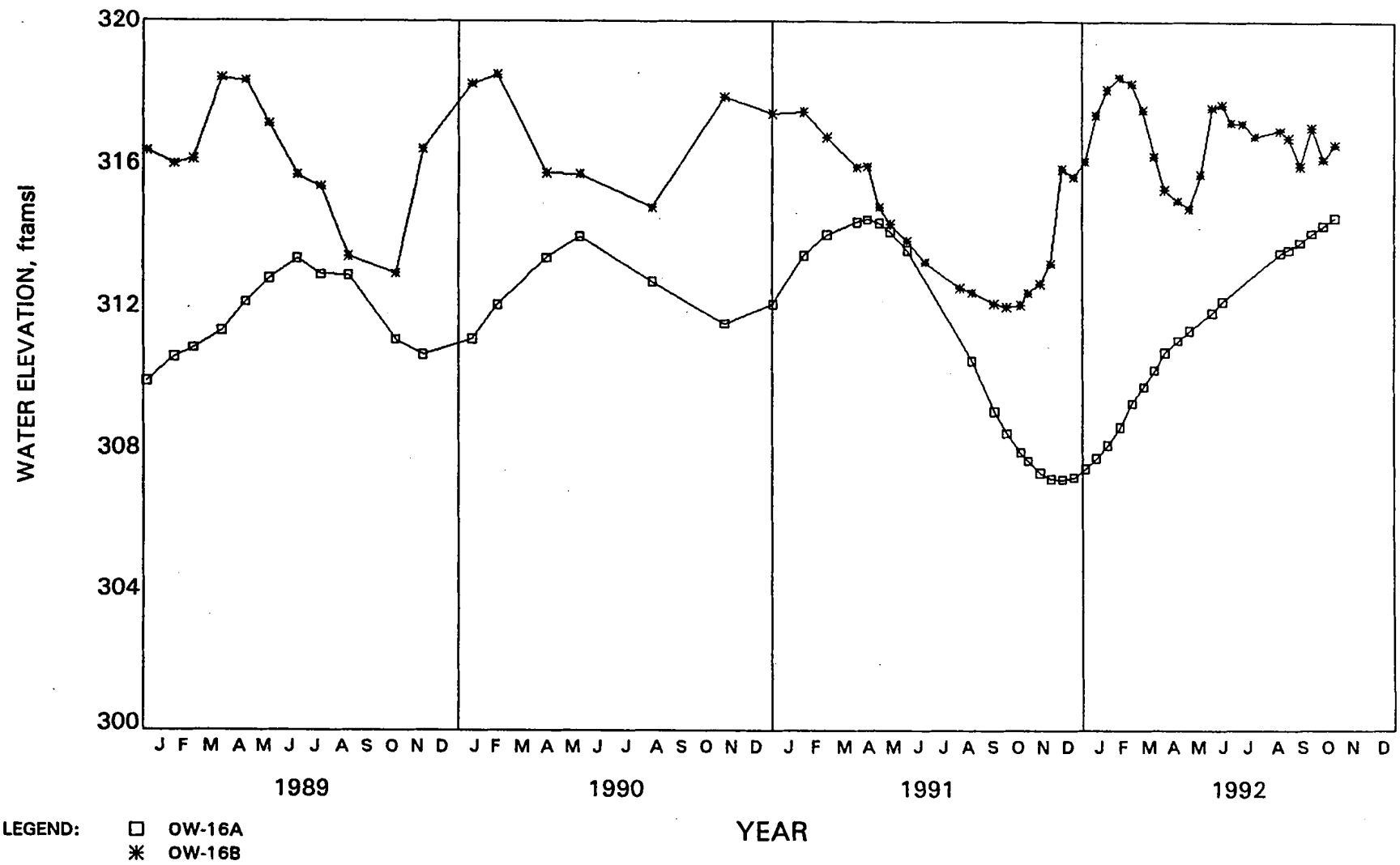


Figure A-16
Four-Year Hydrograph for Wells OW-16A and OW-16B

Table A–1
Niagara Falls Storage Site
Chemical Results – Selected Metals
1991 – 1992
(All units are ug/L)

Page 1 of 7

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
1A	01/09/91 – 1st	15100	45.5	26600	0.2 U	1250	90 U	50 U
	04/05/91 – 2nd	1860	25 U[b]	3270	0.2 U	257	90 U	50 U
	07/16/91 – 3rd	10400	29.4	16800	0.2 U	816	90 U	50 U
	10/11/91 – 4th	956	25 U	1670	0.2 U	181	90 U	50 U
1B	01/08/91 – 1st	345	25 U	622	0.2 U	19.7	90 U	50 U
	04/05/91 – 2nd	4390	25 U	6610	0.2 U	164	90 U	50 U
	07/16/91 – 3rd	3820	25 U	4740	0.2 U	166	90 U	50 U
	10/11/91 – 4th	NS[a]	NS	NS	NS	NS	NS	NS
2A	01/09/91 – 1st	3620	25 U	6480	0.2 U	326	90 U	50 U
	04/05/91 – 2nd	3270	25 U	5870	0.2 U	277	90 U	50 U
	07/16/91 – 3rd	1050	25 U	2270	0.2 U	154	90 U	50 U
	10/11/91 – 4th	756	25 U	1740	0.2 U	155	90 U	50 U
2B	01/08/91 – 1st	200 U	41.7	430	0.2 U	55.8	90 U	50 U
	04/05/91 – 2nd	252	25 U	512	0.2 U	129	90 U	50 U
	07/16/91 – 3rd	200 U	25 U	100 U	0.2 U	144	90 U	50 U
	10/16/91 – 4th	200 U	25 U	311	0.2 U	160	90 U	50 U
3A	01/11/91 – 1st	1500	25 U	2950	0.2 U	255	3 U	50 U
	04/08/91 – 2nd	6120	35.1	11600	0.2 U	610	90 U	50 U
	07/22/91 – 3rd	1440	25 U	2950	0.2 U	221	90 U	50 U
	10/16/91 – 4th	6430	33	12000	0.2 U	652	90 U	50 U
	07/14/92 – 3rd	2080	25 U	3800	0.2 U	185	3 U	50 U
3B	01/08/91 – 1st	296	25 U	1030	0.2 U	42.1	90 U	50 U
	04/08/91 – 2nd	3190	34.5	17400	0.2 U	213	90 U	135
	07/23/91 – 3rd	988	25 U	2960	0.2 U	74.4	90 U	51.9
	10/11/91 – 4th	NS	NS	NS	NS	NS	NS	NS
4A	01/11/91 – 1st	1480	25 U	3120	0.2 U	237	3 U	50 U
	04/04/91 – 2nd	15100	71.9	29700	0.2 U	1460	90 U	50 U
	07/23/91 – 3rd	NS	NS	NS	NS	NS	NS	NS
	10/16/91 – 4th	9960	63.8	18700	0.2 U	963	90 U	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
4B	01/08/91 – 1st	1260	25 U	2420	0.2 U	140	90 U	50 U
	04/04/91 – 2nd	2250	25 U	3940	0.2 U	175	90 U	50 U
	07/16/91 – 3rd	19200	45.9	31800	0.2 U	894	90 U	50 U
	10/16/91 – 4th	1750	25 U	3060	0.2 U	159	90 U	50 U
	10/13/92 – 4th	692	25 U	1410	0.2 U	162	3 U	50 U
5A	01/11/91 – 1st	2590	25 U	4670	0.2 U	233	3 U	50 U
	04/04/91 – 2nd	2190	25 U	3890	0.2 U	173	90 U	50 U
	07/16/91 – 3rd	13800	34.2	26000	0.2 U	1380	90 U	50 U
	10/17/91 – 4th	760	25 U	1560	0.2 U	109	90 U	50 U
	07/14/92 – 3rd	4720	25 U	9320	0.2 U	695	3 U	50 U
5B	01/08/91 – 1st	5660	37.5	9420	0.2 U	331	90 U	50 U
	04/05/91 – 2nd	5790	25.3	9520	0.2 U	271	90 U	50 U
	07/15/91 – 3rd	NS	NS	NS	NS	NS	NS	NS
	10/10/91 – 4th	NS	NS	NS	NS	NS	NS	NS
6A	01/15/91 – 1st	2560	62.8	6680	0.2 U	283	3 U	50 U
	04/08/91 – 2nd	46300	165	81300	0.21	3620	90 U	76.3
	07/15/91 – 3rd	59300	105	99500	0.2 U	3540	90 U	102
	10/10/91 – 4th	14200	85.5	27000	0.2 U	1080	90 U	51.8
6B	01/08/91 – 1st	200 U	25 U	430	0.2 U	70.6	90 U	50 U
	04/08/91 – 2nd	674	25 U	1330	0.2 U	183	90 U	50 U
	07/15/91 – 3rd	2170	26	4170	0.2 U	195	90 U	50 U
	10/11/91 – 4th	738	28.5	1380	0.2 U	77.1	90 U	50 U
7A	01/14/91 – 1st	4150	25 U	7020	0.2 U	338	3 U	50 U
	04/08/91 – 2nd	2560	25 U	4610	0.2 U	288	90 U	50 U
	07/15/91 – 3rd	800	25 U	1590	0.2 U	124	90 U	50 U
	10/09/91 – 4th	17000	58.9	29900	0.2 U	2110	90 U	67
	07/14/92 – 3rd	3780	25 U	6960	0.2 U	446	3 U	50 U
7B	01/09/91 – 1st	2770	25 U	4980	0.2 U	162	90 U	50 U
	04/08/91 – 2nd	12400	54.8	22000	0.2 U	746	90 U	50 U
	07/15/91 – 3rd	4940	25 U	8930	0.2 U	327	90 U	50 U
	10/09/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/17/92 – 3rd	858	25 U	1670	0.2 U	74.6	3 U	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
8A	01/14/91 – 1st	7870	34.1	13500	0.2 U	693	3 U	50 U
	04/02/91 – 2nd	4720	28.7	7600	0.2 U	414	90 U	50 U
	07/12/91 – 3rd	4390	34.5	7730	0.2 U	552	90 U	50 U
	10/08/91 – 4th	6390	37.8	11000	0.2 U	846	90 U	52.6
8B	01/09/91 – 1st	1680	25 U	2740	0.2 U	71.3	90 U	50 U
	04/02/91 – 2nd	1220	25 U	2050	0.2 U	57	90 U	50 U
	07/12/91 – 3rd	5990	29.7	9830	0.2 U	321	90 U	50 U
	10/09/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/16/92 – 3rd	2230	25 U	4210	0.2 U	123	5.2	50.6
9A	01/14/91 – 1st	5090	25 U	8670	0.2 U	651	3 U	50 U
	04/02/91 – 2nd	3390	25 U	6030	0.2 U	499	90 U	50 U
	07/12/91 – 3rd	2740	25 U	4650	0.2 U	450	90 U	50 U
	10/08/91 – 4th	14500	65.5	27600	0.2 U	3360	90 U	72.9
9B	01/09/91 – 1st	6120	27.4	10500	0.2 U	256	90 U	50 U
	04/02/91 – 2nd	11800	38.1	19400	0.2 U	476	90 U	50 U
	07/12/91 – 3rd	3140	25 U	4890	0.2 U	151	90 U	50 U
	10/09/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/16/92 – 3rd	515	25 U	1130	0.2 U	62.2	3 U	54.9
10A	01/14/91 – 1st	1340	26.6	2250	0.2 U	98.7	3.6	50 U
	04/02/91 – 2nd	564	25 U	992	0.2 U	55.6	90 U	50 U
	07/13/91 – 3rd	7020	34.3	11100	0.2 U	370	90 U	50 U
	07/13/91 – 3rd[c]	7380		13000				
	10/08/91 – 4th	6380	40	10700	0.2 U	534	90 U	50 U
10B	01/09/91 – 1st	1530	25 U	3020	0.2 U	225	90 U	50 U
	04/02/91 – 2nd	5020	31.7	9520	0.2 U	581	90 U	50 U
	07/13/91 – 3rd	31400	120	58500	0.2 U	4140	90 U	96
	07/13/91 – 3rd[c]	28900				4830		
	10/08/91 – 4th	17300	73.1	34400	0.2 U	2050	90 U	63
	07/16/92 – 3rd	15900	67.1	31800	0.2 U	1990	7	64.5
11A	01/14/91 – 1st	976	25 U	1800	0.2 U	142	3 U	50 U
	04/03/91 – 2nd	2210	25 U	3820	0.2 U	224	90 U	50 U
	07/13/91 – 3rd	18800	49.2	30800	0.2 U	1740	90 U	65.8
	10/09/91 – 4th	3890	25 U	7070	0.2 U	410	90 U	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
11B	01/09/91 – 1st	6170	38.9	11700	0.2 U	609	90 U	50 U
	04/03/91 – 2nd	2800	25 U	5500	0.2 U	354	90 U	50 U
	07/15/91 – 3rd	5240	26	10200	0.2 U	564	90 U	50 U
	10/08/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/14/92 – 3rd	5280	40.6	10000	0.2 U	430	3.4	50 U
12A	01/15/91 – 1st	606	25 U	3360	0.2 U	189	3 U	50 U
	04/03/91 – 2nd	948	25 U	3680	0.2 U	204	90 U	50 U
	07/15/91 – 3rd	687	25 U	3630	0.2 U	170	90 U	50 U
	10/09/91 – 4th	458	25 U	3000	0.2 U	166	90 U	50 U
12B	01/09/91 – 1st	12400	35.3	19500	0.2 U	443	90 U	50 U
	04/04/91 – 2nd	6050	25 U	9190	0.2 U	212	90 U	50 U
	07/15/91 – 3rd	4990	25 U	7730	0.2 U	221	90 U	50 U
	10/08/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/16/92 – 3rd	484	25 U	1010	0.2 U	62.3	3 U	50 U
13A	01/15/91 – 1st	1100	25 U	2130	0.2 U	104	3 U	50 U
	04/03/91 – 2nd	4460	25 U	8070	0.2 U	318	90 U	50 U
	07/16/91 – 3rd	4890	25 U	8880	0.2 U	327	90 U	50 U
	10/10/91 – 4th	1060	25 U	1980	0.2 U	82.1	90 U	50 U
13B	01/10/91 – 1st	9510	43.1	16800	0.2 U	553	3 U	52.4
	04/03/91 – 2nd	8810	37.2	15800	0.2 U	578	90 U	50 U
	07/15/91 – 3rd	15600	55.4	26700	0.2 U	798	90 U	61.7
	10/11/91 – 4th	26500	79.7	47100	0.2 U	1270	90 U	82.9
	07/14/92 – 3rd	1140	25 U	2400	0.2 U	99.1	3 U	50 U
14A	01/17/91 – 1st	1850	25 U	3510	0.2 U	363	3 U	50 U
	04/09/91 – 2nd	1590	25 U	2920	0.2 U	345	90 U	50 U
	07/17/91 – 3rd	1690	25 U	3060	0.2 U	333	90 U	50 U
	10/16/91 – 4th	1210	25 U	2830	0.2 U	257	90 U	50 U
	07/16/92 – 3rd	4850	25 U	8530	0.2 U	615	3.3	50 U
14B	01/10/91 – 1st	1610	25 U	2770	0.2 U	100	3 U	50 U
	04/09/91 – 2nd	2050	25 U	3460	0.2 U	174	90 U	50 U
	07/17/91 – 3rd	7310	30.7	12300	0.2 U	353	90 U	50 U
	10/16/91 – 4th	29400	96	47900	0.2 U	1170	90 U	58.5
	07/15/92 – 3rd	606	25 U	1420	0.2 U	128	3 U	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
15A	01/15/91 – 1st	12700	33.6	22600	0.2 U	1010	5.5	50 U
	04/09/91 – 2nd	6480	26.1	12500	0.2 U	703	90 U	50 U
	07/17/91 – 3rd	10600	25 U	19500	0.2 U	872	90 U	50 U
	10/15/91 – 4th	1730	25 U	3450	0.2 U	313	90 U	50 U
	07/15/92 – 3rd	8450	31.5	17300	0.2 U	1310	3 U	50 U
15B	01/10/91 – 1st	1110	25 U	1940	0.2 U	60.3	3 U	50 U
	04/09/91 – 2nd	1080	25 U	1880	0.2 U	57.6	90 U	50 U
	07/17/91 – 3rd	24100	74.6	40400	0.2 U	1040	90 U	59.7
	07/17/91 – 3rd[c]	24900		42900				
	10/14/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/16/92 – 3rd	2680	25 U	4720	0.2 U	132	4.1	50 U
16A	01/15/91 – 1st	1030	25 U	2390	0.2 U	131	3 U	50 U
	04/09/91 – 2nd	1790	25 U	4040	0.2 U	244	90 U	50 U
	07/17/91 – 3rd	3250	25 U	6380	0.2 U	300	90 U	50 U
	10/14/91 – 4th	994	25 U	3210	0.2 U	167	90 U	50 U
16B	01/10/91 – 1st	7140	40.2	12300	0.2 U	636	4.9	50 U
	04/09/91 – 2nd	11900	70.4	20300	0.2 U	920	90 U	50 U
	07/17/91 – 3rd	11800	61.5	21300	0.2 U	831	90 U	50 U
	10/14/91 – 4th	35800	214	65400	0.2 U	2280	263	54.8
	07/15/92 – 3rd	200 U	25 U	319	0.2 U	111	3 U	50 U
17A	01/17/91 – 1st	931	25 U	1830	0.2 U	282	3 U	50 U
	04/10/91 – 2nd	6040	39.6	10800	0.2 U	726	90 U	50.8
	04/17/91 – 3rd	17700	33.1	31500	0.2 U	1710	90 U	61.4
	10/14/91 – 4th	18500	54.3	37500	0.2 U	1820	579	50 U
17B	01/10/91 – 1st	213	25 U	403	0.2 U	15.2	3 U	50 U
	04/10/91 – 2nd	4190	25 U	6560	0.2 U	160	90 U	50 U
	07/18/91 – 3rd	2200	25 U	3350	0.2 U	98.5	90 U	50 U
	10/14/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/15/92 – 3rd	200 U	25 U	157	0.2 U	20.4	3 U	50 U
18A	01/17/91 – 1st	7860	36.6	14000	0.2 U	633	7.3	50 U
	04/10/91 – 2nd	1900	25 U	3160	0.2 U	252	90 U	50 U
	07/22/91 – 3rd	727	25 U	1330	0.2 U	172	90 U	50 U
	10/14/91 – 4th	1050	25 U	2280	0.2 U	226	905	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
18B	01/10/91 – 1st	952	25 U	1930	0.2 U	94.1	3 U	50 U
	04/10/91 – 2nd	21700	83.4	37900	0.2 U	1300	90 U	79
	07/19/91 – 3rd	10300	46.3	16700	0.2 U	558	90 U	67.6
	10/14/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	07/15/92 – 3rd	1430	25 U	3040	0.2 U	110	3 U	60.5
19D	01/22/91 – 1st	216	25 U	484	0.2 U	316	3 U	50 U
	04/11/91 – 2nd	200 U	25 U	566	0.2 U	338	90 U	50 U
	07/24/91 – 3rd	40800	61.6	61100	0.2 U	2160	90 U	85.9
	07/24/91 – 3rd[c]	50900		66700				
	10/18/91 – 4th	1040	25 U	1780	0.2 U	325	90 U	50 U
20D	01/22/91 – 1st	954	25 U	1790	0.2 U	337	3 U	50 U
	04/11/91 – 2nd	583	25 U	1070	0.2 U	283	90 U	50 U
	07/23/91 – 3rd	361	25 U	601	0.2 U	220	90 U	50 U
	10/18/91 – 4th	1280	25 U	2070	0.2 U	379	90 U	50 U
20S	01/22/91 – 1st	490	25 U	939	0.2 U	128	3 U	50 U
	04/11/91 – 2nd	5370	25 U	9000	0.2 U	264	90 U	50 U
	07/23/91 – 3rd	7610	25 U	11500	0.2 U	350	90 U	50 U
	10/19/91 – 4th	NS	NS	NS	NS	NS	NS	NS
	10/13/92 – 4th	200 U	25 U	316	0.2 U	41.6	3 U	50 U
BH5	01/23/91 – 1st	200 U	25 U	129	0.2 U	15 U	3 U	50 U
	04/11/91 – 2nd	200 U	25 U	133	0.2 U	15 U	90 U	50 U
	07/22/91 – 3rd	1040	25 U	106	0.2 U	15 U	19.9	50 U
	10/15/91 – 4th	465	25 U	160	0.2 U	15 U	90 U	50 U
BH48	01/22/91 – 1st	24300	53.6	48100	0.2 U	3550	17.5	71.2
	04/11/91 – 2nd	8600	25 U	17000	0.2 U	1590	90 U	50 U
	07/24/91 – 3rd	6890	25.2	11600	0.2 U	1150	90 U	58.9
	10/17/91 – 4th	9930	33.6	20000	0.2 U	2150	90 U	62.5
BH49	01/17/91 – 1st	6450	25 U	11000	0.2 U	408	7.3	50 U
	04/10/91 – 2nd	1380	25 U	2330	0.2 U	117	90 U	50 U
	07/19/91 – 3rd	782	25 U	1380	0.2 U	74.5	90 U	50 U
	10/17/91 – 4th	1020	25 U	1840	0.2 U	106	90 U	50 U

Table A–1
(continued)

WELL ID	DATE – QTR	Al Total	Cu	Fe Total	Hg	Mn Total	Pb	V
BH49A	01/22/91 – 1st	481	25 U	1230	0.2 U	193	3 U	50 U
	04/10/91 – 2nd	6830	25.5	12200	0.2 U	473	90 U	50 U
	07/22/91 – 3rd	35600	123	63600	0.2 U	1650	90 U	72.9
	07/22/91 – 3rd[c]	39000		72500				
	10/17/91 – 4th	31600	114	56800	0.2 U	1860	90 U	76
BH61	01/21/91 – 1st	580	25 U	1980	0.2 U	230	3 U	50 U
	04/11/91 – 2nd	1850	25 U	4250	0.2 U	295	90 U	50 U
	07/19/91 – 3rd	1850	25 U	3390	0.2 U	224	90 U	50 U
	10/17/91 – 4th	566	25 U	1700	0.2 U	166	90 U	50 U
A42	01/21/91 – 1st	200 U	25 U	278	0.2 U	452	3 U	50 U
	04/05/91 – 2nd	248	25 U	510	0.2 U	452	90 U	50 U
	07/16/91 – 3rd	200 U	25 U	279	0.2 U	518	90 U	50 U
	10/11/91 – 4th	200 U	25 U	138	0.2 U	1370	90 U	50 U
	07/17/92 – 3rd	2010	25 U	3490	0.2 U	673	3.6	50 U
A50	01/22/91 – 1st	200 U	25 U	445	0.2 U	85.7	3 U	50 U
	04/10/91 – 2nd	3070	25 U	4880	0.2 U	244	90 U	50 U
	07/23/91 – 3rd	6210	26.5	10500	0.2 U	522	90 U	50 U
	10/11/91 – 4th	NS	NS	NS	NS	NS	NS	NS
A52	01/21/91 – 1st	1480	82.2	3090	0.2 U	1040	3.4	50 U
	04/04/91 – 2nd	9170	81.9	15400	0.2 U	1260	90 U	50 U
	07/23/91 – 3rd	9960	89.8	16200	0.2 U	1270	90 U	50 U
	10/21/91 – 4th	15500	96.7	26800	0.2 U	1650	90 U	52.6

[a] NS= Not Sampled.
[b] U= The analyte was not detected. The minimum quantitation limit was reported.
[c] Specific analytes reanalyzed.

Table A–2
Niagara Falls Storage Site
Chemical Results – Radionuclides

		(pCi/L)		(ug/L)	
WELL NO.	DATE – QTR	RA–226 Total	SIGMA ERROR	TOTAL URANIUM	SIGMA ERROR
1A	01/08/91 – 1st	0.5	0.1	<5	
	04/05/91 – 2nd	0.23	0.06	<5	
	07/16/91 – 3rd	0.44	0.08	<5	
	10/11/91 – 4th	0.8	0.4	1.22	
1B	01/08/91 – 1st	NS		NS	
	04/05/91 – 2nd	0.39	0.06	<5	
	07/16/91 – 3rd	0.4	0.06	<5	
	10/11/91 – 4th	NS	--	NS	
2A	01/08/91 – 1st	0.7	0.1	16	
	04/05/91 – 2nd	0.4	0.07	<5	
	07/16/91 – 3rd	0.39	0.08	5	
	10/11/91 – 4th	<0.3	0.2		
2B	01/08/91 – 1st	0.1	0.1	12	
	04/05/91 – 2nd	0.09	0.05	10	
	07/16/91 – 3rd	0.1	0.06	16	
	10/16/91 – 4th	0.7	0.3		
3A	01/08/91 – 1st	0.3	0.1	9	
	04/08/91 – 2nd	0.35	0.05	6	
	07/22/91 – 3rd	0.26	0.08	6	
	10/16/91 – 4th	0.7	0.5		
	07/14/92 – 3rd	0.21	0.17	9.74	0.99
3B	01/08/91 – 1st	0.2	0.1	21	
	04/08/91 – 2nd	0.4	0.07	22	
	07/23/91 – 3rd	0.15	0.06	19	
	10/11/91 – 4th	NS	--		
4A	01/08/91 – 1st	0.2	0.1	<5	
	04/04/91 – 2nd	0.66	0.07	<5	
	07/23/91 – 3rd	NS	--		
	10/16/91 – 4th	0.2	0.2		
4B	01/08/91 – 1st	0.2	0.1	6	
	04/04/91 – 2nd	0.19	0.07	8	
	07/16/91 – 3rd	0.62	0.12	12	
	10/16/91 – 4th	3.1	1		
	10/13/92 – 4th	0.24	0.2	25.9	3
5A	01/08/91 – 1st	0.3	0.1	<5	
	04/04/91 – 2nd	0.21	0.05	10	
	07/16/91 – 3rd	0.52	0.11	<5	
	10/17/91 – 4th	0.7	0.5		
	07/14/92 – 3rd	0.33	0.32	2.36	0.24
5B	01/08/91 – 1st	NS			
	04/04/91 – 2nd	0.28	0.05	15	
	07/19/91 – 3rd	NS	--		
	10/10/91 – 4th	NS	--		

Table A-2
(continued)

Page 2 of 6

WELL NO.	DATE – QTR	(pCi/L) RA-226 Total	SIGMA ERROR	(ug/L) TOTAL URANIUM	SIGMA ERROR
6A	01/08/91 – 1st	0.2	0.1	<5	
	04/04/91 – 2nd	0.58	0.05	13	
	07/15/91 – 3rd	0.467	0.094	7	
	10/10/91 – 4th	1.7	1.2		
6B	01/08/91 – 1st	0.1	0.1	44	
	04/04/91 – 2nd	0.28	0.03	9	
	07/15/91 – 3rd	0.197	0.084	28	
	10/11/91 – 4th	<0.1	--		
7A	01/14/91 – 1st	0.3	0.1	<5	
	04/04/91 – 2nd	0.22	0.03	9	
	07/15/91 – 3rd	<0.13	--	7	
	10/09/91 – 4th	2.1	1.2	4.21	.44
	07/14/92 – 3rd	0.45	0.37	2.45	0.25
7B	01/09/91 – 1st	0.3	0.1	14	
	04/08/91 – 2nd	0.39	0.05	17	
	07/15/91 – 3rd	0.25	0.11	19	
	10/09/91 – 4th	NS	--		
	07/17/92 – 3rd	0.85	0.43	2.46	0.25
8A	01/14/91 – 1st	0.8	0.1	<5	
	04/04/91 – 2nd	0.58	0.05	17	
	07/12/91 – 3rd	0.87	0.11	6	
	10/08/91 – 4th	1.4	0.9		
8B	01/09/91 – 1st	<0.1			
	04/04/91 – 2nd	0.11	0.04		
	07/12/91 – 3rd	0.25	0.1	39	
	10/09/91 – 4th	NS	--		
9A	01/14/91 – 1st	0.5	0.1		
	04/04/91 – 2nd	0.35	0.04		
	07/12/91 – 3rd	0.31	0.1	7	
	10/08/91 – 4th	2.3	1.3		
9B	01/09/91 – 1st	0.3	0.1		
	04/04/91 – 2nd	0.31	0.04	32	
	07/12/91 – 3rd	<0.13		30	
	10/09/91 – 4th	NS	--		
10A	01/14/91 – 1st	0.2	0.1		
	04/04/91 – 2nd	0.18	0.04		
	07/13/91 – 3rd	0.29	0.11	15	
	10/08/91 – 4th	1.5	1		
10B	01/09/91 – 1st	<0.1			
	04/03/91 – 2nd	0.25	0.05		
	07/13/91 – 3rd	1.66	0.16	41	
	10/08/91 – 4th	0.6	0.8		

Table A–2
(continued)

Page 3 of 6

WELL NO.	DATE – QTR	(pCi/L) RA–226 Total	SIGMA ERROR	(ug/L) TOTAL URANIUM	SIGMA ERROR
11A	01/14/91 – 1st	0.2	0.1		
	04/03/91 – 2nd	<0.05			
	07/13/91 – 3rd	0.57	0.11	10	
	10/09/91 – 4th	4.1	2.5		
11B	01/09/91 – 1st	0.2	0.1		
	04/03/91 – 2nd	<0.05			
	07/15/91 – 3rd	0.3	0.08	35	
	10/09/91 – 4th	NS	--		
	07/14/92 – 3rd	0.28	0.3		5.38
12A	01/15/91 – 1st	0.3	0.1		
	04/03/91 – 2nd	<0.05			
	07/15/91 – 3rd	0.41	0.09	11	
	10/09/91 – 4th	<0.1	--		
12B	01/09/91 – 1st	0.4	0.1		
	04/04/91 – 2nd	<0.05			
	07/15/91 – 3rd	NS	--		
	10/09/91 – 4th	NS	--		
13A	01/15/91 – 1st	0.4	0.1		
	04/03/91 – 2nd	<0.06			
	07/16/91 – 3rd	0.45	0.09	20	
	10/10/91 – 4th	0.4		3.72	
13B	01/10/91 – 1st	0.8	0.1		
	04/03/91 – 2nd	<0.06			
	07/15/91 – 3rd	0.44	0.09	25	
	10/11/91 – 4th	0.7	0.8		
	07/14/92 – 3rd	0.21	0.19		3.32
14A	01/16/91 – 1st	0.5	0.1		
	04/09/91 – 2nd	<0.06			
	07/17/91 – 3rd	0.27	0.08	<5	
	10/16/91 – 4th	<0.5	--		
14B	01/10/91 – 1st	0.2	0.1		
	04/09/91 – 2nd	0.09			
	07/17/91 – 3rd	0.72	0.1	19	
	10/16/91 – 4th	2.2	1		
	07/15/92 – 3rd	0.24	0.19		0.82
15A	01/15/91 – 1st	1.3	0.1		
	04/09/91 – 2nd	<0.1			
	07/17/91 – 3rd	0.53	0.1	6	
	10/15/91 – 4th	1	0.5		
	07/15/92 – 3rd	1.04	0.67		0.27

Table A–2
(continued)

Page 4 of 6

WELL NO.	DATE – QTR	(pCi/L) RA–226 Total	SIGMA ERROR	(ug/L) TOTAL URANIUM	SIGMA ERROR
15B	01/10/91 – 1st	0.2	0.1		
	04/09/91 – 2nd	<0.05			
	07/17/91 – 3rd	0.53	0.1	18	
	10/14/91 – 4th	NS	--		
16A	01/15/91 – 1st	0.9	0.1		
	04/09/91 – 2nd	<0.04			
	07/17/91 – 3rd	0.53	0.09	6	
	10/14/91 – 4th	0.4	0.3		
16B	01/10/91 – 1st	0.5	0.1		
	04/09/91 – 2nd	0.15	0.06		
	07/17/91 – 3rd	0.79	0.11	<5	
	10/14/91 – 4th	2.4	1.2		
	07/15/92 – 3rd	1.61	0.55		0.7
17A	01/17/91 – 1st	0.2	0.1		
	04/10/91 – 2nd	0.53	0.05		
	07/17/91 – 3rd	0.32	0.08	33	
	10/14/91 – 4th	3.6	1.6		
17B	01/10/91 – 1st	0.4	0.1		
	04/10/91 – 2nd	0.37	0.05		
	07/18/91 – 3rd	0.12	0.07	<5	
	10/14/91 – 4th	<0.2	--		
18A	01/17/91 – 1st	0.6	0.1		
	04/10/91 – 2nd	0.39	0.05		
	07/22/91 – 3rd	0.19	0.07	7	
	10/14/91 – 4th	<0.4	--		
18B	01/10/91 – 1st	0.4	0.1		
	04/10/91 – 2nd	0.79	0.08		
	07/18/91 – 3rd	0.45	0.1	17	
	10/14/91 – 4th	NS	--		
19D	01/22/91 – 1st	0.3	0.1		
	04/11/91 – 2nd	0.39	0.05		
	07/24/91 – 3rd	<0.07		<5	
	10/18/91 – 4th	0.7	0.5		
20D	01/22/91 – 1st	0.5	0.1		
	04/11/91 – 2nd	0.62	0.05		
	07/23/91 – 3rd	0.67	0.09	<5	
	10/18/91 – 4th	1.1	0.7		
20S	01/22/91 – 1st	0.3	0.1		
	04/11/91 – 2nd	0.49	0.05		
	07/23/91 – 3rd	0.44	0.08	6	
	10/19/91 – 4th	NS	--		
	10/13/92 – 4th	0.31	0.23		1.4

Table A-2
(continued)

Page 5 of 6

WELL NO.	DATE – QTR	(pCi/L) RA-226 Total	SIGMA ERROR	(ug/L) TOTAL URANIUM	SIGMA ERROR
BH-5	01/23/91 – 1st	0.2	0.1		
	04/11/91 – 2nd	0.44	0.05		
	07/22/91 – 3rd	0.43	0.09	<5	
	10/15/91 – 4th	0.2	0.2		
BH-48	01/22/91 – 1st	2.5	0.1		
	04/11/91 – 2nd	1.08	0.07		
	07/24/91 – 3rd	1.01	0.09	<5	
	10/17/91 – 4th	2.8	1.3		
BH-49	01/17/91 – 1st	0.6	0.1		
	04/10/91 – 2nd	0.49	0.07		
	07/19/91 – 3rd	0.39	0.08	27	
	10/17/91 – 4th	0.9	0.4		
BH-49A	01/22/91 – 1st	0.7	0.1		
	04/10/91 – 2nd	0.47	0.05		
	07/22/91 – 3rd	3.08	0.21	20	
	10/17/91 – 4th	0.5	0.4		
BH-61	01/21/91 – 1st	0.3	0.1		
	04/11/91 – 2nd	0.45	0.05		
	07/19/91 – 3rd	0.69	0.12	<5	
	10/17/91 – 4th	0.2	0.2		
A-50	01/22/91 – 1st	0.2	0.1	9	
	04/10/91 – 2nd	0.42	0.04	15	
	07/23/91 – 3rd	0.51	0.12	6	
	10/11/91 – 4th	NS	--		
A-52	01/21/91 – 1st	0.7	0.1	22	
	04/04/91 – 2nd	0.51	0.06	28	
	07/23/91 – 3rd	0.48	0.11	19	
	10/21/91 – 4th				

Table A–2
(continued)

WELL NO.	DATE – QTR	RA–226 Total	SIGMA ERROR	RA–226 Dissolved	SIGMA ERROR	FILTERED URANIUM	SIGMA ERROR	TOTAL URANIUM	SIGMA ERROR	U – 234 TOTAL	SIGMA ERROR	U – 235 TOTAL	SIGMA ERROR
A–42	01/21/91 – 1st	0.8	0.1	0.4	0.1	70		93					
	04/05/91 – 2nd	0.32	0.05	0.22	0.05	73		83					
	07/16/91 – 3rd	0.15	0.06	0.21	0.09	58		70					
	10/11/91 – 4th												
	07/17/92 – 3rd	0.94	0.42					85.37	9.83				
	10/12/92 – 4th	0.49	0.38	0.45	0.39					50.1	17	1.2	0.82

	U – 238 TOTAL	SIGMA ERROR	U – 234 DISS	SIGMA ERROR	U – 235 DISS	SIGMA ERROR	U – 238 DISS	SIGMA ERROR
01/21/91 – 1st								
04/05/91 – 2nd								
07/16/91 – 3rd								
10/11/91 – 4th								
07/17/92 – 3rd								
10/12/92 – 4th	42.3	14.4	60.7	21.7	1.4	0.96	49.6	17.8

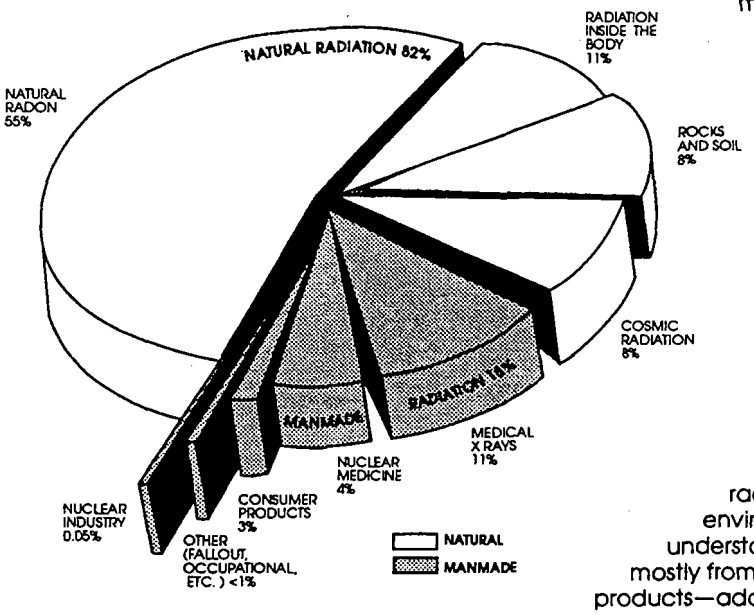
APPENDIX B Radiation in the Environment

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.

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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
McAipe, 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 ..... 100.0 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: 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.

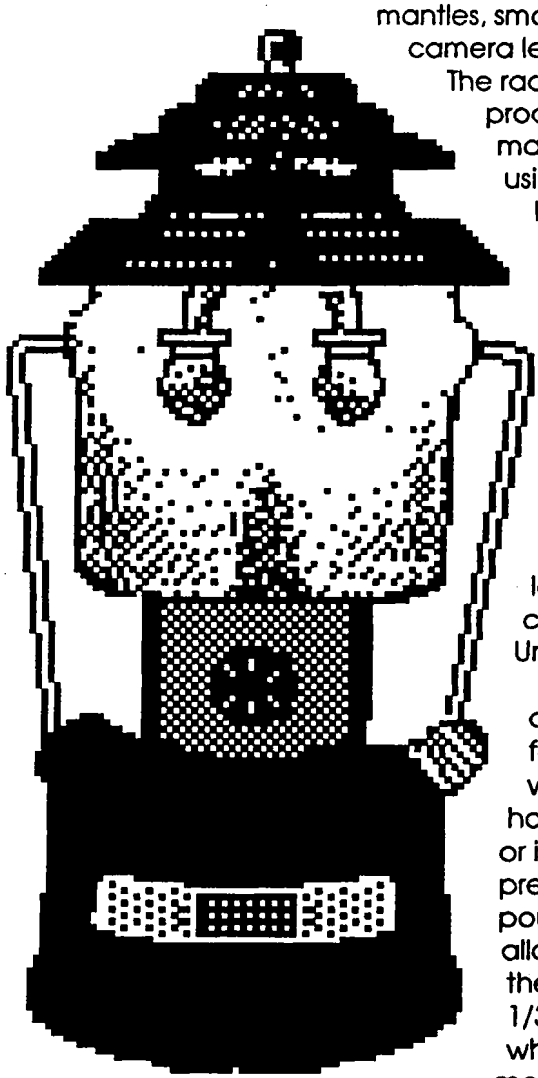
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco	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.

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.

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APPENDIX C Parameters for Analysis

Table C-1

Parameters for Analysis at NFSS, 1992

Medium[a]	Parameter	Technique
Groundwater	Total uranium	Kinetic phosphorescence analysis
	Radium-226	Alpha spectrometry
	Total organic halides	Microcoulimetry
	Total organic carbon	Wet ultraviolet-aided persulfate oxidation
	Total metals: aluminum, copper, iron, manganese, vanadium	Inductively coupled plasma atomic emission spectrophotometry
	Mercury, lead	Atomic absorption/ Spectrophotometry
	Specific conductivity	Electrometric
	pH	Electrometric
Surface Water	Total uranium	Kinetic phosphorescence analysis
	Radium-226	Alpha spectrometry
Sediment	Total uranium	Kinetic phosphorescence analysis
	Radium-226	Gamma spectrometry
Air	Radon-222	Track-etch
	External gamma radiation	Thermoluminescence

[a]Air samples are cumulative; all others are grab samples.

Table C-2

Laboratory Detection Limits for Chemical Analyses at NFSS

Compound	Detection Limit (μg/L)
Aluminum	200
Copper	25
Iron	100
Lead	3.0
Manganese	15
Mercury	0.2
Vanadium	50
Total organic carbon	0.5 mg/L
Total organic halides	5.0 μg/L

APPENDIX D Methodology for Statistical Analysis of Data

METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

Treatment of "Less than Zero" Values

Beginning with the third quarter 1992 environmental monitoring, less-than-zero radiological values have been reported when they occur. This practice will be continued for all future environmental monitoring, which will result in more accurate statistical analysis. For 1992 this results in both negative values and values reported as less than a detection limit being used in the site environmental report. The negative values are used as reported in the statistical calculations. For values that are reported as less than the detection limit, the detection limit is used in the statistical calculations.

Treatment of Rounding and Significant Figures

When performing calculations, the answer can be no more accurate than the least accurate number in the data (i.e., the number with the least number of significant digits). Regardless of whether a number contains a decimal, the number of significant digits is the total number of digits starting with the left-most, non-zero digit and ending with the right-most digit (even if it is a zero). For example, 231, 230, and 23.0 each have three significant digits, while 0.05 and 5 each have one significant digit. Rounding is performed on final calculation results only, not on interim results.

Treatment of Annual Average Concentrations

Annual average concentrations are calculated by adding the results for the year and dividing by the number of quarters for which data have been taken and reported (usually four). An example follows.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter			
	1	2	3	4
1	13	7	12	5

First, results reported for the year are added.

$13 + 7 + 12 + 5 = 37$

Next, the sum of all results is divided by the number of quarters for which data were taken and reported. In this example there were data for all four quarters.

$37 \div 4 = 9.25$

Because there are two single-digit numbers (5 and 7) (the number of significant figures is 1), the result is rounded to 9. This value is entered into the average value column.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter				Average Value
	1	2	3	4	
1	13	7	12	5	9

Treatment of Negative Values

Occasionally a radiological analytical value may be reported as a negative number. This is not a mistake, and the value does not represent "negative radioactivity." Rather, it is a result of the radiological measurement process produced by the subtraction of the background radiation measured by the instrument from the radiation measured in the sample. These results are essentially indistinguishable from zero.

Radioactive decay is a random phenomenon that can be described by a normal distribution (i.e., mean and standard deviation). When a sample contains radioactive elements at activities that are near instrument background, a single measurement of the sample can result in a negative value (when the instrument background is subtracted). If many measurements of the sample were taken and used to calculate the mean, this mean would be positive and would approximate the true radioactivity, however small, of the sample.

APPENDIX E Population Exposure Methodology

POPULATION EXPOSURE METHODOLOGY

DOSE CALCULATION METHODOLOGY

DOE Order 5400.5 requires that the impacts of the site on both the hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site be evaluated. For radioactive materials, this evaluation is usually conducted by calculating the dose received by a hypothetical maximally exposed individual and the general population and comparing this dose with DOE guidelines. This appendix describes the methodology used to calculate the doses discussed in Section 4.0.

PATHWAYS

The purpose of the dose calculation is to identify the potential routes or pathways that are available to transmit either radioactive material or ionizing radiation to the receptor. In general, the pathways are (1) direct exposure to gamma radiation, (2) atmospheric transport of radioactive material, (3) transport of radioactive material via surface water or groundwater, (4) bioaccumulation of radioactive materials in animals used as a food source, and (5) uptake of radioactive materials by plants used as a food source. For FUSRAP sites, the primary pathways are direct gamma radiation and transport of radioactive materials by the atmosphere, groundwater, and surface water. The others are not considered primary pathways because FUSRAP sites are not located in areas where significant sources of livestock are raised or foodstuffs are grown.

Gamma rays can travel until they expend all their energy in molecular or atomic interactions. In general, these distances are not very great and the exposure pathway would affect only the hypothetical maximally exposed individual.

Contamination transported via the atmospheric pathway may take the form of contaminated particulates or dust and can provide a potential dose only when it is inhaled. Doses from radon are intentionally excluded; radon exposure is controlled through compliance with boundary concentration requirements.

Contamination may be transported in surface water when runoff from a rainfall event or some other source of overland flow carries contamination from a site to the surface water system. This contamination poses an exposure potential when the surface water is used to provide municipal drinking water, to water livestock, and/or to irrigate crops. Contamination may be transported via groundwater if contaminants migrate into the groundwater system.

Primary Radionuclides of Concern

The primary radionuclides of concern for these calculations are uranium-238, uranium-235, uranium-234, thorium-232, radium-226, and the daughter products (excluding radon). For several of the dose conversion factors used in these calculations, the contributions of the daughters with half-lives less than one year are included with the parent radionuclide. Table E-1 lists the pertinent radionuclides, their half-lives, and dose conversion factors for ingestion.

DOSE CALCULATION METHOD

Direct Gamma Radiation Exposure

As previously indicated, only direct exposure is important in calculating the dose to the hypothetical maximally exposed individual. The dose from direct gamma radiation exposure is determined by using data collected through the tissue-equivalent thermoluminescent dosimeter (TETLD) program. These data provide a measure of the amount and energy (in units of mR/yr) of the ionizing radiation at 1 m (3 ft) above the ground. For the purposes of this report, the hypothetical maximally exposed individual is assumed to work 40 hours per week for 50 weeks per year at the Modern Disposal Landfill east of the site at an average distance of 10 m (30 ft) from the fenceline. This scenario was used because the nearest residence is 0.8 km (0.5 mi) from the site.

The direct gamma radiation dose to the hypothetical maximally exposed individual is zero, since no levels offsite are above background.

Table E-1

Radionuclides of Interest

Radionuclide	Half-life[a]	Dose Conversion Factor[b] for Ingestion (mrem/pCi)
Uranium-238	4.51×10^9 years	2.5×10^{-4}
Thorium-234	24.1 days	--[c]
Protactinium-234 m	1.17 minutes	--[c]
Protactinium-234	6.75 hours	--[c]
Uranium-234	2.47×10^5 years	2.6×10^{-4}
Thorium-230	8.0×10^4 years	5.3×10^{-4}
Radium-226	1602 years	1.1×10^{-3}
Uranium-235	7.1×10^8 years	2.5×10^{-3}
Thorium-231	25.5 hours	--[d]
Thorium-232	1.4×10^{10} years	2.8×10^{-3}
Protactinium-231	3.25×10^4 years	1.1×10^{-2}
Actinium-227	21.6 years	1.5×10^{-2}
Thorium-227	18.2 days	--[e]
Radium-223	11.43 days	--[e]

[a]Source: *Radiological Health Handbook* (HEW 1970).

[b]Source: *Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion (EPA-520/1-88-020) and International Dose Conversion Factors for Calculation of Dose to the Public* (DOE/EH-0071).

[c]Included in the uranium-238 dose conversion factor.

[d]Included in the uranium-235 dose conversion factor.

[e]Included in the actinium-227 dose conversion factor.

Surface water pathway

Exposures from contaminants in surface water can be important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population; however, surface water is not a factor for NFSS.

Groundwater pathway

Exposures from contaminants in groundwater that are part of a drinking water supply are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the groundwater dose calculations consist of measurements of the concentration of the contaminants in groundwater and an estimate of the dilution that occurs between the measurement location and the intake point; however, groundwater is not used in the vicinity of the site as a drinking water source, and no drinking water wells exist within 5 km (3 mi) of NFSS. Therefore, no dose would be received from this pathway.

Air Pathway (Ingestion, Air Immersion, Inhalation)

The doses to the hypothetical maximally exposed individual and the general public from particulate radionuclides transported through air are calculated using EPA's *Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites* (EPA 1985) and computer dose assessment model CAP88-PC.

The release of particulates from contaminated surface soils is calculated using a model for wind erosion because there are no other mechanisms for releasing particulates from the site. The NFSS storage pile is covered by a clay cap and vegetated topsoil; therefore, the topsoil, and not the radioactive residue stored in the pile, is available for resuspension by wind erosion (i.e., no radioactive material is exposed to the atmosphere and resuspended).

APPENDIX F Environmental Standards

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr (1 mSv/yr) in excess of background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990). Evaluation of exposure pathways and resulting dose calculations is based on assumptions such as the use of occupancy factors in determining 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 represent actual exposure conditions rather than maximum values as applicable; and use of average consumption rates of food and water per individual rather than maximums. Use of such assumptions results in calculated doses that more accurately reflect the exposure potential from site activities.

DERIVED CONCENTRATION GUIDES

DOE orders provide the standards for radionuclide emissions from DOE facilities. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," provides the procedures and requirements for radionuclide releases.

Applicable standards are found in Chapter III of DOE Order 5400.5 and are set as derived concentration guides (DCGs). A DCG is defined as the concentration of a radionuclide in air or water that, under conditions of continuous exposure to a single isotope for one year by one exposure mode (e.g., ingestion of water, inhalation), would result in an effective dose equivalent of 100 mrem (1 mSv). The following table provides reference values for conducting radiological environmental protection programs at operational DOE facilities and sites.

Radionuclide	F1 Value[a]	Ingested Water DCG (μCi/ml)[b]	Inhaled Air DCGs[c]		
			D	W	Y
Radium-226	2E-1	1E-7	--	1E-12	--
Thorium-230	2E-4	3E-7	--	4E-14	5E-14
Thorium-232	2E-4	5E-8	--	7E-15	1E-14
Uranium-234	2E-3	5E-6	--	--	9E-14
Uranium-235	2E-3	5E-6	--	--	1E-13
Uranium-238	2E-3	6E-6	--	--	1E-13
Radon-222[d]	3E-9	3E-9	--	--	3E-9
Radon-220[d]	3E-9	3E-9	--	--	3E-9

[a]F1 is defined as the gastrointestinal tract absorption factor, which measures the uptake fraction of ingestion of a radionuclide into the body.

[b]1E-9 μCi/ml = 1×10^{-9} μCi/ml = 0.037 Bq/L = 1 pCi/L.

[c]Inhaled air DCGs are expressed as a function of time. D, W, and Y represent a measure of the time required for contaminants to be removed from the system (D represents 0.5 day; W represents 50 days; and Y represents 500 days). Times listed for contaminant removal depend on chemical form and dust particle size.

[d]DOE is reassessing the DCGs for radon. Until review is completed and new values issued, the values given in the chart above will be used.

SOIL GUIDELINES

Guidelines for residual radioactivity in soil established for FUSRAP are shown below.

Radionuclide	Soil Concentration (pCi/g) Above Background
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Total uranium	90 pCi/g for any 15-cm-thick soil layer (DOE 1988b) (site-specific).
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use (see DOE 1989).

Source: DOE 1987.

APPENDIX G Distribution List for Niagara Falls Storage Site Environmental Report for Calendar Year 1992

The Department of Energy distributes this report to local, state, and federal agencies; U.S. Congress; the public; and the media (upon request).