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Formerly Utilized Sites Remedial Action Program (FUSRAP)
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WAYNE INTERIM STORAGE SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991

Wayne, New Jersey

September 1992

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WAYNE INTERIM STORAGE SITE

ANNUAL ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1991

WAYNE, NEW JERSEY

SEPTEMBER 1992

Prepared for

United States Department of Energy

Oak Ridge Field Office

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By

Bechtel National, Inc.

Oak Ridge, Tennessee

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EXECUTIVE SUMMARY

This document describes the environmental monitoring program at the Wayne Interim Storage Site (WISS) and surrounding area, implementation of the program, and monitoring results for 1991. Environmental monitoring of WISS and surrounding area began in 1984 when Congress added the site to the U.S. Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a DOE program to 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. WISS is a National Priorities List site.

The environmental monitoring program at WISS includes sampling networks for radon and thoron concentrations in air; external gamma radiation exposure; and radium-226, radium-228, thorium-232, and total uranium concentrations in surface water, sediment, and groundwater. Several nonradiological parameters are also measured in groundwater.

Monitoring results are compared with applicable Environmental Protection Agency standards, DOE derived concentration guides, dose limits, and other requirements in DOE orders. Environmental standards are established to protect public health and the environment.

Results of environmental monitoring during 1991 show that the concentrations of all radiological and nonradiological contaminants of concern were well below applicable standards. The potential radiation dose calculated for a hypothetical maximally exposed individual is 0.84 mrem (milliroentgen equivalent man) per year, which is less than an individual would receive while traveling in an airplane at 12,000 meters (39,000 feet) for two hours.

During 1991, site activities were limited to routine maintenance, environmental monitoring, and onsite chemical sampling in support of the Wayne site remedial investigation. There were no nonroutine releases from the site; WISS was in compliance with applicable release regulations.

As part of the ongoing environmental monitoring program at WISS, the adequacy of existing monitoring activities is assessed annually. Results from this assessment are used to identify any necessary changes in the scope of the monitoring program. Such changes may result from changing site conditions, changing regulatory requirements, or newly identified data needs to support the remedy selection process being conducted for the site. Additionally, as monitoring data are accumulated, decisions may be made to adjust monitoring requirements. Future annual site environmental reports will reflect any changes to the routine monitoring program.

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FIGURES

FIGURES

(continued)

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TABLES

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ACRONYMS

BNAE	base/neutral and acid extractable
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CWA	Clean Water Act
CX	categorical exclusion
DCG	derived concentration guide
DOE	Department of Energy
DQO	data quality objective
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
FFA	federal facilities agreement
FUSRAP	Formerly Utilized Sites Remedial Action Program
MSD	matrix spike duplicate
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NJDEPE	New Jersey Department of Environmental Protection and Energy
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCB	polychlorinated biphenyl

ACRONYMS
(continued)

QA	quality assurance
QAPmP	quality assurance program plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
RPD	relative percent difference
SRM	standard reference material
TAL	Target Analyte List
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TETLD	tissue-equivalent thermoluminescent dosimeter
TMA/E	Thermo Analytical/Eberline
TOC	total organic carbon
TOX	total organic halides
TPQ	threshold planning quantity
TSCA	Toxic Substances Control Act
VOC	volatile organic compound
WISS	Wayne Interim Storage Site

UNITS OF MEASURE

Bq	becquerel
C	Celsius
Ci	curie
cm	centimeter
F	Fahrenheit
ft	foot
ft msl	feet above mean sea level
g	gram
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
L	liter
m	meter
µCi	microcurie
µg	microgram
mg	milligram
mi	mile
ml	milliliter
mm	millimeter
µmhos	micromhos
mph	miles per hour
mR	milliroentgen
mrem	millirem
mSv	millisievert
pCi	picocurie
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) Wayne Interim Storage Site (WISS) and surrounding area began in 1984. This document describes the environmental monitoring program, implementation of the program, monitoring results for 1991, and special occurrences (if any) during 1991 and the first quarter of 1992.

1.1 DOE INVOLVEMENT

WISS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to 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.

1.2 SITE DESCRIPTION

WISS occupies approximately 2.6 ha (6.5 acres) in the Piedmont Plateau of north-central New Jersey within Wayne Township, Passaic County (Figure 1-1). WISS, Pompton Plains Railroad Spur, and vicinity properties comprise the Wayne site. The WISS property includes a two-story masonry building and a 0.88-ha (2.2-acre) interim storage pile covered with geotextile material (Figure 1-2). No effluents are generated. The WISS property is entirely fenced, and public access is restricted.

1.3 SITE HISTORY

From 1948 through 1971, Rare Earths, Inc., and, later, W.R. Grace & Co., processed monazite sand to extract thorium and rare earths. Rare Earths received a license to conduct the operations from the Atomic Energy Commission in 1954, after passage of the Atomic Energy Act. In 1957, W.R. Grace (Davison Chemical Division) purchased the facility and continued production until

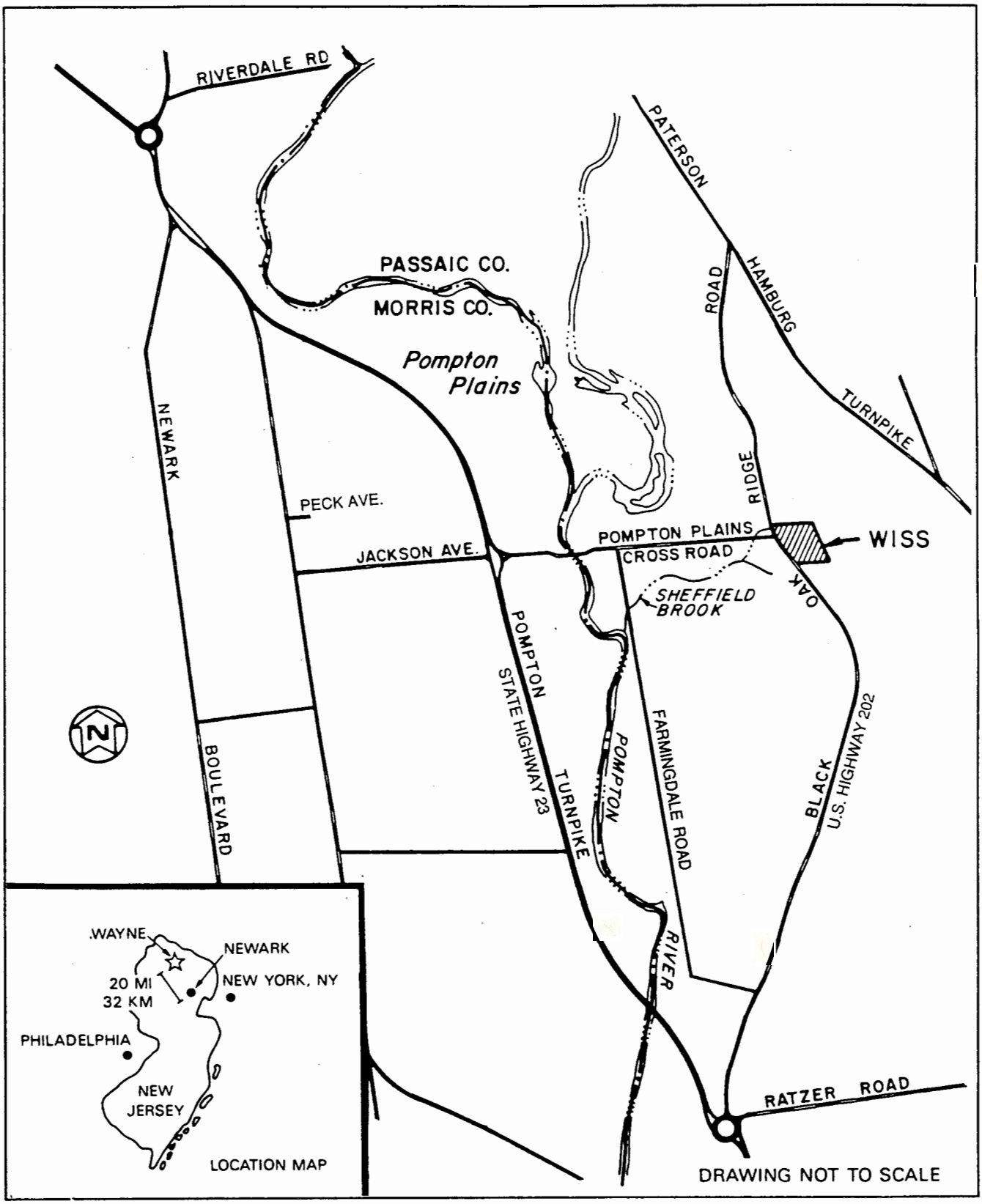
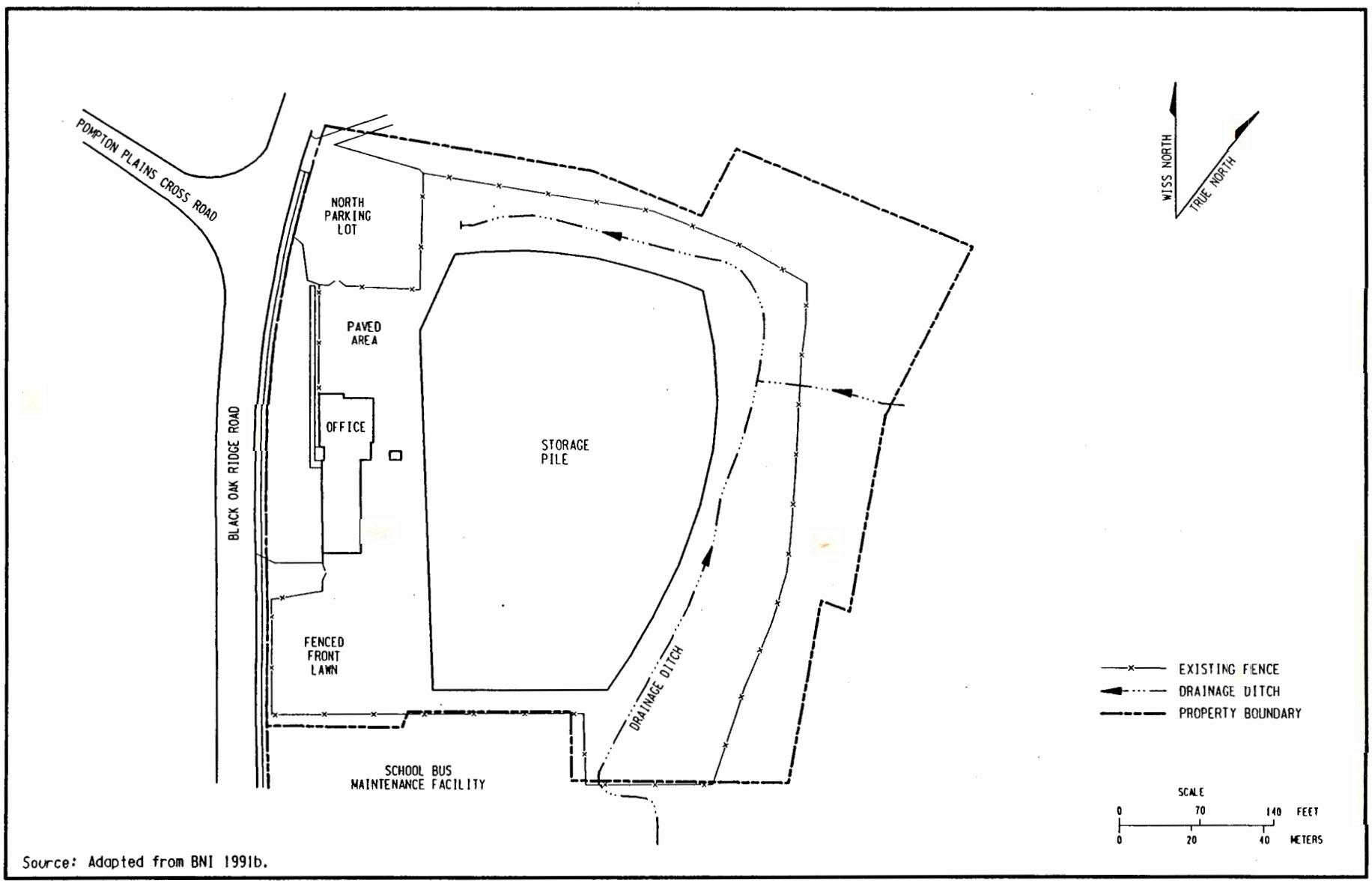


Figure 1-1
Location Of WISS



Source: Adapted from BNI 1991b.

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Figure 1-2
Plan View of WISS

July 1971. During the years of operation, some of the thorium process waste was buried onsite, and some was spread to low-lying properties by erosion and through storm drains and storm sewers. Process waste and residues included ore tailings, yttrium sludges, and sulfate precipitates.

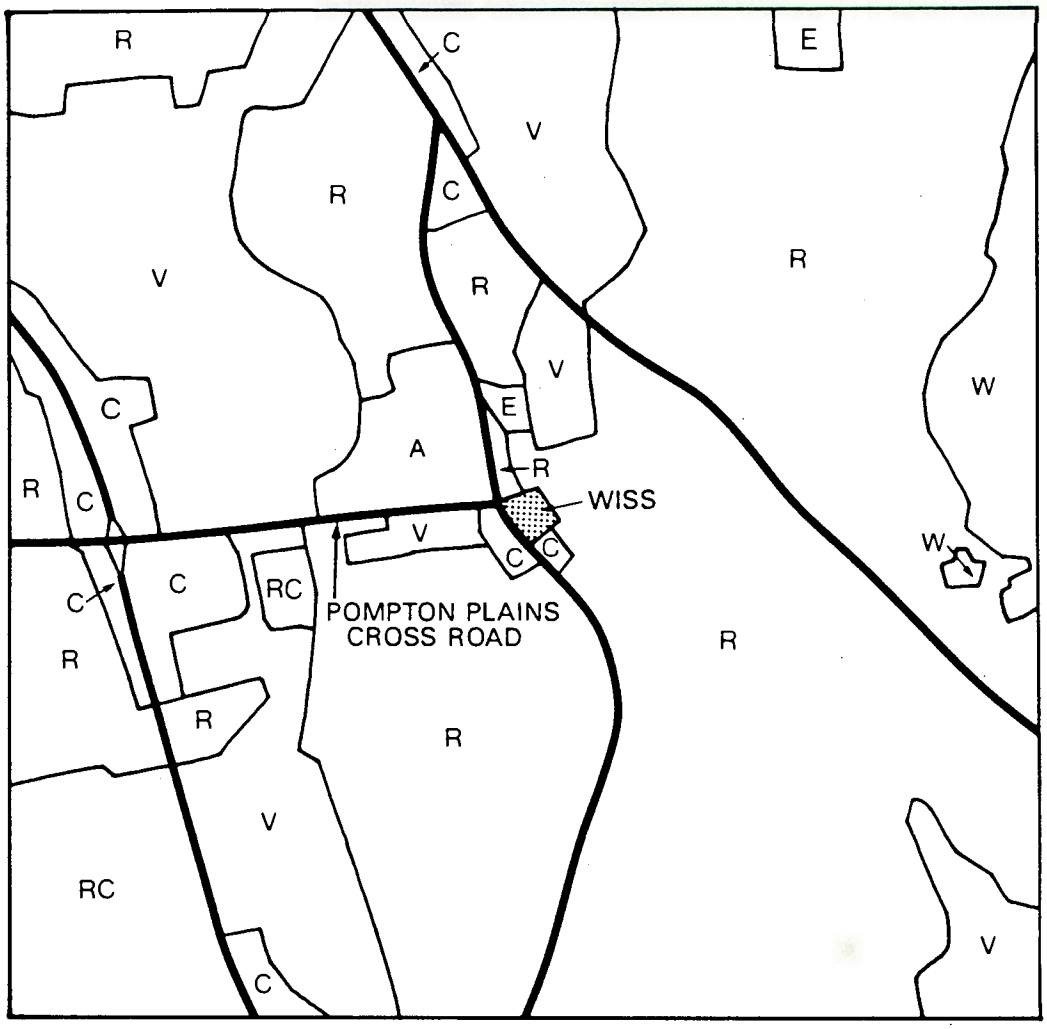
After processing ceased in 1971, the facility was licensed only for storage. In 1974, W.R. Grace performed a partial decontamination during which some buildings were razed, and the rubble and equipment were buried onsite; the remaining buildings were decontaminated. In 1975, the facility was decommissioned, and W.R. Grace's license was terminated.

In 1980, the New Jersey Department of Environmental Protection and Energy (NJDEPE) conducted a radiological survey of the area that identified areas of elevated contamination. In September 1984 the Environmental Protection Agency (EPA) added the Wayne site to the National Priorities List (NPL). Since 1984, when the site was assigned to DOE by Congress through the Energy and Water Development Appropriations Act, WISS has served as an interim storage area. Contaminated materials removed from WISS and vicinity properties during 1985 through 1987 were consolidated in the interim storage pile.

1.4 LAND USE

As shown in Figure 1-3, land use in the vicinity of WISS is predominantly a mixture of residential and commercial. The site is bordered by residential property to the north and east, commercial property to the south and west, and agricultural property to the northwest. Figure 1-4 is an aerial photograph of WISS and its vicinity.

The principal source of potable water in the WISS area is the Pompton River; approximately 90 percent of Wayne Township uses this source. Sheffield Brook empties into the Pompton River, which joins the Passaic River before it discharges into Newark Bay. The stratified glacial deposits along the western side of Wayne Township are an important source of groundwater.



BASED ON AERIAL PHOTOGRAPHS, SITE VISITS, AND USGS TOPOGRAPHIC MAP, 1:24000 SCALE, HACKENSACK NJ QUADRANGLE (PHOTO REVISED 1982)

A	AGRICULTURAL	RC	RECREATIONAL
C	COMMERCIAL	V	VACANT
E	EDUCATIONAL	W	RESERVOIR
R	RESIDENTIAL		

0 0.5 MI
0 0.8 KM

N

Figure 1-3
Generalized Land Use in the Vicinity of WISS

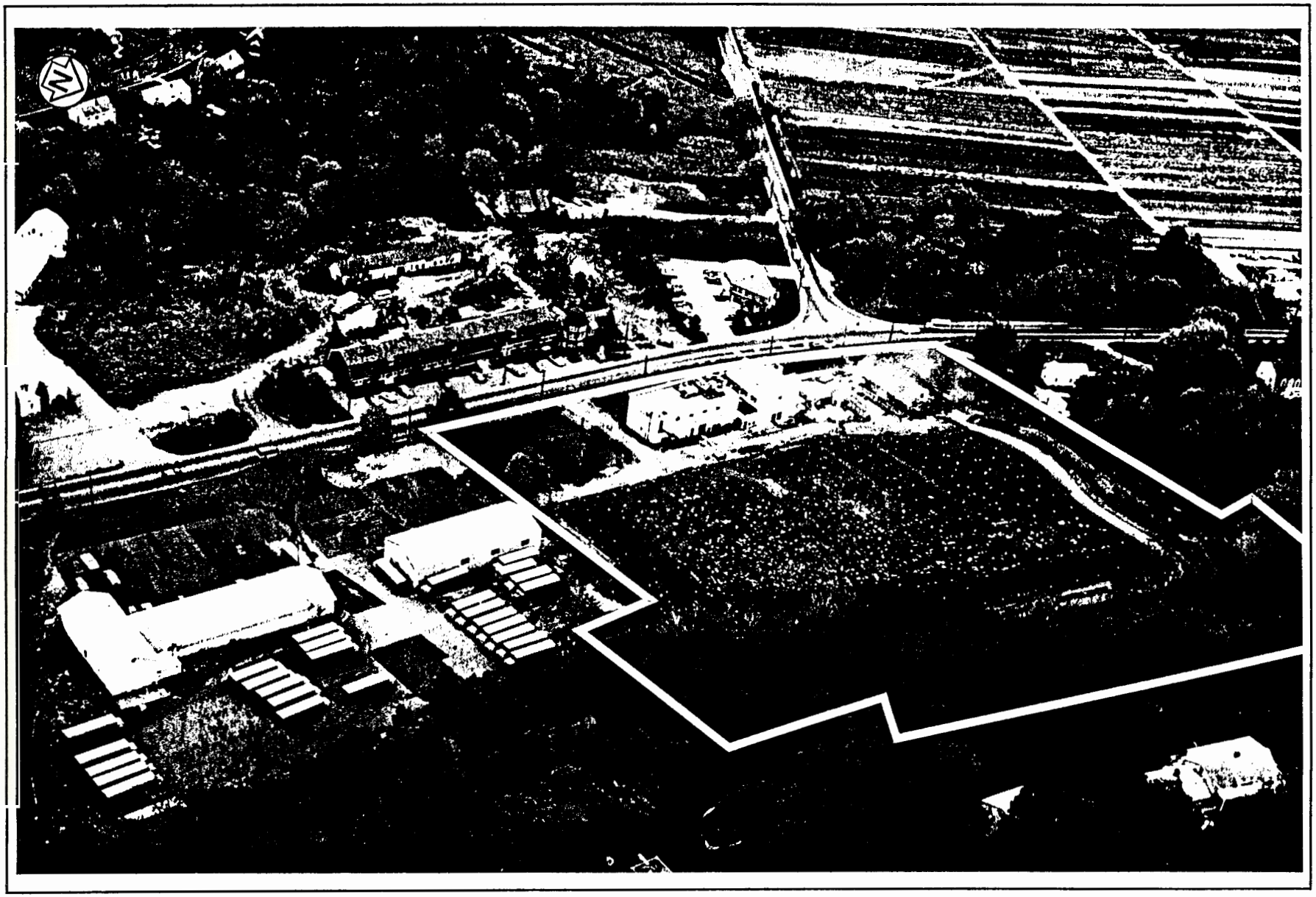


Figure 1-4
Aerial View of WISS

The nearest residential areas, primarily a mixture of single- and multiple-family dwellings, are less than 0.2 km (0.1 mi) from the site. The total population of the area within an 80-km (50-mi) radius is over 10 million (the population density of this area is approximately 10,000 people per square mile).

1.5 CLIMATE

Table 1-1 is a summary of 1991 climatological data from the National Oceanic and Atmospheric Administration (NOAA) for the Newark vicinity. Temperature extremes ranged from -13 to 39°C (9 to 102°F). Monthly average wind speeds ranged from 13 to 18 km/h (8.0 to 11.2 mph), and the predominant resultant wind direction was from the west (NOAA 1992).

Table 1-1
Summary of Climatological Data for the Newark Vicinity, 1991

Month	Temperature (°F) Min	Max	Avg	Total Precip (in.)	Wind Avg Speed (mph)	Resultant Direction
January	9	55	33.6	3.72	9.7	W
February	15	69	38.6	1.81	10.4	W
March	24	77	44.4	5.49	11.2	W
April	34	88	54.8	3.91	10.6	W
May	46	93	68.9	4.80	9.8	NW
June	53	97	74.2	2.95	9.7	NW
July	65	102	77.9	5.21	8.0	W
August	62	96	77.7	5.63	9.1	NW
September	44	95	68.0	3.24	9.0	NW
October	39	82	58.3	1.29	9.2	N
November	27	73	47.6	2.04	9.6	NW
December	14	65	38.8	3.67	10.6	W

Source: NOAA 1992.

2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE

The primary regulatory guidelines and limits are given in the DOE orders and are authorized by six federal acts: the Clean Air Act (CAA); the Clean Water Act (CWA); the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the National Environmental Policy Act (NEPA).

The following summaries describe compliance requirements as they existed in 1991 and first quarter 1992, as well as anticipated regulatory requirements that could affect the site in the future.

2.1 PRIMARY REGULATORY GUIDELINES

DOE Orders for Radionuclide Releases

Site releases must comply with specific DOE orders [5400 series and DOE Order 5820.2A, "Radioactive Waste Management" (DOE 1988a)] that establish quantitative limits, derived concentration guides (DCGs), and dose limits for radiological releases from DOE facilities. The applicable guidelines and dose limits are presented in Appendix A. DOE orders are treated as legal requirements, and releases of source, special nuclear, or by-product material in compliance with DOE orders at its facilities are considered "federally permitted actions" (54 FR 22524).

A review of environmental monitoring results for calendar year 1991 shows that WISS was in compliance with applicable radionuclide release standards in DOE orders. Detailed monitoring results for radionuclides are presented in Section 4.0.

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 WISS are radionuclide emissions from the waste pile and onsite soil. To date, WISS does not require any state or federal air permits,

pursuant to the authority of CERCLA Section 121; although WISS is a nonoperating DOE facility, only Subparts H and Q of National Emission Standards for Hazardous Air Pollutants (NESHAPs) are potentially applicable (DOE 1990a). However, Subpart Q was determined to not apply to the WISS interim storage pile because calculations show that the waste does not contain radium-226 of sufficient concentration to emit radon-222 in excess of the applicable standards established in this regulation.

Subpart H has been determined to not apply to WISS because the waste pile is only a diffuse or fugitive emission source, not a point source as defined by the NESHAPs regulation. However, compliance with the non-radon radionuclide standard in Subpart H of NESHAPs has been determined by evaluating the site using the computer model AIRDOS (Version 3.0) approved by EPA. This evaluation was completed, and the information was submitted to EPA in the form of a draft Memorandum of Understanding between DOE and EPA, dated December 1990, for compliance with NESHAPs and by agreement with EPA Region II.

NESHAPS Subpart M contains the National Asbestos Emission Standards. If asbestos is found during the remedial investigation, compliance with standards in Subpart M will be required.

Clean Water Act

Pollutants discharged to waters of the United States are regulated under the federal CWA.

Stormwater and shallow groundwater are the primary pathways of discharges to surface water. On November 16, 1990, EPA promulgated its federal program for the control of stormwater discharges from sites associated with industrial activity, including sites containing waste. New Jersey is an authorized state for implementation of the federal program, and permit applications will be due to the NJDEPE Bureau of Industrial Discharge Permits by October 1, 1992. Stormwater sampling is being planned to support this application.

Resource Conservation and Recovery Act

RCRA is the principal federal statute governing the management of hazardous waste. September 25, 1990, was the effective date for implementation of the new toxicity characteristic leaching procedure (TCLP) for determining whether a solid waste exhibits the RCRA characteristic of toxicity. In 1991 approximately 40 soil samples were taken from the interim storage pile at WISS for analysis using the TCLP to determine the toxicity levels. One sample failed the TCLP for the presence of two RCRA-regulated solvents; however, further analysis of the sample using EPA-approved analytical methodology indicated that these constituents were at levels below regulatory criteria.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA are polychlorinated biphenyls (PCBs) and asbestos. TSCA-regulated waste has not been detected at WISS.

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan are the primary sources of federal regulatory authority for remedial action activities at WISS.

Because WISS is on the NPL, a federal facilities agreement (FFA) is required for site remedial action. EPA and DOE signed an FFA on September 17, 1990 (EPA 1990), which became effective on April 22, 1991. Specifically, the parties to the FFA intend that activities covered by the agreement will achieve compliance with CERCLA and will meet or exceed all applicable or relevant and appropriate requirements.

Remediation of the site is being managed pursuant to Executive Order 12580, which delegates to DOE the authority to conduct remedial investigations at sites under the agency's jurisdiction.

National Environmental Policy Act

In the past, compliance with NEPA has been documented through the use of action description memoranda and corresponding memoranda-to-file. Information on the integrated CERCLA/NEPA process is provided in Subsection 2.3.

Other Major Environmental Statutes and Executive Orders

In addition to these DOE orders and statutes, several other major environmental statutes have been reviewed for applicability. For example, the Federal Insecticide, Fungicide, and Rodenticide Act; the Endangered Species Act; the Safe Drinking Water Act; the Emergency Planning and Community Right-to-Know Act; and the National Historic Preservation Act have been found to impose no current requirements on WISS. Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands") have also been reviewed for applicability and compliance. WISS is in compliance with all applicable environmental statutes, regulations, and executive orders.

2.2 APPLICABLE ENVIRONMENTAL PERMITS

The FFA for WISS reiterates the DOE policy that all applicable permit conditions will be met even though no permits are required for onsite actions. Although CERCLA Section 121 provides the statutory authority for an exemption to permitting requirements for onsite CERCLA remedial actions, the CWA permit under the National Pollutant Discharge Elimination System (NPDES) does not exempt CERCLA remedial actions. Therefore, a stormwater discharge permit application for WISS will be submitted to NJDEPE by the regulatory deadline of October 1, 1992.

2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

An environmental impact statement (EIS) is required as part of the overall effort for WISS. Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an EIS into the remedial investigation/ feasibility study (RI/FS) to produce an RI/FS-EIS for the site. This document is scheduled for completion in fiscal year 1995.

2.4 SUMMARY OF REGULATORY COMPLIANCE IN CALENDAR YEAR 1992 (FIRST QUARTER)

During the first quarter of 1992, routine site maintenance, surveillance, and monitoring activities were conducted. In addition, onsite sampling activities for the remedial investigation were completed, including the surveillance of properties in the vicinity of WISS for radioactive contamination; bladder pumps were installed on site monitoring wells to enhance sampling capabilities; and a plan is being devised to conduct performance tests on and possibly to redevelop these wells. The site continues to be evaluated for the presence of RCRA-regulated waste. Also, a stormwater sampling effort is being developed to support the permit application.

3.0 ENVIRONMENTAL PROGRAM INFORMATION

Routine monitoring for radiation, radioactive materials, and chemical substances at WISS is used to document compliance with appropriate standards, provide the public with information, provide a historical record for year-to-year comparisons, and identify environmental impacts. The environmental monitoring program assists in fulfilling the DOE policy of protecting public health and the environment and mitigating environmental impacts.

The objectives of this report are to:

- Describe efforts to control stored pollutants until further remediation
- Describe the environmental monitoring program
- Report the radiological and nonradiological conditions of the site and surrounding areas during 1991
- Provide comparison of monitoring results and applicable regulations and DOE orders (Appendix A)
- Provide trend analyses, where applicable, to indicate increases or decreases in environmental impact

To ensure that the environmental monitoring data are of sufficient quality to meet these objectives, all personnel involved in sampling are trained in site-specific requirements and sampling techniques. This training is conducted before each sampling event begins and is followed up by a "lessons learned" analysis after sampling is completed. The environmental monitoring group supervisor is responsible for ensuring that all Oak Ridge support staff and site support personnel are properly trained.

The primary audience for the environmental monitoring results includes the general public; property owners; news media; community interest groups; federal, state, and local government agencies; and regulatory personnel.

3.1 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM

3.1.1 Environmental Monitoring Requirements

Requirements for environmental monitoring of radioactive materials are found in the DOE orders dealing with radiation protection of the public and the environment. These requirements include the monitoring of radionuclides in groundwater, surface water, and sediment. Requirements for environmental monitoring of airborne pollutants (radon and other radionuclides) are found in NESHAPs. Requirements for monitoring of nonradiological parameters are found in DOE Order 5400.1 (DOE 1988b). Nonradiological parameters were monitored to obtain information on groundwater quality.

3.1.2 Monitoring Networks

The monitoring networks at WISS are as follows:

- All radon, thoron, and external gamma radiation exposure monitoring stations, except background stations, are onsite and accessible only to employees and authorized visitors.

- Background stations are located offsite in areas known to be uncontaminated. Measured background values are compared with site values to determine compliance with DOE orders.

3.2 SUMMARY OF SPECIAL ENVIRONMENTAL ACTIVITIES

In July 1991 groundwater samples were analyzed for priority pollutant organics, including 36 volatile compounds, 65 semivolatile compounds, and 27 pesticides and PCBs, as part of the RI/FS-EIS characterization of the Wayne site.

In October 1991 remedial investigation activities were performed to characterize the area around and under the pile and on the Pompton Plains Railroad Spur where material was unloaded to be transported to W.R. Grace for processing.

3.3 SELF-ASSESSMENTS

During April 1991, Bechtel National, Inc. (BNI), the project management contractor for FUSRAP, conducted a self-assessment of the environmental monitoring activities at the site. Findings from this self-assessment focused on monitoring techniques, field documentation of monitoring events, and agreement between sampling practices and stated procedures. As a result of this assessment, corrective actions were developed and implemented.

An action remaining open from 1990 assessments was to develop environmental monitoring plans [required by DOE Order 5400.1 (DOE 1988b)] to document the rationale for the environmental monitoring networks at FUSRAP sites. These plans were published in November 1991.

Any deficiencies identified in self-assessments are processed through the corrective action process established by BNI. Depending on the nature of the deficiency, a corrective action request, nonconformance report, or observation report is used to document the deficiency and begin the corrective action process. The method of identification, documentation, and final corrective action enables the information to be retained and improvements incorporated into the program.

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

WISS is not an active site and produces no processing effluents; thus, the only possibility for contamination to be released from the site would be through migration by routes such as infiltration into groundwater, surface water runoff, or suspension and dispersion into the air.

Radiological environmental monitoring at WISS in 1991 included sampling for:

- Radon and thoron concentrations in air
- External gamma radiation exposure
- Radium-226, radium-228, thorium-232, and total uranium concentrations in surface water, sediment, and groundwater

The monitoring systems included onsite, fenceline, and offsite stations 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 B.

This section contains the quarterly radiological data for each sampling point, annual averages, and trend information. Although trends are calculated, the limited number of annual data points, the analytical error, and the natural and site variability restrict the representativeness of the expected range. The methodology for calculating the averages and standard deviations is provided in Appendix C. All quarterly data are reported as received from the laboratory; however, the annual averages, standard deviations, and expected ranges are reported using the smallest number of significant figures from the quarterly data (e.g., 3.2 and 32 both have two significant figures). Where appropriate, data are presented using powers of ten (e.g., $0.32 = 3.2 \times 10^{-1}$).

Some of the quarterly results are reported using a "less than" (<) sign to denote results that are below the limit of sensitivity of the analytical method, based on a statistical analysis of parameters. When computing annual averages, quarterly values reported as less than a given limit of sensitivity are considered equal to that limit.

The following subsections discuss the radiological monitoring program, results for 1991, and any possible radioactive contaminant migration indicated by the results. Concentration trends are also shown in graphical representations, which include up to six of the highest values for each analyte and matrix sampled during the past five years. The scales for these graphs are set to a percentage of the appropriate guideline based on the values of the samples to ensure maximum resolution. Measured background values are also displayed when appropriate.

4.1 ENVIRONMENTAL MONITORING FOR RADIOACTIVE CONTAMINANTS

4.1.1 Radon and Thoron Monitoring

A major pathway of radiation exposure from the uranium-238 decay series is from the inhalation of the short-lived radionuclides, radon (radon-222) and radon daughter products. Thoron (radon-220) is the short-lived gaseous decay product of the thorium-232 decay series. Radon and thoron are radioactive (alpha-particle-emitting) gases that are very mobile in air. Radon and thoron monitoring is conducted at WISS to measure their concentrations at the site boundary and to demonstrate compliance with environmental regulations. Radon and thoron detector locations are shown in Figure 4-1.

Data and discussion

No annual average radon concentration was greater than 50 percent of the DOE interim storage site guideline of 3.0×10^{-9} μCi/ml (0.11 Bq/L) (see Table 4-1). Because most of the radon monitoring stations at WISS are located on the fenceline, nearly all radon levels measured indicate the potential levels of exposure to the public. Information on public exposure can be found in Subsection 4.2.

The maximum thoron concentration detected was 20.1×10^{-9} μCi/ml (0.744 Bq/L), which appears to be an anomaly, given the previous quarterly concentration at this location. Aside

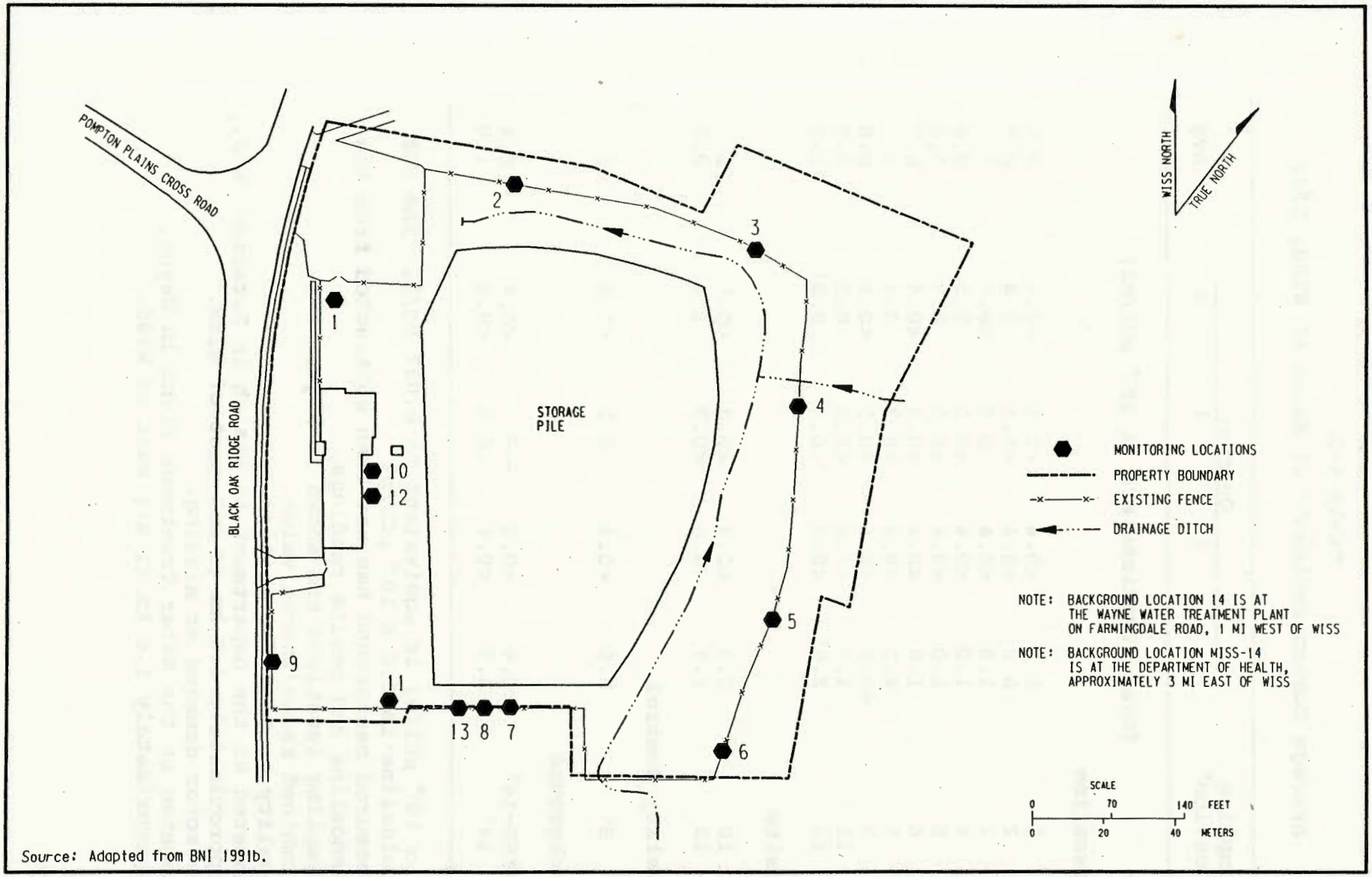


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Figure 4-1
Radon, Thoron, and External Gamma Radiation Monitoring Locations at WISS

Table 4-1

Average Concentrations[a,b] of Radon at WISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} μCi/ml)				
Fenceline					
1	1.6	<0.4	<0.3	<0.4	0.7
2	0.8	<0.4	<0.3	0.4	0.5
3	1.8	<0.4	0.3	<0.5	0.8
4	1.0	<0.4	<0.3	0.5	0.6
5	1.0	<0.4	<0.3	0.7	0.6
6	1.8	<0.4	<0.3	<0.4	0.7
7	4.7	<0.4	<0.3	0.4	2
9	<0.6	<0.4	<0.3	<0.5	0.5
11	1.4	<0.4	<0.3	0.5	0.7
13	2.9[d]	<0.3	<0.3[d]	0.5[d]	1.0
Onsite					
10	3.3	<0.4	<0.3	<0.5	1
12	1.1	<0.4	<0.3	1.4	0.8
Quality Control					
8[e]	5.9	<0.4	<0.3	<0.4	2
Background					
MISS-14[f]	<0.9	<0.3	--[g]	<0.4	0.4
14[h]	2.7	<0.4	<0.3	<0.4	1.0

[a] 1 x 10^{-9} μCi/ml is equivalent to 0.037 Bq/L. The DOE guideline is 3.0 x 10^{-9} μCi/ml.
[b] Measured background has not been subtracted from the fenceline and onsite readings.
[c] Sampling locations are shown in Figure 4-1.
[d] Combined radon/thoron value.
[e] Quality control for station 7.
[f] Located at the Department of Health in Paterson, N.J., approximately 4.8 km (3 mi) east of WISS.
[g] Detector damaged or missing.
[h] Located at the Water Treatment Plant in Wayne, approximately 1.6 km (1 mi) west of WISS.

from this one elevated value, all other values were less than or equal to 0.3 x 10^{-9} μCi/ml (0.01 Bq/L) (Table 4-2). DOE is assessing the DCG for thoron; until this review is completed, the DCG for radon (3.0 x 10^{-9} μCi/ml) will be used.

Trends

Trends in average annual concentrations of radon in air measured from 1986 through 1991 are presented in Table 4-3 and shown in Figure 4-2. Average radon concentrations for 1991 fell within the expected range of values for the site except at stations 3, 7, and 8 (the quality control location for station 7), which were slightly above expected concentrations possibly because of analytical anomalies in the first quarter results. No trend analysis was performed for thoron because 1991 was the first full year of thoron monitoring.

4.1.2 External Gamma Radiation Exposure Monitoring

External gamma radiation exposure rates were measured as part of the routine environmental monitoring program to confirm that gamma radiation from WISS was not significantly increasing external gamma radiation exposure rates above natural background and to ensure compliance with DOE guidelines for exposure of members of the general public.

Although the tissue-equivalent thermoluminescent dosimeters used for monitoring are state-of-the-art, the dosimeter accuracy is approximately ±10 percent at radiation exposure rates between 100 and 1,000 mR/yr and ±25 percent at rates between 0 and 70 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

Table 4-2

Average Concentrations[a,b] of Thoron at WISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
(Concentrations are in 10^{-9} µCi/ml)					
Fenceline					
1	0	0.1	0.2	0.9	0.3
2	1.0	0	0.4	0.8	0.6
3	0	0	0	<0.1	0.1
4	0.8	0	0	<0.1	0.2
5	2.1	0	0	20.1	6
6	0.7	0	0	<1.5	0.6
7	0	0	0	0.3	0.1
9	0	0	0	<0.2	0.1
11	0	0	2.7	3.0	2
13	2.9[d]	0.6	0.3[d]	0.5[d]	1
Onsite					
10	0	0	0	<0.1	0.1
12	1.1	0.1	0.2	--[e]	0.5
Quality Control					
8[f]	0	0	0.1	<2.0	0.5
Background					
MISS-14[g] 14[h]	1.8	0	0	--[e]	0.6

[a]1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DCG for thoron is being assessed by DOE; until this review has been completed and new guidelines have been issued, the DCG for radon (3.0 x 10^{-9} µCi/ml) can be used for comparison.
[b]Measured background has not been subtracted from the fenceline and onsite readings.
[c]Sampling locations are shown in Figure 4-1.
[d]Combined radon/thoron value.
[e]Thoron level was undetectable.
[f]Quality control for station 7.
[g]Located at the Department of Health in Paterson, N.J., approximately 4.8 km (3.0 mi) east of WISS.
[h]Located at the Water Treatment Plant in Wayne, approximately 1.6 km (1 mi) west of WISS.

Table 4-3

Trend Analysis for Radon Concentrations[a,b] at WISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{x} \pm 2s$)	Average Annual Concentration 1991
	(Concentrations are in 10^{-9} µCi/ml)						
Fenceline							
1	1.0	0.6	0.3	0.5	0.3	0 - 1	0.7
2	1.0	0.9	0.3	0.4	0.4	0 - 1	0.5
3	0.4	0.4	0.3	0.6	0.3	0.2 - 0.6	0.8
4	0.5	0.5	0.4	0.7	0.4	0.3 - 0.7	0.6
5	0.8	0.8	0.5	0.6	0.5	0.3 - 0.9	0.6
6	0.9	0.5	0.5	0.5	0.4	0.2 - 1	0.7
7	0.6	0.5	0.5	0.7	0.5	0.4 - 0.8	2
9	0.9	1.3	0.3	0.4	0.4	0 - 2	0.5
11[e]	--	--	--	--	0.7	--	0.7
13[e]	--	--	--	--	0.3	--	1.0
Onsite							
10[e]	--	--	--	--	0.4	--	1
12[e]	--	--	--	--	0.4	--	0.8
Quality Control							
8[f]	0.8	0.5	0.3	0.4	0.4	0.1 - 0.9	2
Background							
MISS-14[g]	1.0	1.8	0.3	0.6	0.3	0 - 2	0.4
14[h]	--	--	--	0.7	0.5	--	1.0

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991a).

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

[b] Measured background has not been subtracted from the fenceline and onsite readings.

[c] Sampling locations are shown in Figure 4-1.

[d] Average value ±2 standard deviations (approximately 95 percent confidence level).

[e] Added to environmental monitoring program in 1990.

[f] Quality control for station 7.

[g] Located at the Department of Health in Paterson, N.J., approximately 4.8 km (3 mi) east of WISS.

[h] Located at Water Treatment Plant in Wayne, approximately 1.6 km (1 mi) west of WISS; established in January 1989.

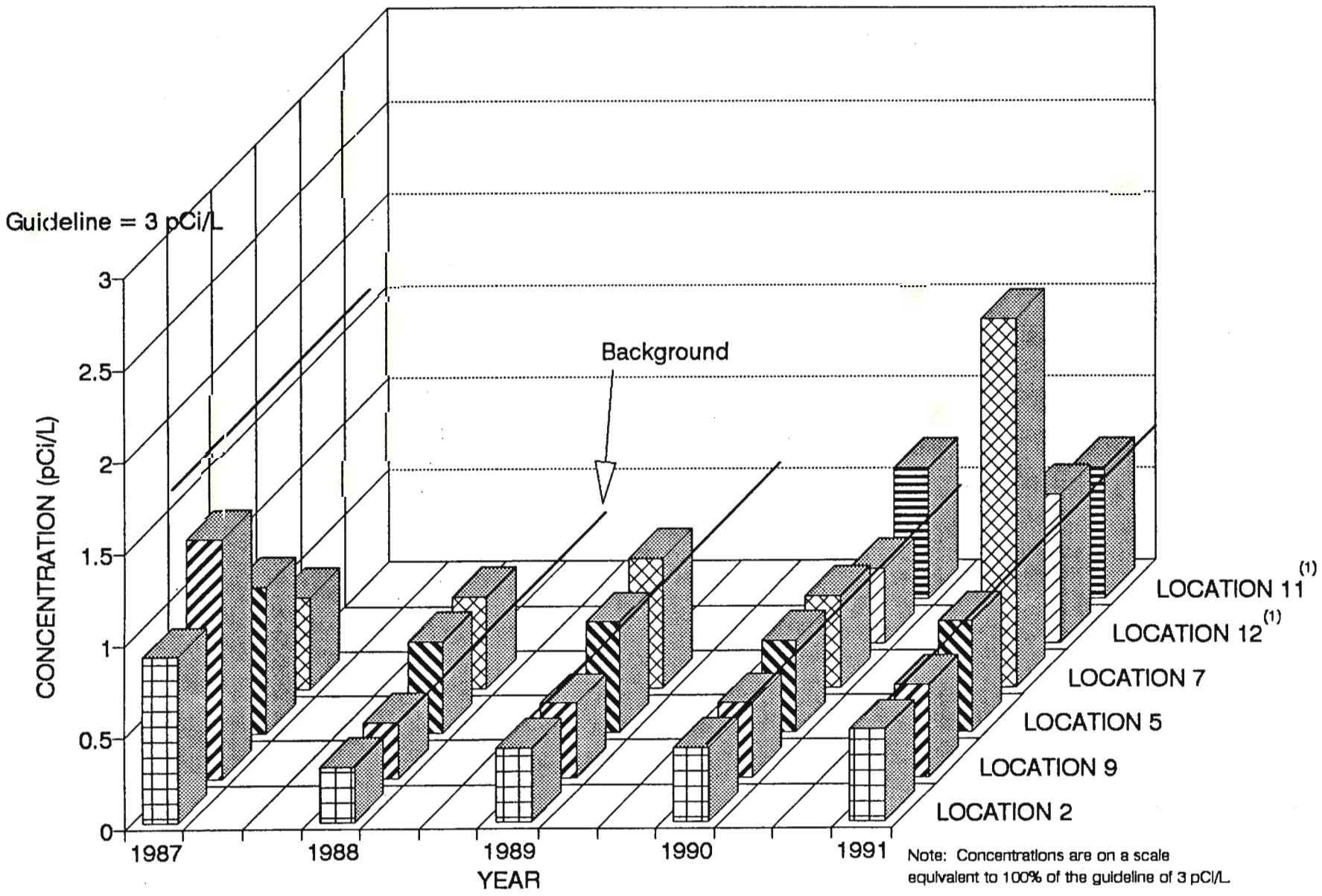

Guideline = 3 pCi/L
Background
CONCENTRATION (pCi/L)
3
2.5
2
1.5
1
0.5
0
1987
1988
1989
1990
1991
YEAR
LOCATION 11 (1)
LOCATION 12 (1)
LOCATION 7
LOCATION 5
LOCATION 9
LOCATION 2
Note: Concentrations are on a scale equivalent to 100% of the guideline of 3 pCi/L.
(1) Sampling initiated in 1990.

FIGURE 4-2

activity (Eisenbud 1987). Thus, external gamma radiation exposure rates at the boundary could be less than the background rate measured at some distance from the site, and rates onsite could be lower than at the boundary.

Data and discussion

The annual average external gamma radiation exposure rates at WISS in 1991 ranged from 60 to 69 mR/yr onsite and from 0 to 65 mR/yr at the fenceline, not including an average background value of 79 mR/yr. Information on public exposure can be found in Subsection 4.2. The results of external gamma radiation monitoring are presented in Table 4-4. Monitoring locations are shown in Figure 4-1. Exposure rates above background were measured only at locations 10, 11, and 12, which are in areas containing radioactively contaminated material. Gamma log subsurface surveys of these areas indicate that the gamma count rates are from 11 to 17 times higher [averaged over the range of depths from 0 to 1 m (0 to 3 ft)] than gamma log results in background locations at similar depths.

For comparison, Figure 4-3 shows the average annual external gamma radiation exposure rates for locations onsite, at the fenceline, offsite, and across the nation. Based on these data, the low-level radioactively contaminated soil stored at WISS does not present a threat to the public from external gamma radiation exposure because the rates are far below any level of concern or regulatory limit and access to the material is restricted.

Trends

Trends in external gamma radiation exposure rates measured from 1986 through 1991 are presented in Table 4-5 and shown in Figure 4-4. The expected exposure rate ranges shown are based on calculation of the standard deviation of the yearly means.

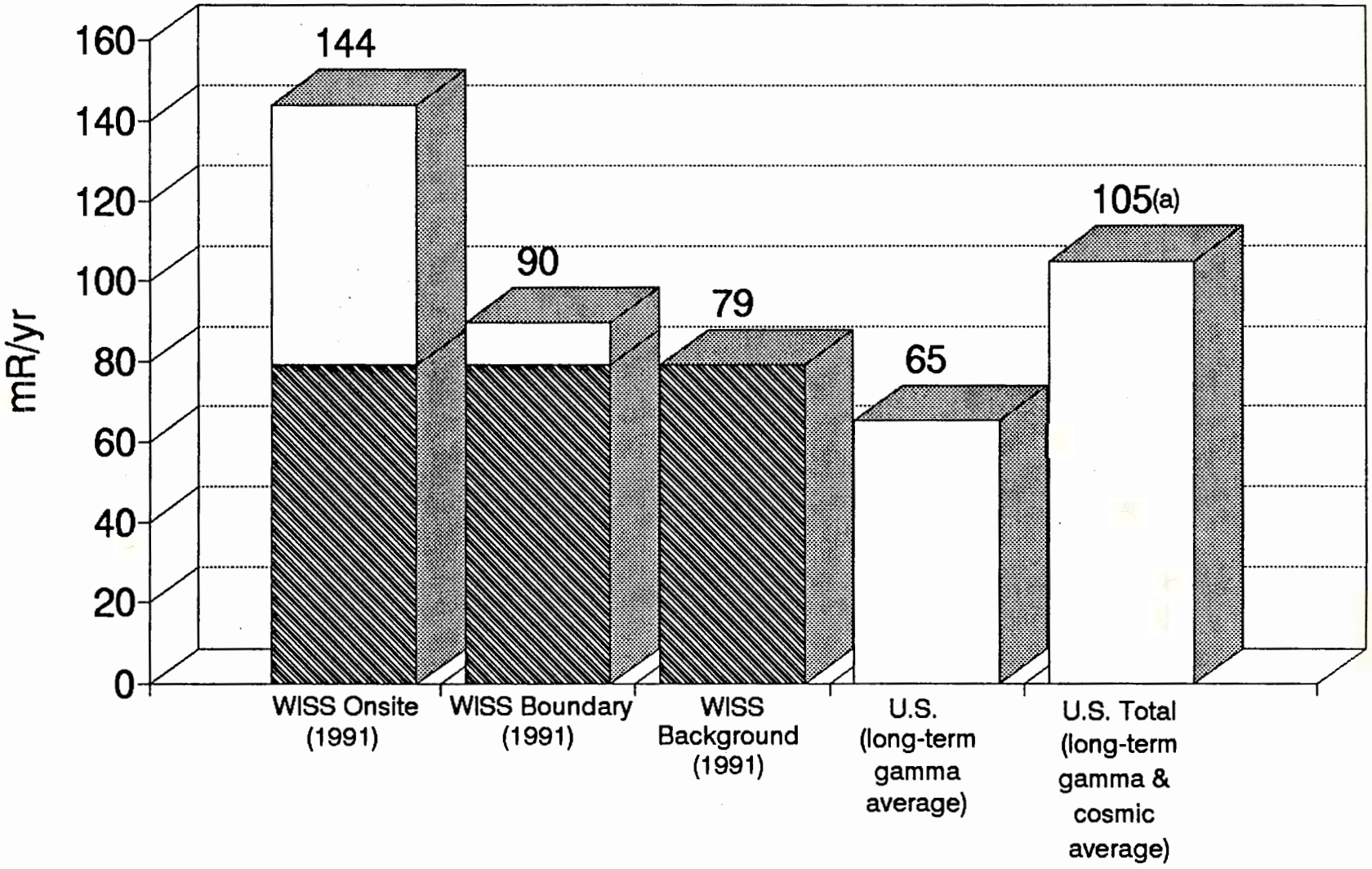
After the site was remediated in 1986, exposures were reduced at locations 1 through 9. No trends can yet be identified for locations 14 (established in 1989) or 10, 11, and 12 (added to the

Table 4-4

Average External Gamma Radiation Exposure Rates[a] at WISS, 1991

Sampling Location[b]	Quarter 1	2	3	4	Avg
	(Rates are in mR/yr)				
Property Line (measured background subtracted)[c]					
1	3	0[d]	0	5	2
2	0	0	1	2	1
3	0	0	0	1	1
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	1	1
7	0	0	0	8	2
9	0	0	0	8	2
11	55	69	61	74	65
Onsite (measured background subtracted)[c]					
10	51	58	58	73	60
12	59	69	69	81	69
Quality Control					
8[e]	0	0	0	9	2
Background					
MISS-14[f]	67	69	63	37	59
14[g]	89	104	103	98	99

[a]Dosimeters evaluated each quarter have been in place for 1 yr. 1 mR is approximately equivalent to 1 mrem. The DOE guideline is 100 mrem/yr above background.
[b]Sampling locations are shown in Figure 4-1.
[c]Measured background has been subtracted from the property-line and onsite readings.
[d]A zero indicates that the measured value was not distinguishable from background levels.
[e]Quality control for station 7.
[f]Located at the Department of Health in Paterson, N.J., approximately 4.8 km (3 mi) east of WISS.
[g]Located at the Water Treatment Plant in Wayne, approximately 1.6 km (1 mi) west of WISS.



Note: The DOE guideline for external gamma radiation exposure is 100 mrem/yr above background level (DOE 1990b). Note: 1 mrem is approximately equivalent to 1 mR.

(a) Source: Martin Marietta Energy Systems, Inc., 1989.

Background

Figure 4-3
External Gamma Radiation Exposure Rates

Table 4-5

Trend Analysis for External Gamma Radiation Exposure Rates[a] at WISS, 1986-1991

Sampling Location[b]	Average Annual Rate 1986	1987	1988	1989	1990	Expected Range[c] ($\bar{X} \pm 2s$)	Average Annual Rate 1991
				(Rates are in mR/yr)			
Fenceline (measured background subtracted)[d]							
1	48	28	28	8	10	0 - 57	2
2	26	27	23	6	4	0 - 40	1
3	20	29	13	--[e]	2	0 - 37	1
4	18	18	10	--[e]	--[e]	0 - 26	--[e]
5	15	18	5	--[e]	1	0 - 24	--[e]
6	22	22	10	1	2	0 - 32	1
7	77	45	15	1	2	0 - 93	2
9	21	38	22	2	2	0 - 47	2
11[f]	--	--	--	--	67	--	65
Onsite (measured background subtracted)[d]							
10[f]	--	--	--	--	64	--	60
12[f]	--	--	--	--	69	--	69
Quality Control							
8[g]	82	40	19	1	3	0 - 96	2
Background							
MISS-14[h]	63	58	78	63	63	50 - 80	59
14[i]	--	--	--	94	95	--	99

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991a).

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

[b]Sampling locations are shown in Figure 4-1.

[c]Average value ±2 standard deviations (approximately 95 percent confidence level).

[d]Measured background has been subtracted from fenceline and onsite readings.

[e]Measurement is not distinguishable from the average annual background rate.

[f]Added to environmental monitoring program in 1990.

[g]Quality control for station 7.

[h]Located at the Department of Health in Paterson, N.J., approximately 4.8 km (3 mi) east of WISS.

[i]Located at the Water Treatment Plant in Wayne, approximately 1.6 km (1 mi) west of WISS; established in January 1989.

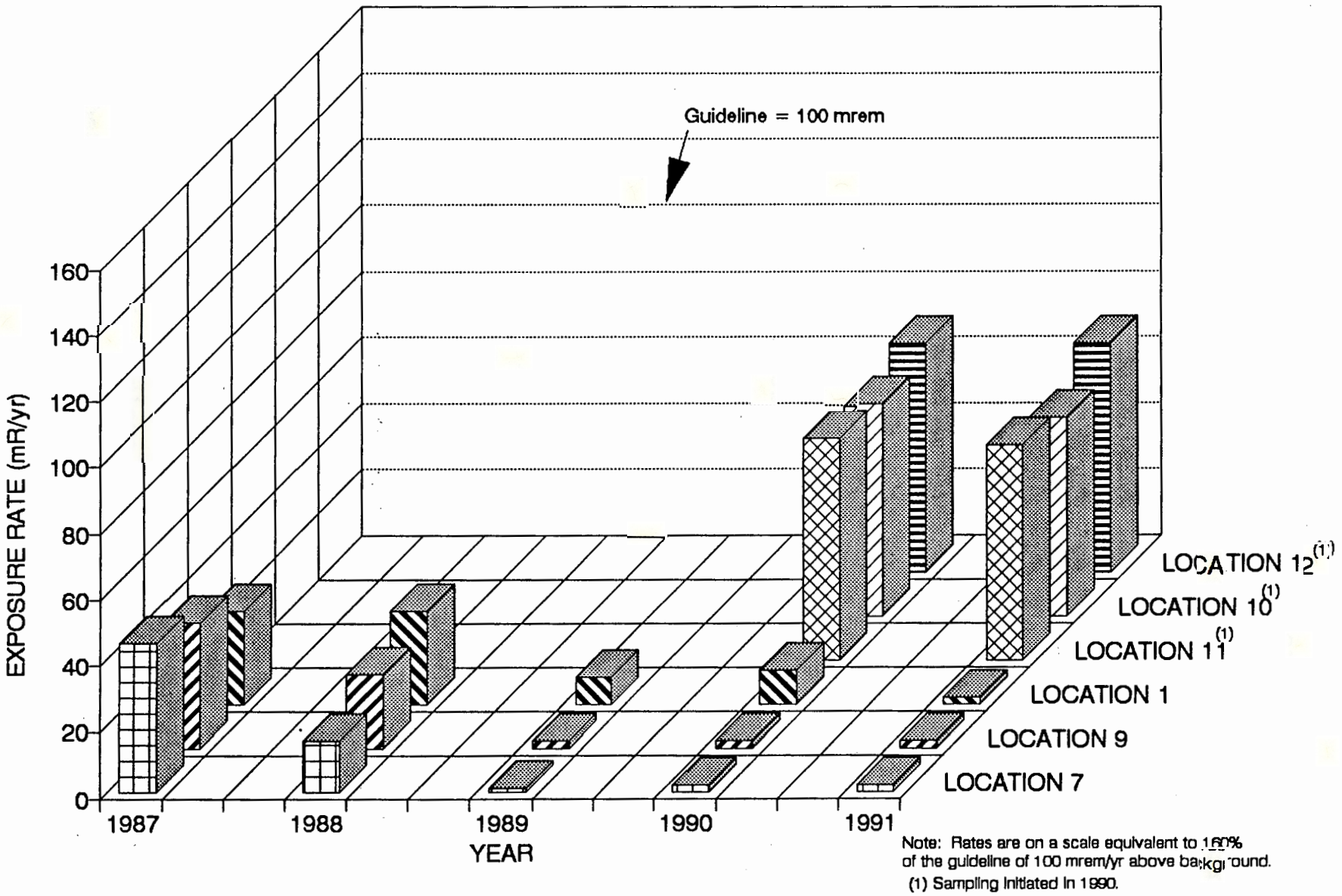


FIGURE 4-4
Average Annual External Gamma Radiation Exposure Rates Above Background at WISS

environmental monitoring program in 1990). In general, exposure rates since 1986 are fairly consistent among data sets, and quarterly results for 1991 fell within the expected range of values.

4.1.3 Surface Water Monitoring

Surface water monitoring is conducted to ensure compliance with environmental regulations and to determine whether runoff from WISS contributes to surface water contamination in the area. Sampling locations are shown in Figure 4-5.

Data and discussion

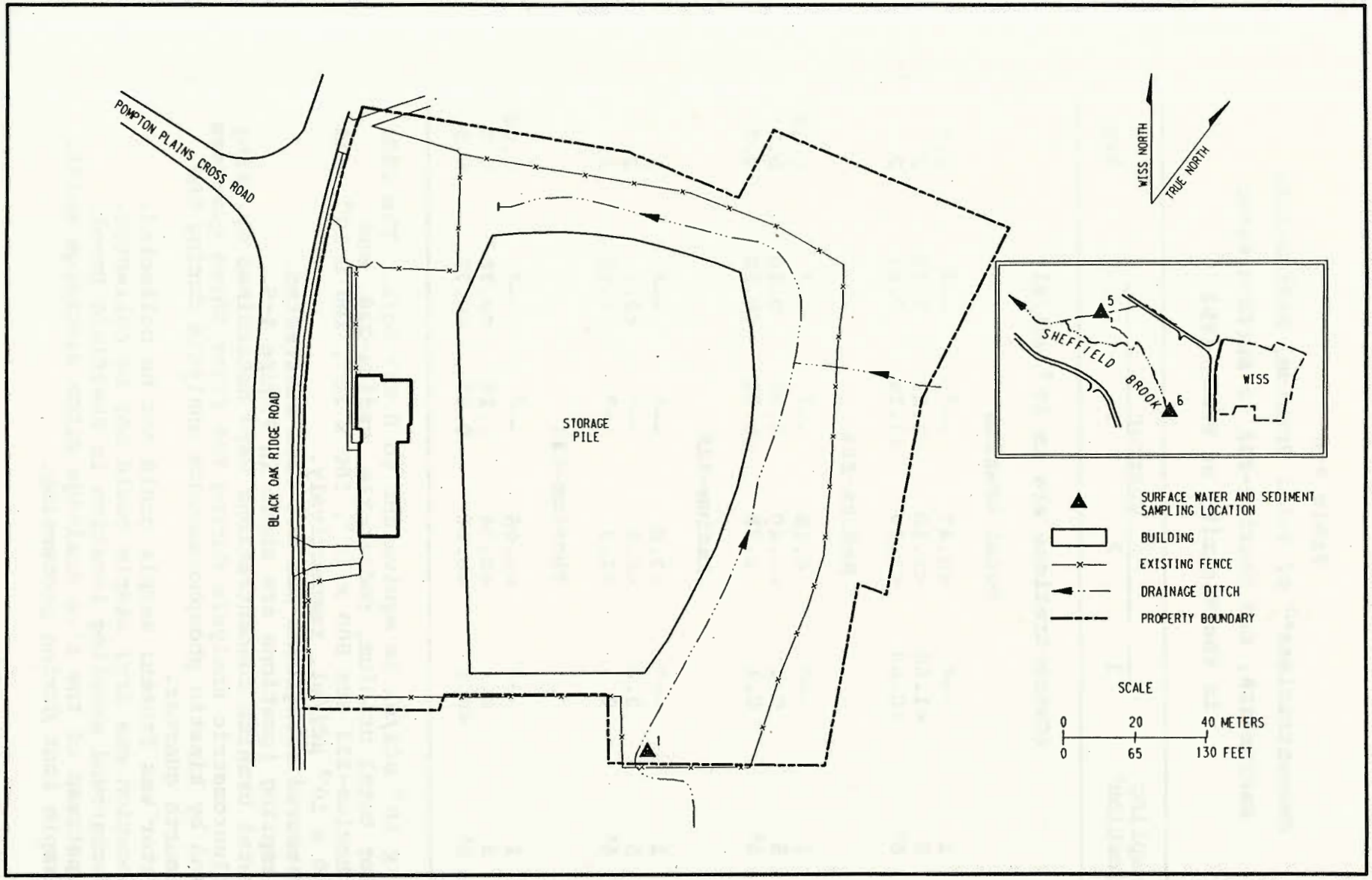
Table 4-6 presents 1991 concentrations of total uranium, radium-226, radium-228, and thorium-232 in surface water, which were well within their respective background ranges.

Trends

Trends in average annual radionuclide concentrations measured in surface water from 1986 through 1991 are presented in Table 4-7 and shown in Figures 4-6 through 4-8. Results for radium-228 analyses are not included because they were not performed before 1991. The expected value ranges shown are based on the calculation of the standard deviation of the yearly mean. In general, the ranges were fairly consistent among data sets, and quarterly results for 1991 fell within the expected range of values.

4.1.4 Sediment Monitoring

Sediment monitoring is conducted to determine whether contaminants are accumulating in onsite and/or offsite sediment and to ensure compliance with environmental regulations. Sediment sampling locations are shown in Figure 4-5.



137 R11F002.DGN F2

Figure 4-5
Surface Water and Sediment Sampling Locations at WISS

Table 4-6

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Surface Water in the Vicinity of WISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
	(Concentrations are in 10^{-9} µCi/ml)				
	Total Uranium[d]				
1	--[e]	<0.47	--[f]	--[f]	0.5
5	<1.60	<1.10	<3.39	1.50	2
6[g]	<0.60	<1.29	<3.39	0.81	2
	Radium-226				
1	--[e]	0.19	--[f]	--[f]	0.19
5	0.1	<0.40	0.16	0.10	0.2
6[g]	0.1	0.28	<0.08	<0.20	0.2
	Radium-228				
1	--[e]	<3.0	--[f]	--[f]	3
5	2.0	<2.8	--[h]	<2.9	2
6[g]	0	<2.3	--[h]	<.30	1
	Thorium-232				
1	--[e]	<0.06	--[f]	--[f]	0.06
5	0.1	<0.04	0.18	<0.78	0.3
6[g]	<0.1	<0.06	0.05	<0.79	0.3

[a]1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DCGs for total uranium, radium-226, radium-228, and thorium-232 are 600 x 10^{-9}, 100 x 10^{-9}, 100 x 10^{-9}, and 50 x 10^{-9} µCi/ml, respectively.
[b]Measured background has not been subtracted.
[c]Sampling locations are shown in Figure 4-5.
[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.
[e]Water was frozen; sample could not be collected.
[f]Location was dry; sample could not be collected.
[g]Background sampling location in Sheffield Brook, upstream of the site drainage ditch discharge point.
[h]Sample lost during processing.

Table 4-7

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Surface Water in the Vicinity of WISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{X} \pm 2s$)	Average Annual Concentration 1991
	(Concentrations are in 10^{-9} µCi/ml)						
	Total Uranium[e]						
1	3	3.4	3.2	5	0.7	0 - 6	0.5
5	3	3.4	4	5	2.6	2 - 6	2
6[f]	3	3.4	5	5	2.5	2 - 6	2
	Radium-226						
1	0.2	0.1	0.8	0.5	0.6	0.0 - 1.0	0.2
5	0.3	0.2	0.3	0.4	0.1	0.1 - 0.5	0.2
6[f]	0.2	0.1	0.3	0.4	0.1	0.0 - 0.5	0.2
	Thorium-232						
1	0.2	0.1	2.6	0.2	0.1	0 - 3	0.1
5	0.3	0.2	0.1	0.1	0.1	0.0 - 0.4	0.3
6[f]	0.3	0.1	0.1	0.1	0.1	0 - 0.3	0.3

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991a).

[a] 1×10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DCGs for total uranium, radium-226, and thorium-232 are 600×10^{-9}, 100×10^{-9}, and 50×10^{-9} µCi/ml, respectively.

[b] Measured background has not been subtracted.

[c] Sampling locations are shown in Figure 4-5.

[d] Average value ±2 standard deviations (approximately 95 percent confidence level).

[e] 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.

[f] Background sampling location in Sheffield Brook, upstream of the site drainage ditch discharge point.

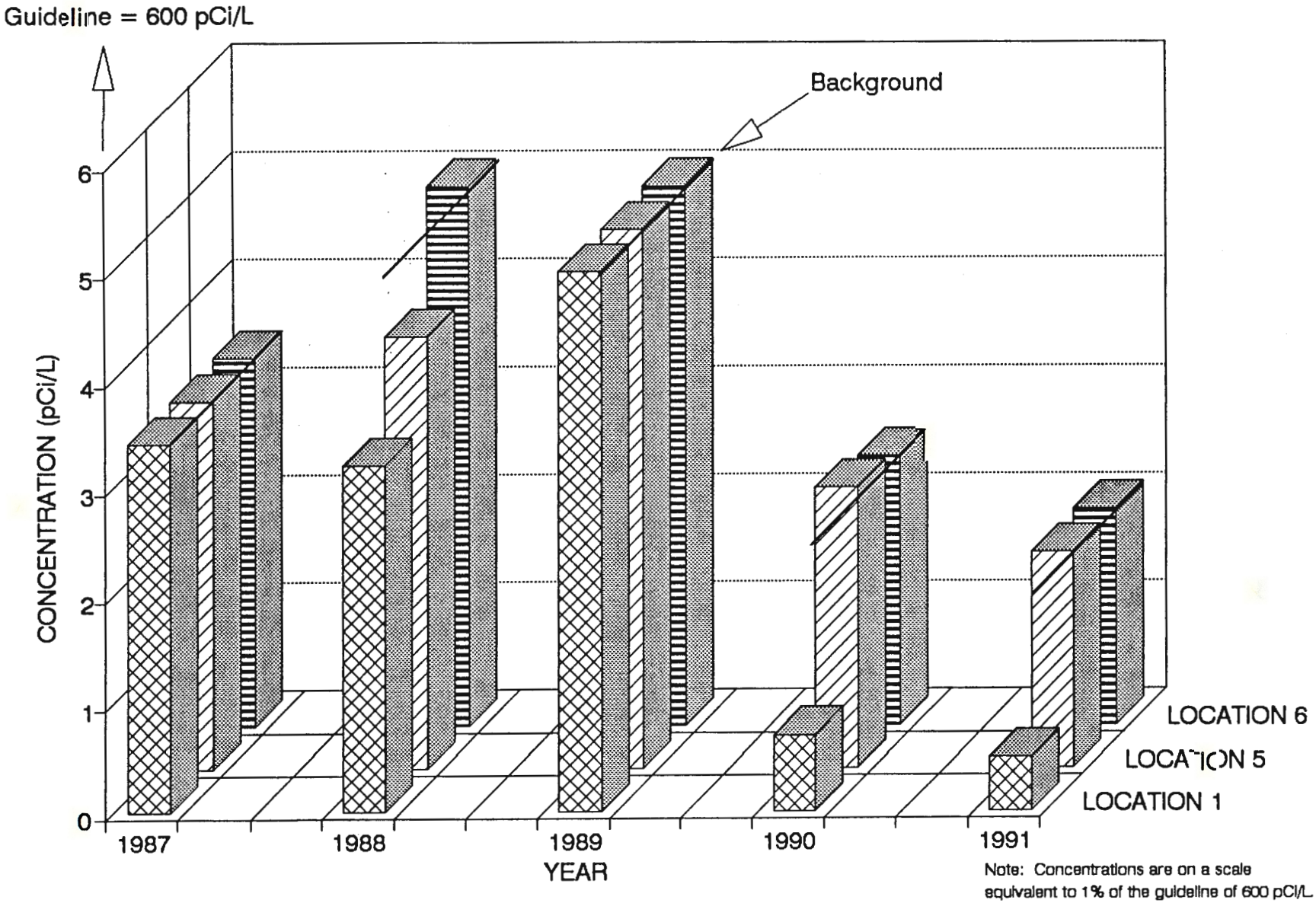


FIGURE 4-6
Average Annual Total Uranium Concentrations in Surface Water at WISS

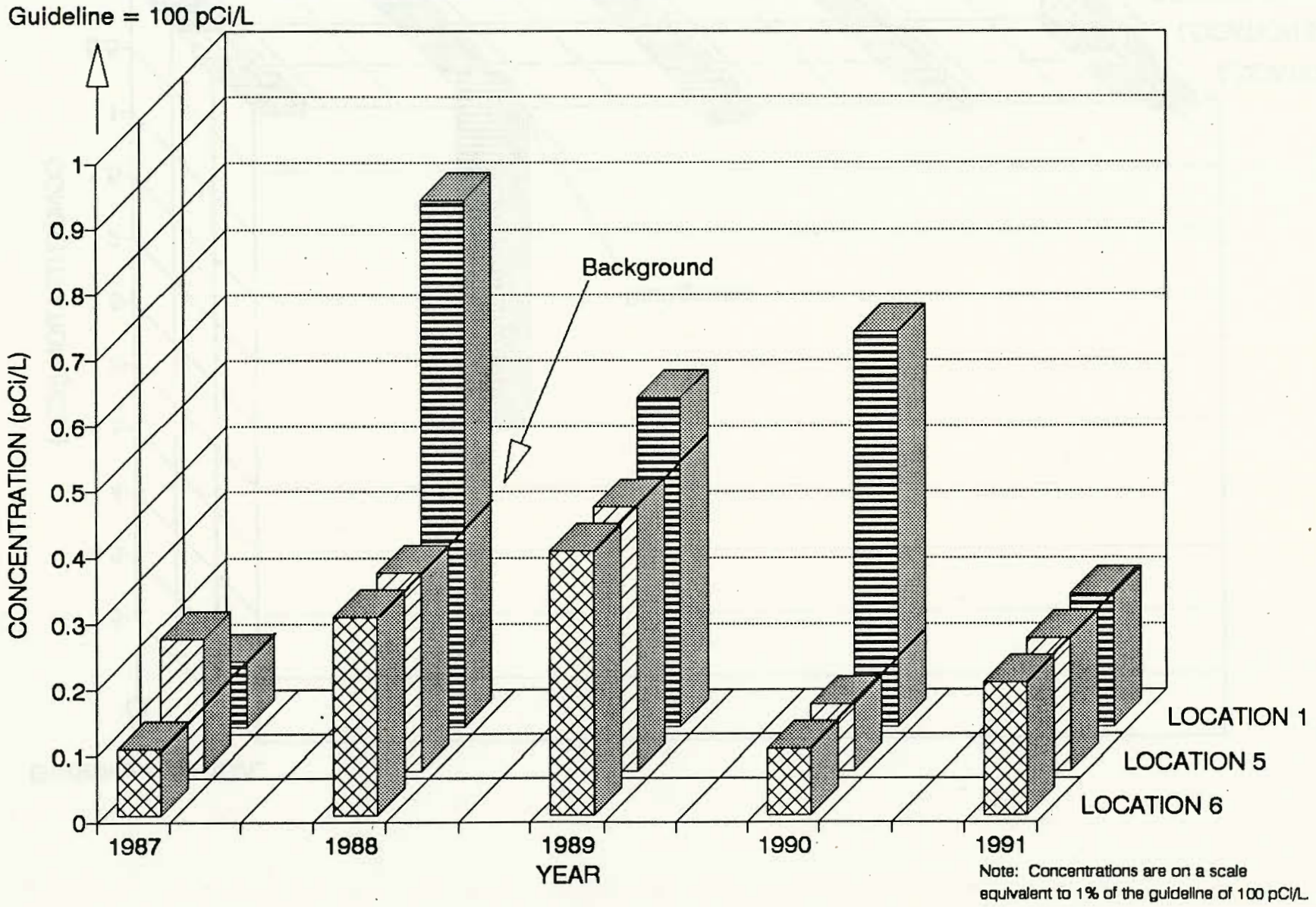


FIGURE 4-7
Average Annual Radium-226 Concentrations in Surface Water at WISS

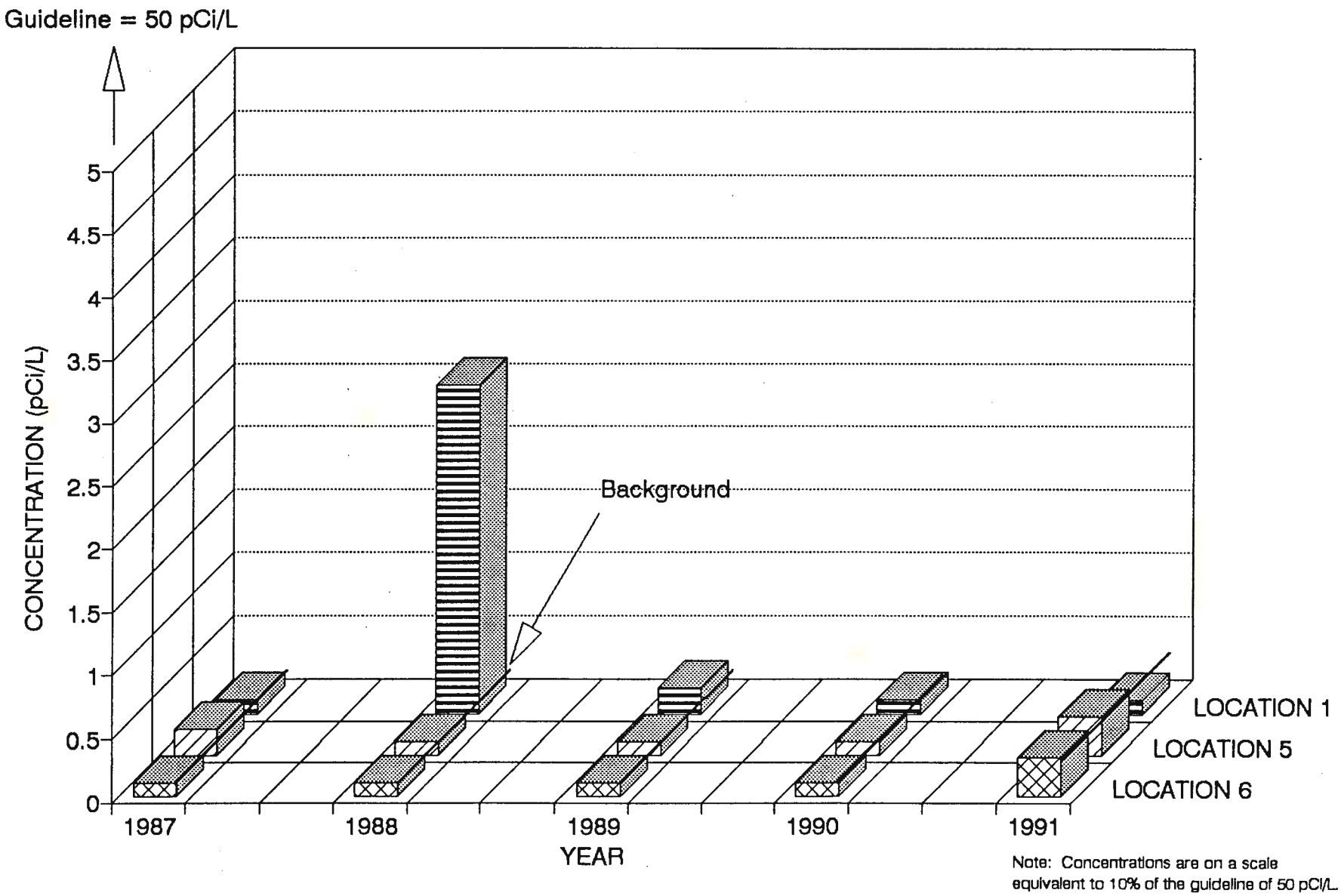


FIGURE 4-8
Average Annual Thorium-232 Concentrations in Surface Water at WISS

Data and discussion

Table 4-8 presents 1991 concentrations of total uranium, radium-226, radium-228, and thorium-232 in sediment; these concentrations reflect background conditions. All radionuclide concentrations in sediment were below the levels normally found in phosphate fertilizers (Appendix F).

Trends

Trends in average annual radionuclide concentrations measured in sediment from 1986 through 1991 are presented in Table 4-9 and shown in Figures 4-9 through 4-11. Results for radium-228 analyses are not included because they were not performed before 1991. Although some average concentrations exceeded the expected range (because of analytical variability and limited sample size), all concentrations continue to approximate natural background conditions.

4.1.5 Groundwater Monitoring

Groundwater monitoring is conducted to ensure compliance with environmental regulations and to provide information on potential migration of contaminants. There are two groundwater systems at WISS: an upper system monitored by wells identified with an "A" (e.g., WISS-1A), and a lower system monitored by wells identified with a "B" (e.g., WISS-1B). Groundwater monitoring locations are shown in Figure 4-12.

Five additional wells were sampled for the first time during the fourth quarter of 1991. The environmental monitoring plan for WISS (BNI 1991b) requires that these additional wells be sampled annually, effective January 1, 1992. The locations and sampling frequency were determined to be adequate and in accordance with DOE Order 5400.1, based on the groundwater flow velocity in both the upper and lower groundwater systems and the proximity of the wells to the site boundary.

Table 4-8

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Sediment in the Vicinity of WISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
			(Concentrations are in pCi/g)		
			Total Uranium[d]		
1	--[e]	--[f]	1.0	--[f]	1.0
5	1.8	1.8	3.3	2.0	2.2
6[g]	--[e]	1.5	3.7	3.6	2.9
			Radium-226		
1	--[e]	--[f]	0.59	--[f]	0.59
5	1.30	0.80	0.38	0.43	0.73
6[g]	--[e]	0.80	0.44	0.73	0.66
			Radium-228		
1	--[e]	--[f]	1.21	--[f]	1.21
5	6.3	1.9	0.72	0.76	2.4
6[g]	--[e]	1.4	0.87	1.73	1.3
			Thorium-232		
1	--[e]	--[f]	1.55	--[f]	1.55
5	0.30	1.70	0.72	0.80	0.88
6[g]	--[e]	0.70	0.83	1.20	0.91

[a]1 pCi/g is equivalent to 0.037 Bq/g. The DOE FUSRAP soil concentration guideline is 5 pCi/g each for radium-226, radium-228, and thorium-232. There is no guideline for total uranium.
[b]Measured background has not been subtracted.
[c]Sampling locations are shown in Figure 4-5.
[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.
[e]Water was frozen; sample could not be collected.
[f]Insufficient sediment for sampling.
[g]Background sampling location in Sheffield Brook, upstream of the site drainage ditch discharge point.

Table 4-9

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Sediment in the Vicinity of WISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{X} \pm 2s$)	Average Annual Concentration 1991
				(Concentrations are in pCi/g)			
				Total Uranium[e]			
1[f]	--	--	--	--	--	--	1.0
5	1.6	1.2	1	1.1	1	0.5 - 2	2.2
6[g]	0.8	1	0.9	1	1	0.8 - 1	2.9
				Radium-226			
1[f]	--	--	--	--	--	--	0.59
5	0.6	0.5	0.4	0.6	0.6	0.3 - 0.7	0.73
6[g]	0.5	0.4	0.4	0.5	0.7	0.3 - 0.7	0.66
				Thorium-232			
1[f]	--	--	--	--	--	--	1.55
5	2.0	0.6	0.7	0.8	1	0 - 2	0.88
6[g]	0.5	0.3	0.5	0.4	0.8	0.1 - 0.9	0.91

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991a).

[a]1 pCi/g is equivalent to 0.037 Bq/g. The FUSRAP soil concentration guideline for radium-226 and thorium-232 is 5 pCi/g. There is no guideline for total uranium.

[b]Measured background has not been subtracted.

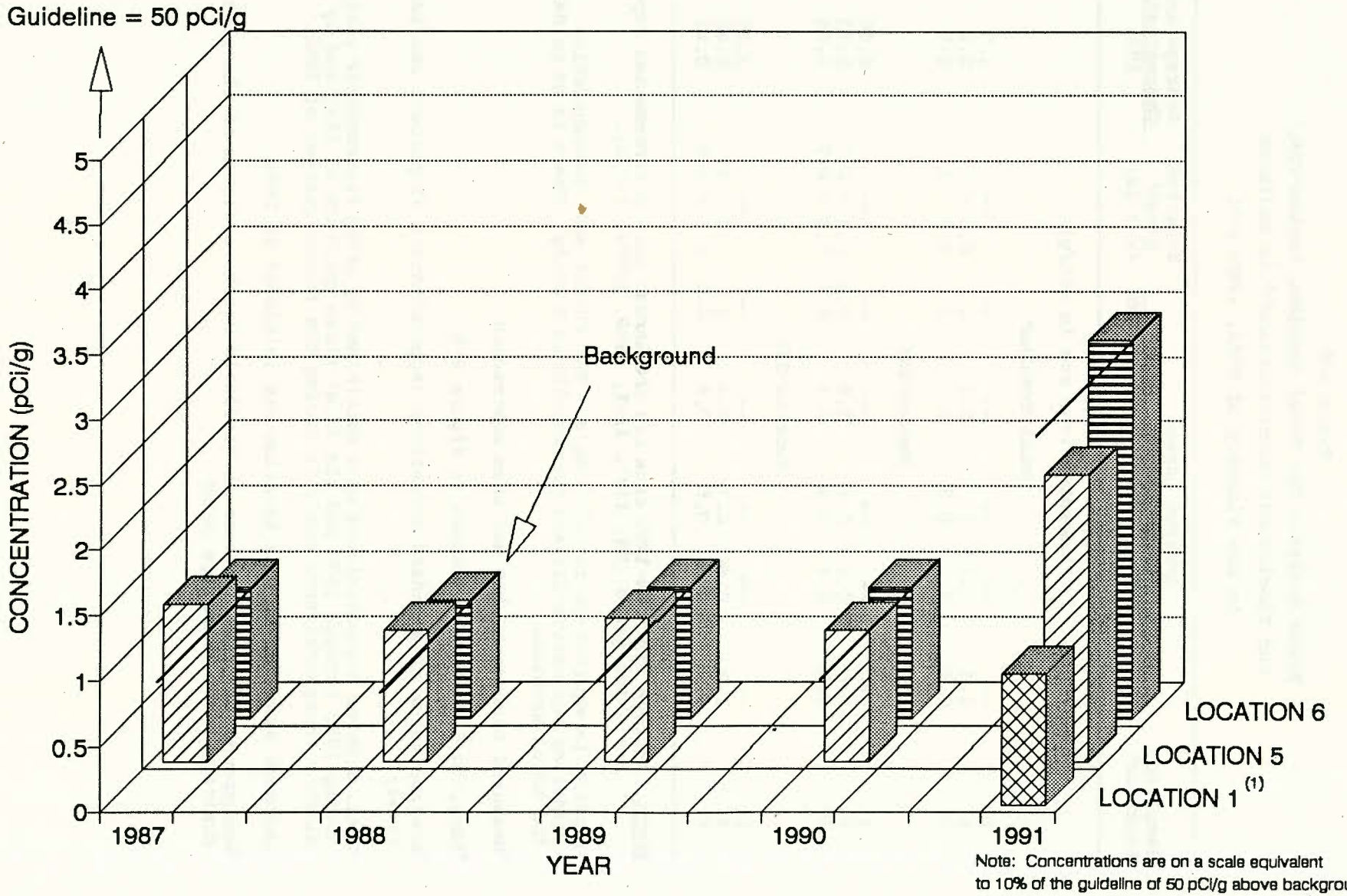
[c]Sampling locations are shown in Figure 4-5.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]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.

[f]Sediment sampling in this location was initiated in 1991.

[g]Background sampling location in Sheffield Brook, upstream of the site drainage ditch discharge point.



Note: Concentrations are on a scale equivalent to 10% of the guideline of 50 pCi/g above background.

(1) Sampling initiated in 1991.

FIGURE 4-9
Average Annual Total Uranium Concentrations in Sediment at WISS

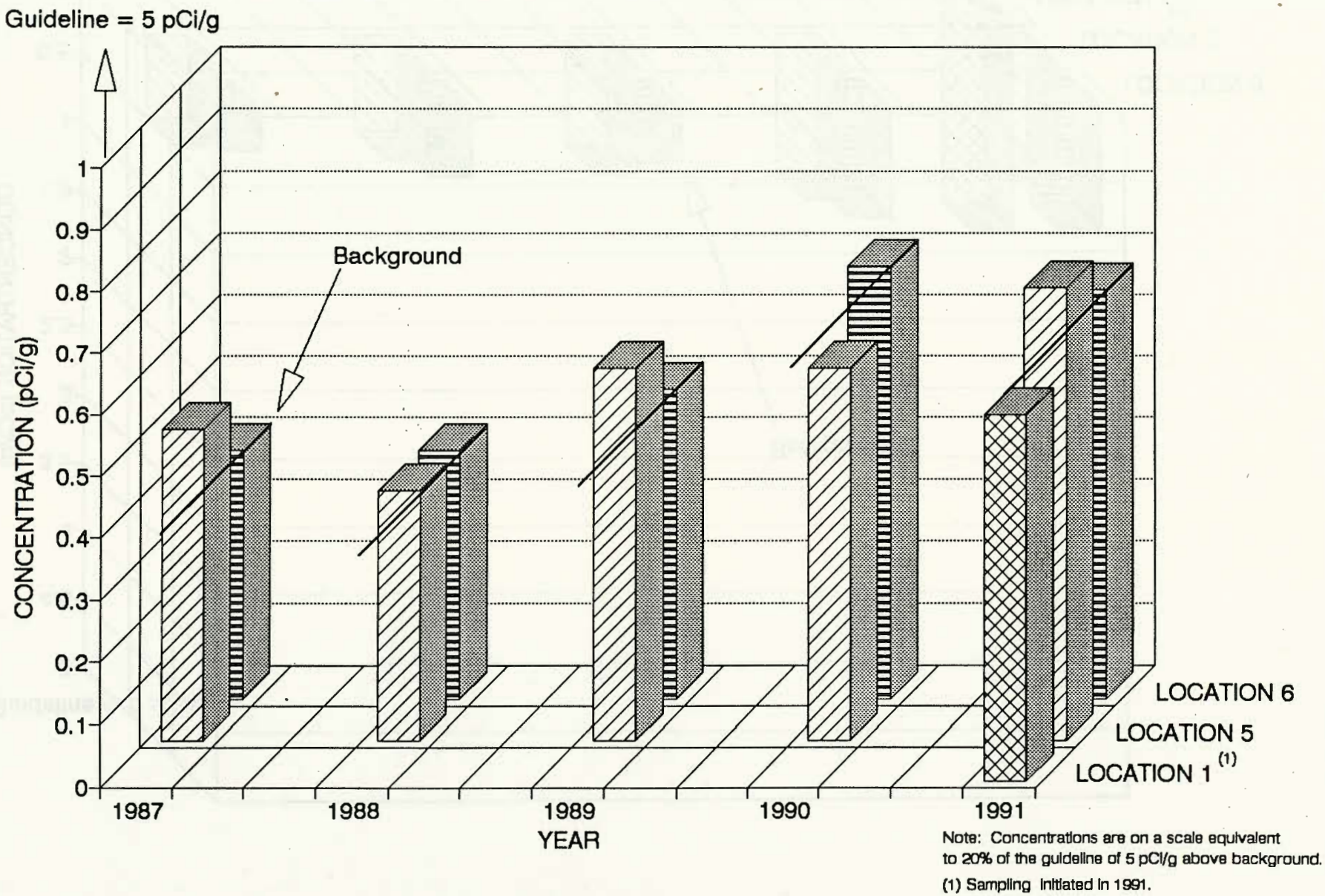
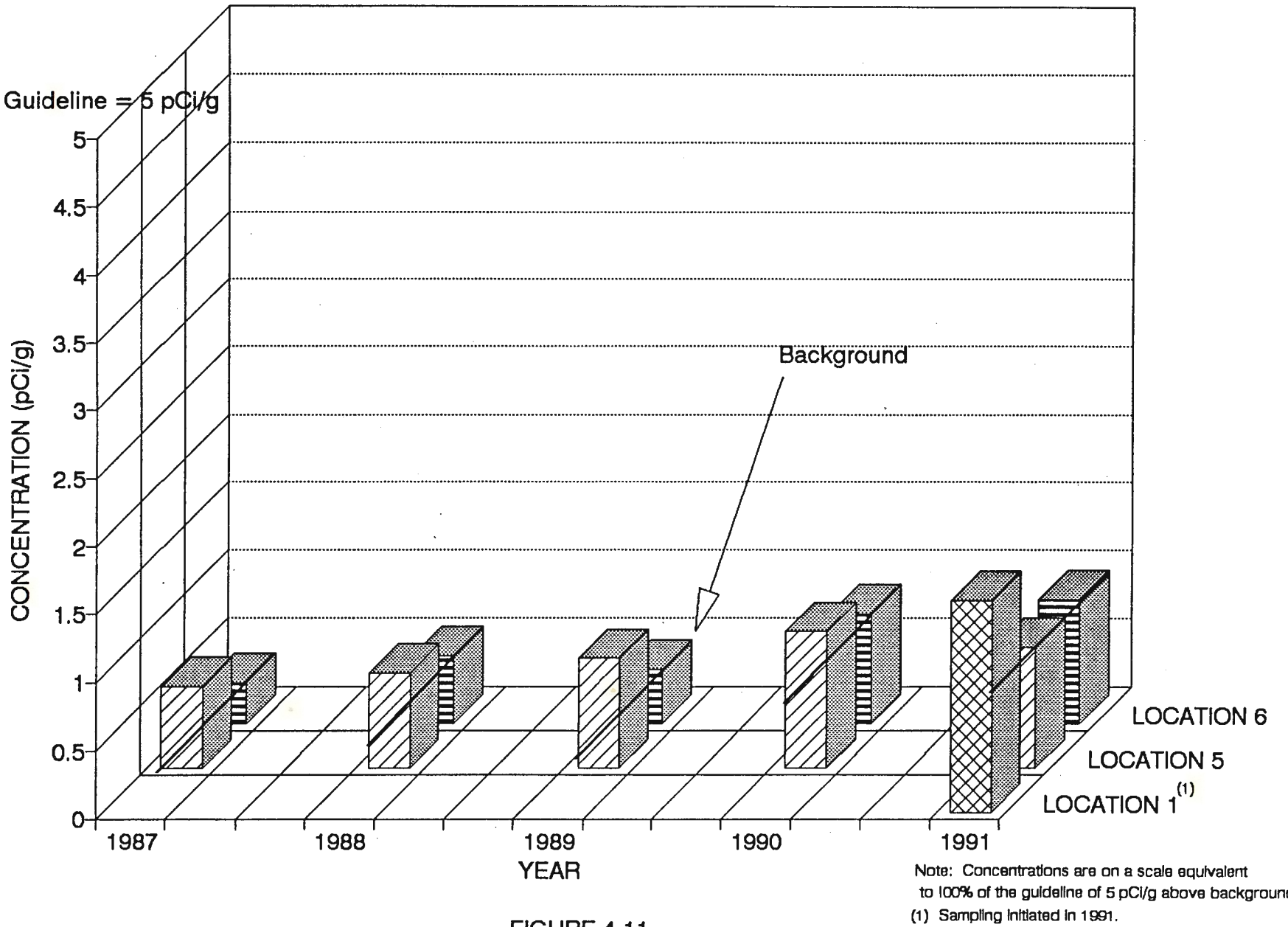


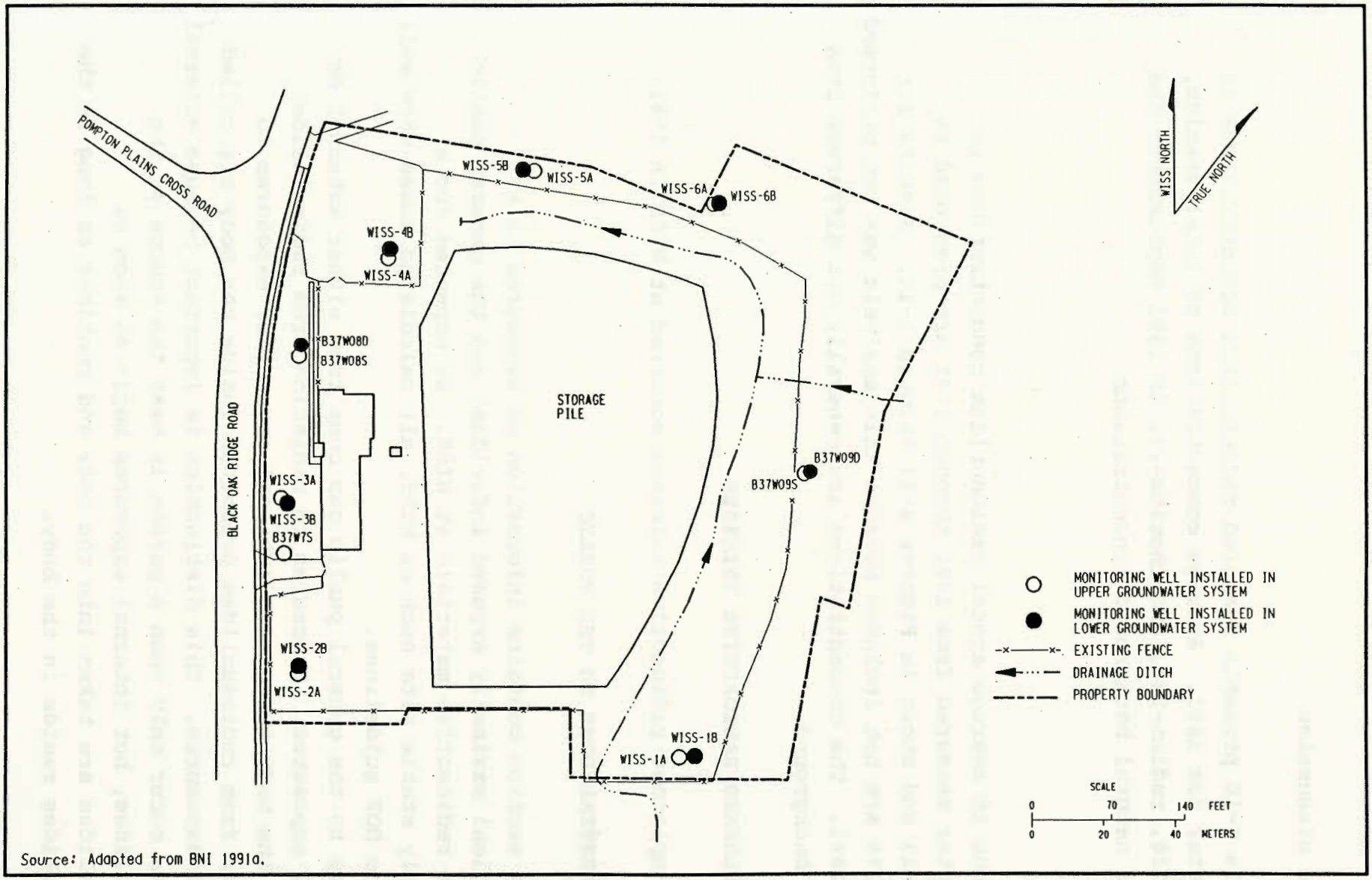
FIGURE 4-10
Average Annual Radium-226 Concentrations in Sediment at WISS



Note: Concentrations are on a scale equivalent to 100% of the guideline of 5 pCi/g above background.

(1) Sampling initiated in 1991.

FIGURE 4-11
Average Annual Thorium-232 Concentrations in Sediment at WISS



Source: Adapted from BNI 1991a.

137F006.DGN GIG03

Figure 4-12
Groundwater Sampling Locations at WISS

Data and discussion

Table 4-10 presents measured radionuclide concentrations in groundwater for 1991. Average concentrations of total uranium, radium-226, radium-228, and thorium-232 in 1991 approximate the range of natural background concentrations.

Trends

Trends in average annual radionuclide concentrations in groundwater measured from 1986 through 1991 are presented in Table 4-11 and shown in Figures 4-13 through 4-15. Results for radium-228 are not included because this analysis was not performed before 1991. The concentrations are generally not different from natural background.

4.2 UNPLANNED RADIOACTIVE RELEASES

No unplanned radioactive releases occurred at WISS in 1991.

4.3 POTENTIAL DOSE TO THE PUBLIC

This section contains information on exposures to a hypothetical maximally exposed individual and the general public from the radioactive materials at WISS. As expected for a relatively stable site such as WISS, all calculated doses were well below the DOE guidelines.

Doses to the general public 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. This distinction is important because external exposures occur only when a person is near the source of the radionuclides, but internal exposures begin as soon as radionuclides are taken into the body and continue as long as the radionuclides reside in the body.

Table 4-10

Concentrations[a,b] of Total Uranium, Radium-226, Radium-228, and Thorium-232 in Groundwater at WISS, 1991

Sampling Location[c]	Quarter 1	2	3	4	Avg
(Concentrations are in 10^{-9} µCi/ml)					
Total Uranium[d]					
WISS-2A	<3.39	<3.39	4.00	1.71	3
WISS-2B	<3.39	<3.39	<3.39	1.56	3
WISS-3A	<3.39	<3.39	10.1	1.71	5
WISS-3B	<3.39	4.06	<3.39	1.47	3
WISS-4A	6.90	9.70	6.67	13.61	9.22
WISS-4B	1.80	2.10	<3.39	4.16	3
WISS-5A	<3.39	4.06	3.39	0.88	3
WISS-5B	<3.39	3.39	3.39	0.85	3
WISS-6A	<3.39	3.39	<3.39	0.38	3
WISS-6B	<3.39	<3.39	12.11	0.61	5
B37W07S[e]	--	--	--	1.81	1.81
B37W08D[e]	--	--	--	0.80	0.80
B37W08S[e]	--	--	--	3.09	3.09
Background[f]					
WISS-1A	<0.30	<1.40	<3.39	7.81	3
WISS-1B	<0.30	<0.70	<3.39	1.93	2
B37W09D[e]	--	--	--	0.50	0.50
B37W09S[e]	--	--	--	1.73	1.73
Radium-226					
WISS-2A	0.40	0.55	1.68	3.30	1.5
WISS-2B	0.40	0.80	0.11	0.10	0.35
WISS-3A	0.60	0.17	0.07	0.20	0.26
WISS-3B	0.30	0.74	0.37	<0.10	0.4
WISS-4A	0.20	0.70	<0.07	<0.10	0.3
WISS-4B	0.40	0.60	0.23	<0.10	0.3
WISS-5A	0.20	0.40	0.09	<0.10	0.2
WISS-5B	0.30	0.45	0.94	<0.10	0.4
WISS-6A	0.20	0.70	0.72	0.10	0.43
WISS-6B	0.40	0.40	0.22	0.10	0.28
B37W07S[e]	--	--	--	15.3	15.3
B37W08D[e]	--	--	--	0.7	0.7
B37W08S[e]	--	--	--	11.3	11.3

Table 4-10

(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
		Radium-226 (cont.)			
Background[f]					
WISS-1A	0.40	0.75	0.24	<0.10	0.4
WISS-1B	0.40	<0.09	0.17	<0.10	0.2
B37W09D[e]	--	--	--	0.1	0.1
B37W09S[e]	--	--	--	0.4	0.4
		Radium-228			
WISS-2A	--[g]	<3.6	2.61	<0.50	2
WISS-2B	--[g]	<1.6	<3.03	<0.50	2
WISS-3A	--[g]	<3.6	<4.90	<0.50	3
WISS-3B	--[g]	<1.7	<5.26	<0.50	2
WISS-4A	0.0	<1.6	<0.07	<.32	0.7
WISS-4B	0.0	<1.4	<1.91	<.32	1
WISS-5A	--[g]	<4.0	<1.6	<.50	2
WISS-5B	--[g]	<4.5	<3.00	<.50	3
WISS-6A	--[g]	4.8	<1.96	<.50	2
WISS-6B	--[g]	<4.2	2.5	<.50	2
B37W07S[e]	--	--	--	<.50	0.5
B37W08D[e]	--	--	--	<.50	0.5
B37W08S[e]	--	--	--	<.50	0.5
Background[f]					
WISS-1A	<24	<2.9	<2.00	<.30	2
WISS-1B	<6.1	<3.2	<2.42	<.31	2
B37W09D[e]	--	--	--	<.50	0.5
B37W09S[e]	--	--	--	<.30	0.5
		Thorium-232			
WISS-2A	4.6	<0.04	1.43	1.80	2
WISS-2B	<0.1	<0.05	<0.04	0.80	0.3
WISS-3A	<0.1	<0.06	2.93	0.20	0.8
WISS-3B	<0.1	<0.02	0.4	<0.19	0.2
WISS-4A	0.1	0.19	0.04	<0.78	0.3
WISS-4B	<0.10	<0.1	<0.05	<0.79	0.3
WISS-5A	<0.10	<0.04	<0.03	<0.24	0.1
WISS-5B	0.1	<0.07	<0.05	<0.10	0.1
WISS-6A	<0.1	<0.06	0.24	<0.18	0.2
WISS-6B	<0.2	<0.04	<0.06	<0.11	0.1

Table 4-10

(continued)

Sampling Location[c]	Quarter 1	2	3	4	Avg
Thorium-232 (cont.)					
B37W07S[e]	--	--	--	0.90	0.90
B37W08D[e]	--	--	--	0.17	0.17
B37W08S[e]	--	--	--	0.50	0.50
Background[f]					
WISS-1A	<.10	<0.33	0.61	<0.78	0.5
WISS-1B	<0.10	<0.05	<0.07	<0.79	0.3
B37W09D[e]	--	--	--	<0.08	0.1
B37W09S[e]	--	--	--	1.60	1.60

[a]1 x 10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DCGs for total uranium, radium-226, radium-228, and thorium-232 are 600 x 10^{-9}, 100 x 10^{-9}, 100 x 10^{-9}, and 50 x 10^{-9} µCi/ml, respectively.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-12.

[d]Total uranium concentrations were determined by using fluorometric analysis during the first three quarters and by kinetic phosphorescence analysis during the fourth quarter.

[e]Sampling in this well was initiated during fourth quarter.

[f]Upgradient wells.

[g]Analysis not requested.

Table 4-11

Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations[a,b] in Groundwater at WISS, 1986-1991

Sampling Location[c]	Average Annual Concentration 1986	1987	1988	1989	1990	Expected Range[d] ($\bar{X} \pm 2s$)	Average Annual Concentration 1991
				(Concentrations are in 10^{-9} µCi/ml)			
				Total Uranium[e]			
WISS-1A[f]	0.8	1.2	1.6	1.5	2	0.5 - 2	3
WISS-1B[f]	0.2	0.5	1.1	1	2	0 - 2	2
WISS-2A	0.4	1.4	3.3	2.3	3	0 - 5	3
WISS-2B	0.6	1.1	2	1.8	3	0 - 4	3
WISS-3A	0.8	1.1	2.1	2.3	3	0.1 - 4	5
WISS-3B	0.2	0.7	1.7	1.9	3	0 - 4	3
WISS-4A	4.7	4.6	8.3	6.3	5	3 - 9	9.22
WISS-4B	0.4	0.9	1	1.4	2	0 - 2	3
WISS-5A	1.1	1.5	2.2	1.9	3	0.5 - 3	3
WISS-5B	0.5	1.2	1.5	1.2	3	0 - 3	3
WISS-6A	0.6	4.3	1.6	1.4	3	0 - 5	3
WISS-6B	0.7	1.2	2	1.8	3	0 - 3	5
				Radium-226			
WISS-1A[f]	0.7	0.3	1	1.2	0.4	0.1 - 2	0.4
WISS-1B[f]	0.4	0.4	0.8	1.2	0.3	0 - 1	0.2
WISS-2A	0.1	0.4	1.3	1.7	0.6	0 - 2	1.5
WISS-2B	0.5	0.4	1.1	1.1	0.6	0 - 1	0.35
WISS-3A	0.4	0.4	0.9	1	0.5	0 - 1	0.26
WISS-3B	0.5	0.4	1	0.9	0.6	0.2 - 1	0.4
WISS-4A	0.4	0.2	0.8	0.9	0.4	0 - 1	0.3
WISS-4B	0.2	0.3	1	0.8	0.3	0 - 1	0.3
WISS-5A	0.4	0.3	1	0.8	0.4	0 - 1	0.2
WISS-5B	0.4	0.3	0.9	1	0.2	0 - 1	0.4
WISS-6A	0.3	0.4	1	0.9	0.6	0 - 1	0.43
WISS-6B	0.6	0.3	1	0.9	0.3	0 - 1	0.28
				Thorium-232			
WISS-1A[f]	0.1	0.1	0.4	0.2	0.1	0 - 0.5	0.5
WISS-1B[f]	0.1	0.1	0.2	0.2	0.1	0 - 0.2	0.3
WISS-2A	0.1	0.1	1	0.5	0.2	0 - 1	2
WISS-2B	0.1	0.1	0.2	0.2	0.1	0 - 0.2	0.3
WISS-3A	0.2	0.1	0.3	0.4	0.1	0 - 0.5	0.8
WISS-3B	0.2	0.1	0.2	0.2	0.1	0.1 - 0.3	0.2
WISS-4A	0.1	0.1	0.3	0.2	0.1	0 - 0.4	0.3
WISS-4B	0.1	0.1	0.2	0.2	0.2	0.1 - 0.3	0.3
WISS-5A	0.1	0.1	0.2	0.2	0.1	0 - 0.2	0.1
WISS-5B	0.1	0.1	0.2	0.2	0.1	0 - 0.2	0.1
WISS-6A	0.1	0.3	0.3	0.2	0.2	0 - 0.4	0.2
WISS-6B	0.2	0.2	0.2	0.3	0.1	0.1 - 0.3	0.1

Table 4-11

(continued)

NOTE: Sources for 1986-1990 data are the annual site environmental reports for those years (BNI 1987, 1988, 1989, 1990a, 1991a).

[a]1×10^{-9} µCi/ml is equivalent to 0.037 Bq/L. The DOE guidelines for total uranium, radium-226, and thorium-232 are 600×10^{-9}, 100×10^{-9}, and 50×10^{-9} µCi/ml, respectively.

[b]Measured background has not been subtracted.

[c]Sampling locations are shown in Figure 4-12.

[d]Average value ±2 standard deviations (approximately 95 percent confidence level).

[e]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.

[f]Upgradient, background well.

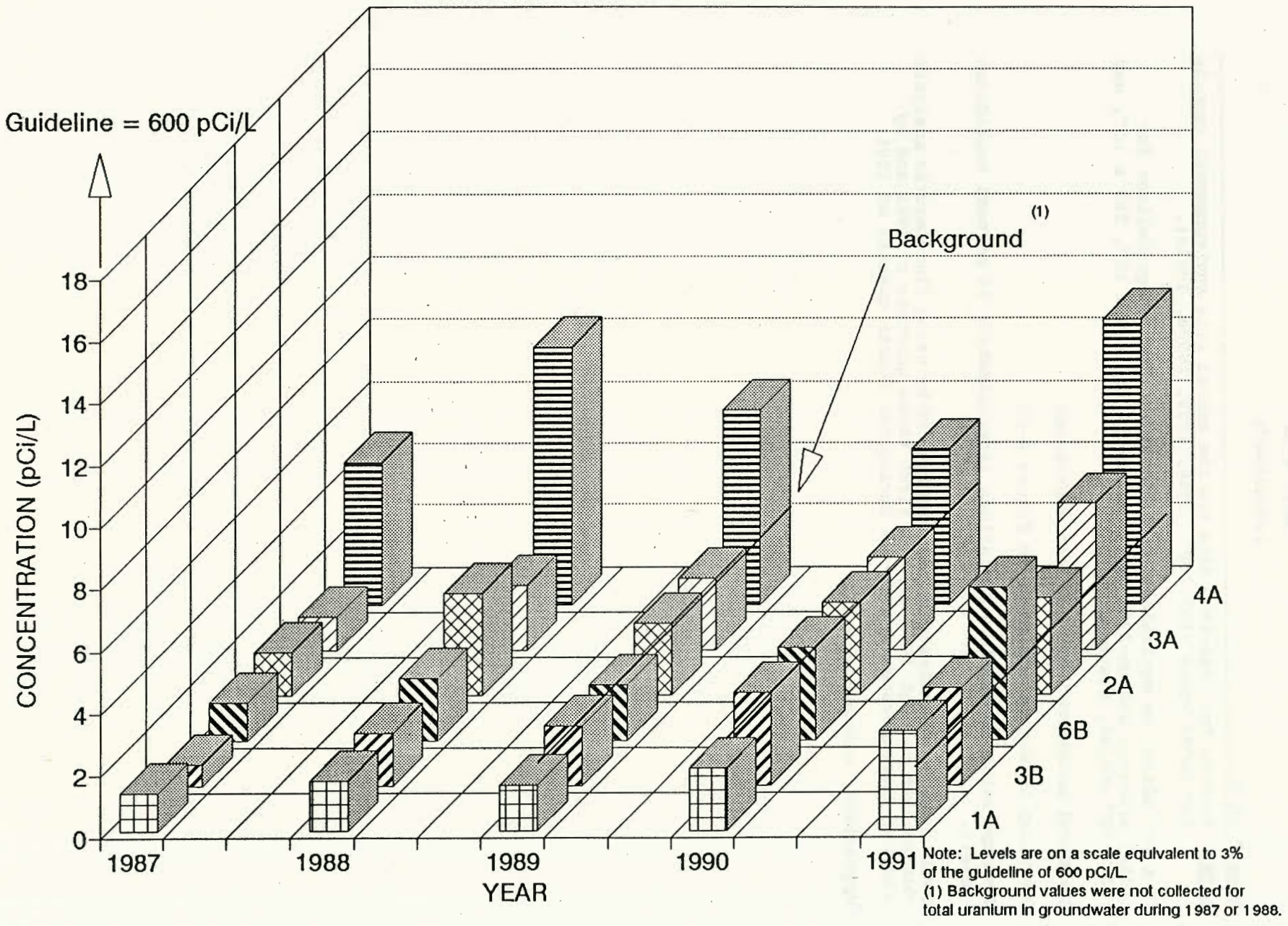
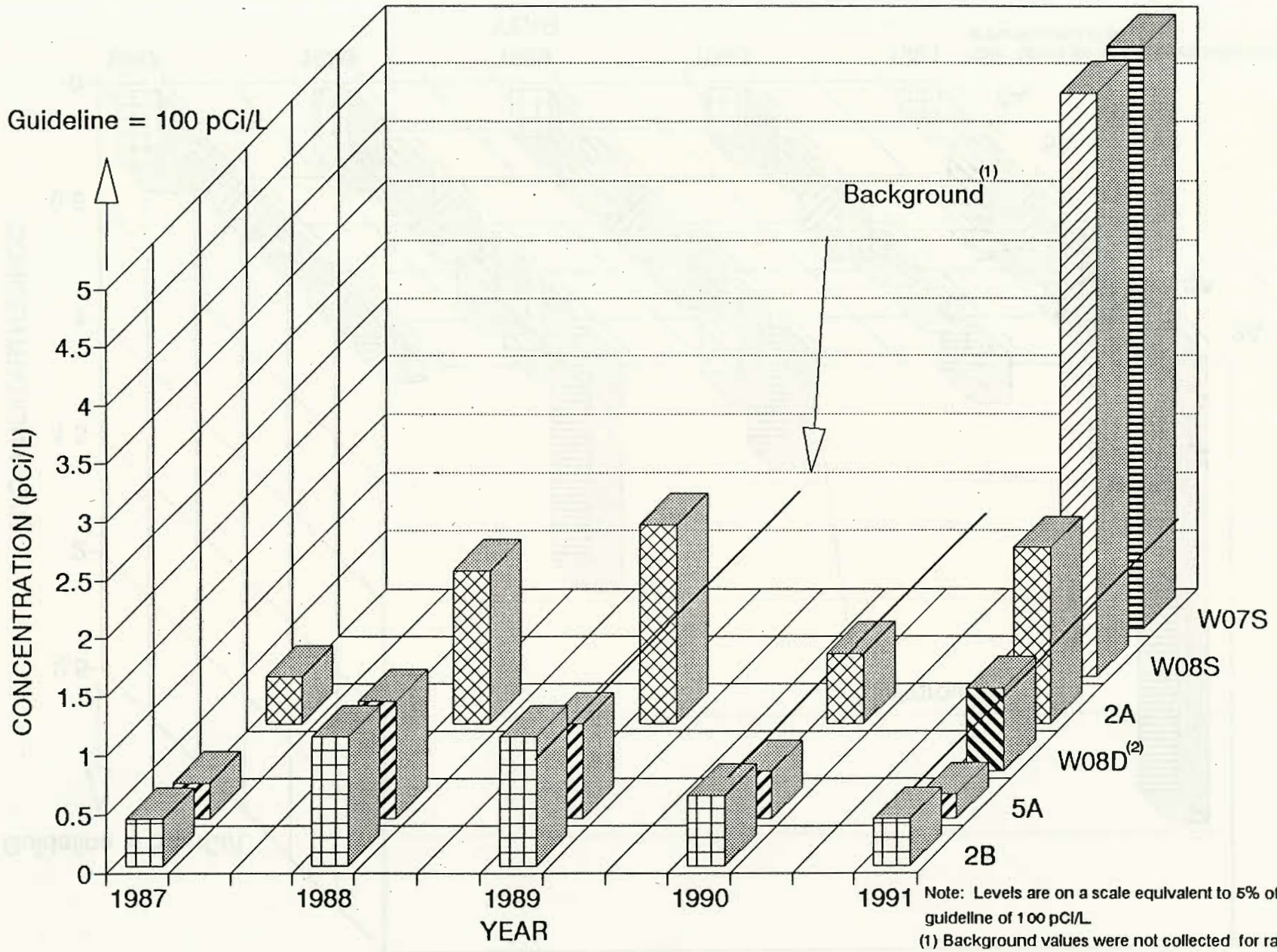


FIGURE 4-13
Average Annual Total Uranium Concentrations in Groundwater at WISS



Note: Levels are on a scale equivalent to 5% of the guideline of 100 pCi/L.
(1) Background values were not collected for radium-226 in groundwater during 1987 or 1988.
(2) Sampling initiated in 1991.

FIGURE 4-14
Average Annual Radium-226 Concentrations in Groundwater at WISS

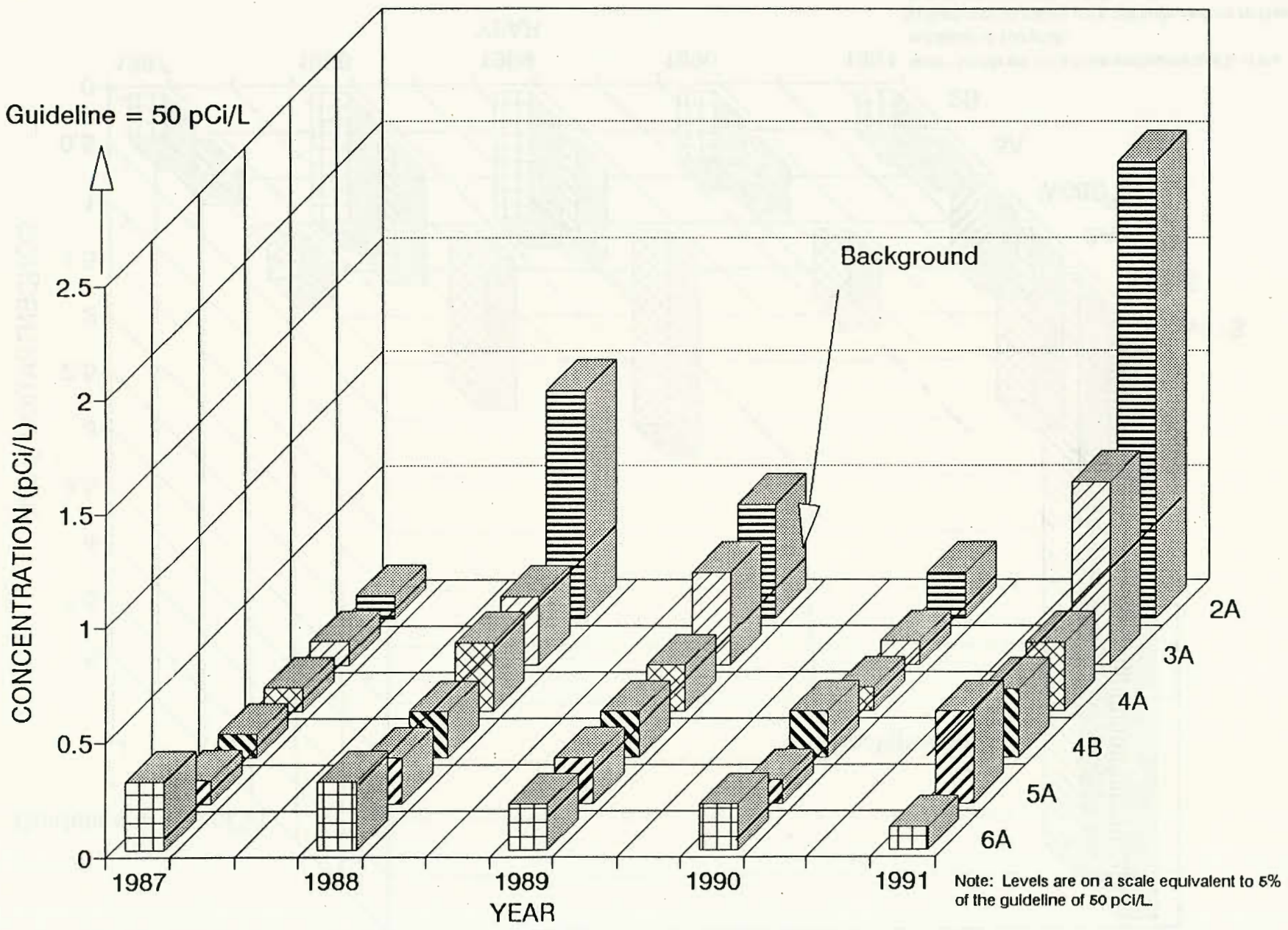


FIGURE 4-15
Average Annual Thorium-232 Concentrations in Groundwater at WISS

To assess the potential health effects of the materials stored at WISS, 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 pathways considered are surface water, groundwater, air, and direct exposure. All doses presented in this section are estimated and do not represent actual doses. A summary is provided in Table 4-12.

4.2.1 Hypothetical Maximally Exposed Individual

Direct gamma radiation pathway

The hypothetical maximally exposed individual is assumed to work 10 m (30 ft) from the southern WISS fenceline and spend 40 hours per week of his or her time there. (This location was chosen because the exposure levels are greater along the southern fenceline.)

The yearly dose from direct exposure to the hypothetical person was calculated by using the equation given in Appendix D for direct gamma radiation exposure. The calculated dose for this individual is 0.6 mrem/yr (0.006 mSv/yr), well below the DOE guideline of 100 mrem/yr above the background level. This calculation is conservative because an individual would not likely spend 40 hours per week at this location.

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 of the site. Because concentrations of total uranium, radium-226, and thorium-232 in groundwater, Sheffield Brook, and Pompton River are barely detectable above normal background levels and there are no drinking water wells within

Table 4-12

Summary of Calculated Doses[a] for WISS, 1991

Exposure Pathway	Dose to Hypothetical Maximally Exposed Individual (mrem/yr)[b]	Collective Dose for Population Within 80 km of Site (person-rem/yr)[b]
Direct gamma radiation[c]	0.6	--[d]
Drinking water	--[d]	--[d]
Ingestion	--[d]	--[d]
Air immersion	--[d]	--[d]
Inhalation[e]	9.4×10^{-5}	0.022
Total	0.6[f]	0.022
Background[g]	78	7.8×10^{5} [h]

[a]Does not include radon.

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

[c]Does not include contribution from background.

[d]No credible exposure pathway identified.

[e]Calculated using EPA's AIRDOS model (Version 3.0). Based on the AIRDOS PC user manual, the 50-yr effective dose equivalent factors were used to determine the committed effective dose equivalent to various critical organs. Therefore, the "mrem/yr" unit of effective dose equivalent from internal deposition of radionuclides should be interpreted as the "50-yr" committed dose equivalent based on total radiological particulate intake for a given year.

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

[g]Direct gamma radiation exposure only.

[h]Calculated by the following: (78 mrem/yr) (10×10^{6} people).

1.6 km (1 mi) of the site, the dose contribution of these radionuclides from these sources to the individual is negligible.

Air pathway (ingestion, air immersion, inhalation)

To calculate a conservative dose to the hypothetical maximally exposed individual, the individual was assumed to live and work within 300 m (1,000 ft) of the site. Air doses determined using EPA's AIRDOS model were found to be negligible [9.4×10^{-5} mrem/yr (9.4×10^{-7} mSv/yr)], well below the 10-mrem/yr (0.1-mSv/yr) limit given in 40 CFR Part 61, Subpart H, and the DOE 100-mrem/yr (1-mSv/yr) basic dose limit. The 1991 Clean Air Act compliance report is provided in Appendix E.

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 estimated radioactive particulates released in 1991 and the effective dose equivalent due to total external direct gamma radiation measured at the fenceline in 1991. When these doses are added together, the total dose is 0.6 mrem/yr (6×10^{-3} mSv/yr). This dose is less than an individual receives from a two-hour flight at 12,000 m (39,000 ft) (Appendix F).

4.2.2 Population Dose

The collective dose that the general population living within 80 km (50 mi) of the site would receive was also calculated.

Direct gamma radiation pathway

Distance from the site to the nearest residential areas and the presence of intervening structures reduce direct gamma radiation exposure from WISS. Given this additional shielding and the low

dose calculated for the hypothetical maximally exposed individual, it is reasonable to assume that there is no detectable collective exposure to the general public above variations in the normal background levels.

Drinking water pathway

Because there are no nearby drinking water wells, radionuclide concentrations in groundwater and surface water are low, and the hypothetical maximally exposed individual would receive no significant dose commitment from radionuclides in drinking water, it is reasonable to assume that the general public would not receive a committed dose in drinking water either.

Air pathway (ingestion, air immersion, inhalation)

The AIRDOS model provides an effective dose equivalent for contaminants transported via the atmospheric pathway at different distances from the site (Table 4-13). Using these effective dose equivalents and the population density, the collective dose for the general population within 80 km (50 mi) of the site was calculated to be 0.022 person-rem/yr (2.2×10^{-4} person-Sv/yr).

Total population dose

The total population dose is the sum of the doses from all exposure pathways. Because the only pathway with a major contribution to the population dose is the air pathway, the total population dose is equal to that given for the air pathway [0.022 person-rem/yr (2.2×10^{-4} person-Sv/yr)]. The collective population dose is extremely small when compared with the collective population dose due to natural background gamma radiation in the area [7.8×10^{5} person-rem/yr (7.8×10^{3} person-Sv/yr)] for the same population within 80 km (50 mi) of WISS.

Table 4-13

Maximum Effective Dose to the General Public from WISS, 1991

Distance from the Site (m) (inner radius)	(outer radius)	Effective Dose Equivalent (mrem/yr)[a,b]	Population Dose (person-rem/yr)[c,d]
0 -	1,000	9.7×10^{-5} *	1.2×10^{-3}
1,000 -	3,000	1.0×10^{-5}	9.7×10^{-4}
3,000 -	10,000	1.6×10^{-6}	1.8×10^{-3}
10,000 -	80,000	2.4×10^{-7}	1.8×10^{-2}
		Total Dose	0.022

[a]To be conservative, the effective dose equivalent used for each range was that for the distance closest to the site. The effective dose equivalent is 100 mrem/yr above background.

[b]Values were obtained using AIRDOS (Version 3.0).

[c]A population density of 3,900 persons/km^2 (10,000 persons/mi^2) was used in the calculation.

[d]Calculated using: Population dose = [population density] [π(outer radius)^2 - π(inner radius)^2] [effective dose equivalent].

*Effective dose equivalent for 300 m.

5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM

The environmental monitoring program at WISS includes surface water, sediment, and groundwater monitoring for nonradiological parameters.

Surface water and groundwater samples were analyzed for the indicator parameters total organic carbon, total organic halides, pH, and specific conductivity; mobile ions; organic compounds; and a suite of metals. Sediments were analyzed for metals. The indicator parameters are not addressed in this report because they are only gross indicators of ambient water quality; the parameters indicate that the groundwater and surface water associated with WISS is of a quality that might be expected in an area of mixed residential/commercial establishments.

Nonradiological parameters are monitored as specified by EPA requirements; DOE directives; and federal, state, and local statutes, regulations, and requirements applicable to DOE.

WISS is not an active site; therefore, the only "effluents" from the site would be contaminants that migrate by routes such as infiltration into groundwater, surface water runoff, or suspension and dispersion of airborne contaminants. Based on current site information, very limited nonradiological contamination of the soil exists in localized areas and does not pose a potential threat to human health or the environment.

Tables 5-1 and 5-2 give laboratory detection limits for the metals and volatile and semivolatile organic compound analyses performed on samples from WISS. Several metals identified at the site (e.g., calcium, potassium, sodium, magnesium, and manganese) were not considered because of the variability in their relative abundance in undisturbed soils and their common occurrence in the earth's crust.

To determine whether any metals have been released to the environment or are at concentrations potentially harmful to human health and the environment, comparisons were made between downgradient locations and upgradient (background) locations to

Table 5-1

Laboratory Detection Limits for Metals Analyses of Surface Water, Sediment, and Groundwater at WISS

Analyte	Laboratory Detection Limit for Sediment (mg/kg)	Laboratory Detection Limit for Water (µg/L)
Aluminum	40	200
Antimony	12	60
Arsenic		
(ICPAES[a] scan)	100	500
(Atomic absorption)	2	10
Barium	40	200
Beryllium	1	5
Boron	20	100
Cadmium	1	5
Calcium	1,000	5,000
Chromium	2	10
Cobalt	10	50
Copper	5	25
Iron	20	100
Lead		
(ICPAES scan)	100	500
(Atomic absorption)	1	5
Lithium	20	100
Magnesium	1,000	5,000
Manganese	3	15
Molybdenum	20	100
Nickel	8	40
Potassium	1,000	5,000
Selenium		
(ICPAES scan)	100	500
(Atomic absorption)	1	5
Silver	2	10
Sodium	1,000	5,000
Thallium		
(ICPAES scan)	100	500
(Atomic absorption)	2	10
Vanadium	10	50
Zinc	4	20

[a]ICPAES - Inductively coupled plasma atomic emission spectrophotometry.

Table 5-2
Laboratory Detection Limits for
Organic Chemical Analyses of Surface Water
and Groundwater at WISS

Compound	Laboratory Detection Limit (µg/L)
Volatile Organic Compounds	
Chloromethane	10
Bromomethane	10
Vinyl chloride	10
Chloroethane	10
Methylene chloride	3
Acetone	10
Carbon disulfide	5
1,1-Dichloroethene	5
1,1-Dichloroethane	5
1,2-Dichloroethene (total)	5
Chloroform	5
1,2-Dichloroethane	5
2-Butanone	10
1,1,1-Trichloroethane	5
Carbon tetrachloride	5
Vinyl acetate	10
Bromodichloromethane	5
1,2-Dichloropropane	5
cis-1,3-Dichloropropene	5
Trichloroethene	5
Dibromochloromethane	5
1,1,2-Trichloroethane	5
Benzene	5
trans-1,3-Dichloropropene	5
Bromoform	5
4-Methyl-1,2-pentanone	10
2-Hexanone	10
Tetrachloroethene	5
1,1,2,2-Tetrachloroethane	5
Toluene	5
Chlorobenzene	5
Ethylbenzene	5
Styrene	5
Xylene (total)	5

Table 5-2

(continued)

Compound	Laboratory Detection Limit (µg/L)
Semivolatile Organic Compounds	
Phenol	10
Bis(2-chloroethyl)ether	10
2-Chlorophenol	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
Benzyl alcohol	10
1,2-Dichlorobenzene	10
2-Methylphenol	10
Bis(2-chloroisopropyl)ether	10
4-Methylphenol	10
N-Nitroso-di-n-propylamine	10
Hexachloroethane	10
Nitrobenzene	10
Isophorone	10
2-Nitrophenol	10
2,4-Dimethylphenol	10
Benzoic acid	50
Bis(2-chloroethoxy)methane	10
2,4-Dichlorophenol	10
1,2,4-Trichlorobenzene	10
Naphthalene	10
4-Chloroaniline	10
Hexachlorobutadiene	10
4-Chloro-3-methylphenol	10
2-Methylnaphthalene	10
Hexachlorocyclopentadiene	10
2,4,6-Trichlorophenol	10
2,4,5-Trichlorophenol	50
2-Chloronaphthalene	10
2-Nitroaniline	50
Dimethylphthalate	10
Acenaphthylene	10
2,6-Dinitrotoluene	10
3-Nitroaniline	50
Acenaphthene	10
2,4-Dinitrophenol	50
4-Nitrophenol	50
Dibenzofuran	10
2,4-Dinitrotoluene	10
Diethylphthalate	10
4-Chlorophenyl-phenylether	10
Fluorene	10

Table 5-2

(continued)

Compound	Laboratory Detection Limit (µg/L)
Semivolatile Organic Compounds (cont'd)	
4-Nitroaniline	50
4,6-Dinitro-2-methylphenol	50
N-Nitrosodiphenylamine (1)	10
4-Bromophenyl-phenylether	10
Hexachlorobenzene	10
Pentachlorophenol	50
Phenanthrene	10
Anthracene	10
Di-n-butylphthalate	10
Fluoranthene	10
Pyrene	10
Butylbenzylphthalate	10
3,3'-Dichlorobenzidine	20
Benzo(a)anthracene	10
Chrysene	10
Bis(2-ethylhexyl)phthalate	10
Di-n-octyl phthalate	10
Benzo(b)fluoranthene	10
Benzo(k)fluoranthene	10
Benzo(a)pyrene	10
Indeno(1,2,3-cd)pyrene	10
Dibenzo(a,h)anthracene	10
Benzo(g,h,i)perylene	10

detect any concentrations significantly (greater than ten times) above known background concentrations. No concentrations met this criterion; data are included in Appendix G.

Surface water, sediment, and groundwater samples analyzed for chemical contaminants to date do not comprise an adequate data group sufficient to support a trend analysis.

5.1 SURFACE WATER MONITORING

No metals were detected in the surface water at concentrations significantly different from background, and no organic compounds were detected in the surface water. Therefore, WISS does not appear to be adversely affecting the quality of the surface water in the area.

5.2 SEDIMENT MONITORING

Concentrations of metals in downstream samples were comparable to those in upstream samples. Because these concentrations were similar, metals do not appear to be migrating from WISS.

5.3 GROUNDWATER MONITORING

Nonradiological groundwater monitoring is conducted primarily to provide information on the groundwater quality in the area.

Organic compounds were not detected in groundwater at WISS. Slightly elevated levels of metals were observed in the third quarter; these concentrations were the result of anomalies in the hydraulic characteristics of the site during this period (i.e., localized drought and poor sample quality due to excess turbidity). Generally, concentrations of metals were comparable to background results (all were less than the ten-times-background criterion).

5.4 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

A permit application to comply with the EPA NPDES requirements will be completed in 1992. Stormwater discharges will be sampled in the third quarter of 1992 to meet the application requirements.

5.5 OTHER EMISSIONS MONITORING

WISS is not an active site; therefore there are no emissions, other than those already discussed, to monitor.

5.6 ENVIRONMENTAL OCCURRENCES

No unplanned releases occurred at WISS in 1991.

5.7 SARA TITLE III REPORTING

No reports under Section 313 of the Emergency Preparedness and Community Right-to-Know Act were filed during 1991. FUSRAP sites were not subject to toxic chemical release reporting provisions under 40 CFR 372.22 in 1991. However, in accordance with the spirit and language of DOE Order 5400.1, FUSRAP evaluates and inventories toxic chemicals used onsite to ensure that no threshold planning quantities (TPQs) are exceeded.

Toxic chemicals, such as nitric acid, are used at FUSRAP sites for sampling and other purposes. However, the quantities of such chemicals stored onsite are well below TPQs. If a TPQ is exceeded at a site, the Toxic Chemical Release Inventory Reporting Form (Form R) under 40 CFR 372.85 will be filed with EPA.

6.0 GROUNDWATER PROTECTION PROGRAM

6.1 HYDROGEOLOGICAL CHARACTERISTICS

6.1.1 Site Hydrogeology

WISS is located within the glaciated section of the Piedmont Plateau. The ground surface at the site slopes gently toward the northwest. The site is underlain by unstratified till deposits consisting of boulders, gravel, sand, silt, and clay (ERM-Southeast, Inc. 1983). The thickness of these glacial deposits ranges from 6.1 to 15 m (20 to 50 ft). Underlying the unconsolidated glacial deposits is the Triassic Brunswick Formation, which typically consists of alternating beds of reddish-brown sandstone and mudstone. Groundwater in the vicinity of WISS is found in both the unconsolidated glacial deposits and the underlying bedrock.

Potentiometric levels in wells completed in the upper groundwater system generally range from 0.1 to 2.3 m (0.36 to 7.7 ft) below ground surface. However, levels in WISS-6A (Figure 6-1) range from ground surface to 0.4 m (1.3 ft) above ground surface in the spring. This is indicative of a local discharge area along the base of the hillside. Wells in this zone are screened at depths of 1.5 to 9.8 m (5 to 32 ft).

Flowing conditions were encountered in most of the lower groundwater system wells. Six of the wells in this system are open-hole completions (i.e., no screen or filter pack) below a surface casing grouted into the Brunswick Formation from depths of 7.9 to 24 m (26 to 79 ft). Two of the wells finished in this system are screened at depths ranging from 11.6 to 19.8 m (38 to 65 ft). One well (B37W07S) is completed in an intermediate zone that is 5.5 to 7 m (18 to 23 ft) deep.

6.1.2 Groundwater Quality and Usage

Groundwater in the unconsolidated material is an important local source of water for public supply and industrial use in

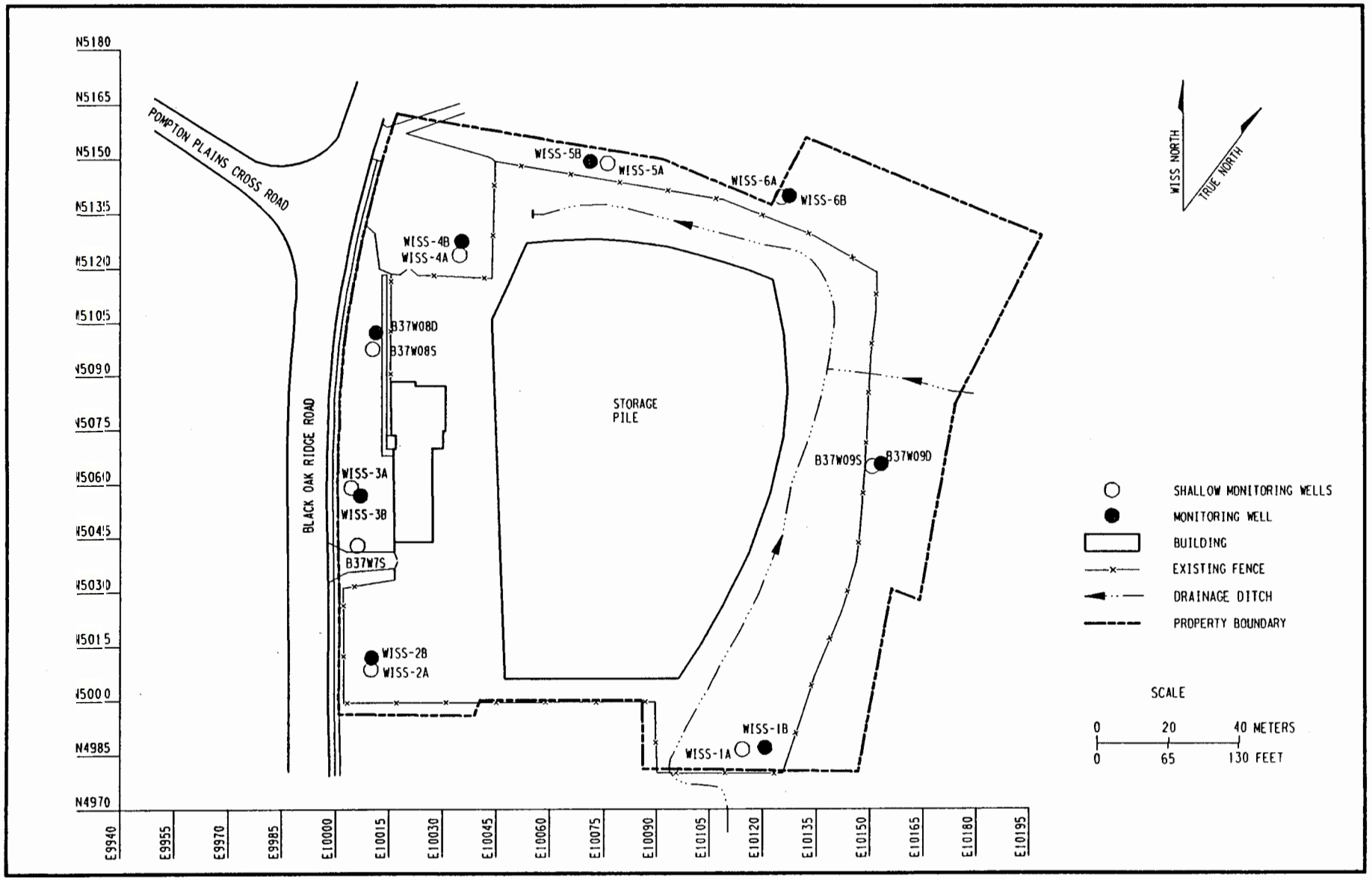


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Figure 6-1
Monitoring Well Locations at WISS

Wanaque and Pompton Lakes townships and the western side of Wayne Township. These unconsolidated deposits have not been extensively explored but are considered to be a potentially important source of groundwater for future development (Carswell and Rooney 1976). Water obtained from the unconsolidated deposits is highly variable in quality but is generally not mineralized. Wells that draw from this material have low yields and are used for domestic purposes. However, some wells located in areas with thicker surfical deposits of stratified glacial drift have high yields and have been developed for industrial and public uses.

The Brunswick Formation is the major source of groundwater for public supply and industrial use in Passaic County. Groundwater obtained from this bedrock aquifer is moderately mineralized and moderately to very hard.

A well canvass of the area within a 4.8-km (3-mi) radius of WISS conducted in 1987 and 1988 yielded records for 260 wells drilled between 1954 and 1984. Of these wells, 157 were used to obtain water for domestic purposes; the others were used mainly for irrigation and industrial purposes. No private wells obtained water specifically for drinking, but 16 public supply wells were identified during the canvass.

6.2 GROUNDWATER MONITORING

Wells at WISS were monitored for the presence of radioactive and chemical contamination and for hydrogeologic purposes. Sections 4.0 and 5.0 of this report address the results of the radiological and chemical investigations, and this section describes the hydrogeologic results.

6.2.1 Methods

The hydrogeological interpretations presented here are based on groundwater levels measured at the site during 1991. Groundwater levels are measured at weekly intervals using an electric downhole probe water level indicator.

Twelve groundwater monitoring wells were installed in late 1982 through early 1985; five additional wells were installed in 1989 (Figure 6-1). Well construction information for active wells included in the monitoring program is summarized in Table 6-1. Examples of well construction details are provided in Appendix H. Further background information on site geology, hydrogeology, and well construction details can be found in Report on Drilling and Well Installations at the Wayne Interim Storage Site, Wayne, New Jersey (BNI 1986).

Water level measurements from monitoring wells are used to prepare two types of graphic exhibits (hydrographs and potentiometric surface maps) that demonstrate hydrogeological conditions. Hydrographs are line graphs that display changes in water levels for each monitoring well throughout the year. The WISS hydrographs also include bar graphs of precipitation records from the site to aid in evaluating the influence of precipitation on water level fluctuations.

The hydraulic gradient and the flow direction of the upper groundwater system are determined from potentiometric surface (water level) maps, which are prepared by plotting water level measurements for selected dates on a base map and contouring the values.

6.2.2 Results and Conclusions

Hydrographs showing water levels measured in 1991 are in Appendix H. Conclusions derived from these hydrographs and from the potentiometric surface maps are presented in the following subsections.

Upper groundwater system

Hydrographs for most of the wells screened in the upper groundwater system show slight seasonal fluctuations in groundwater levels. Generally, the levels in 1991 tend to be highest in the spring and lowest in the fall and winter, as in 1990 (BNI 1991a). Water level changes in most of the wells seem to be related to

Table 6-1

WISS Monitoring Well Construction Summary

Well Number[a]	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material[b]
WISS-1A	Nov. 1984	9.8 (32.0)	1.2 - 9.8 (4.0 - 32.0)	PVC
WISS-1B	Dec. 1984	22.3 (73.0)	13.1 - 22.3 (43.0 - 73.0)[c]	Steel
WISS-2A[d]	Dec. 1982	6.1 (20.0)	4.6 - 6.1 (15.0 - 20.0)	PVC
WISS-2B	Dec. 1984	23.2 (76.0)	14.0 - 23.2 (46.0 - 76.0)[c]	Steel
WISS-3A	Dec. 1984	5.6 (18.5)	1.4 - 5.3 (4.5 - 17.5)	PVC
WISS-3B	Jan. 1985	24.1 (79.0)	14.9 - 24.1 (49.0 - 79.0)[c]	Steel
WISS-4A	Dec. 1984	6.1 (20.0)	1.5 - 6.1 (5.0 - 20.0)	PVC
WISS-4B	Jan. 1985	18.3 (60.0)	9.2 - 18.3 (30.0 - 60.0)[c]	Steel
WISS-5A	Dec. 1984	7.3 (24.0)	1.2 - 7.3 (4.0 - 24.0)	PVC
WISS-5B	Jan. 1985	18.6 (61.0)	9.5 - 18.6 (31.0 - 61.0)[c]	Steel
WISS-6A	Dec. 1984	5.5 (18.0)	1.5 - 5.5 (5.0 - 18.0)	PVC
WISS-6B	Jan. 1985	17.1 (56.0)	7.9 - 17.1 (26.0 - 56.0)[c]	Steel
B37W07S[e]	Oct. 1989	7.3 (24)	5.5 - 7.1 (18.2 - 23.2)	SS
B37W08S	Oct. 1989	4.3 (14)	2.4 - 4.3 (7.9 - 14)	SS
B37W08D	Oct. 1989	19.7 (64.7)	11.7 - 14.9 (38.5 - 48.8)	SS
B37W09S	Oct. 1989	6.2 (20.3)	4.4 - 5.9 (14.4 - 19.4)	SS
B37W09D	Oct. 1989	24.7 (80.9)	16.6 - 1.97 (54.4 - 64.7)	SS

[a]"A" and "S" designate wells installed in upper groundwater system; "B" and "D" designate wells in lower system. Locations are shown in Figure 6-1.

[b]PVC - polyvinyl chloride; SS - stainless steel.

[c]Carbon steel casing extends through overburden and 0.6 m (2 ft) into bedrock; monitored interval is a 7.6-cm (3-in.) diameter open hole in bedrock.

[d]Formerly designated EN-4.

[e]Well installed in intermediate zone.

NOTE: Water level elevations for wells monitored in 1991 are shown as hydrographs in Appendix H.

changes in the other wells. There also appears to be a slight correlation between precipitation and changes in the water levels in some of the wells.

The hydraulic gradient and flow direction of the upper groundwater system were determined from potentiometric surface maps (Figures 6-2 and 6-3). The general flow direction at WISS is to the west, and the hydraulic gradient was 0.07 in March 1991 and 0.06 in September 1991. The hydraulic gradient was calculated using the western flow direction and was similar to that calculated for 1989 (BNI 1990) and 1990 (BNI 1991a).

Lower groundwater system

Flowing conditions encountered in most of the lower (confined) groundwater system wells indicate that the system is confined. Water from these wells normally flows from the top of the casing, except in wells WISS-1B and WISS-9D, which are located in the area of the highest ground surface elevation onsite. As a result, WISS-1B and WISS-9D were the only lower system wells for which static water level measurements were recorded and for which hydrographs are presented (Appendix H). The water levels measured in WISS-1B are similar to those in WISS-1A, but because of the confined nature of the lower system, they behave independently. Changes in water levels in WISS-1B appear to be related to precipitation.

Hydraulic gradient and flow direction for the lower groundwater system could not be determined for 1991. Data for 1985 (BNI 1986) show a flow direction from east to west and a hydraulic gradient on the order of 0.01, which represents a lower hydraulic gradient than that for the upper system. Because confined conditions still prevail, the slope and flow direction are probably similar to those measured in 1985.

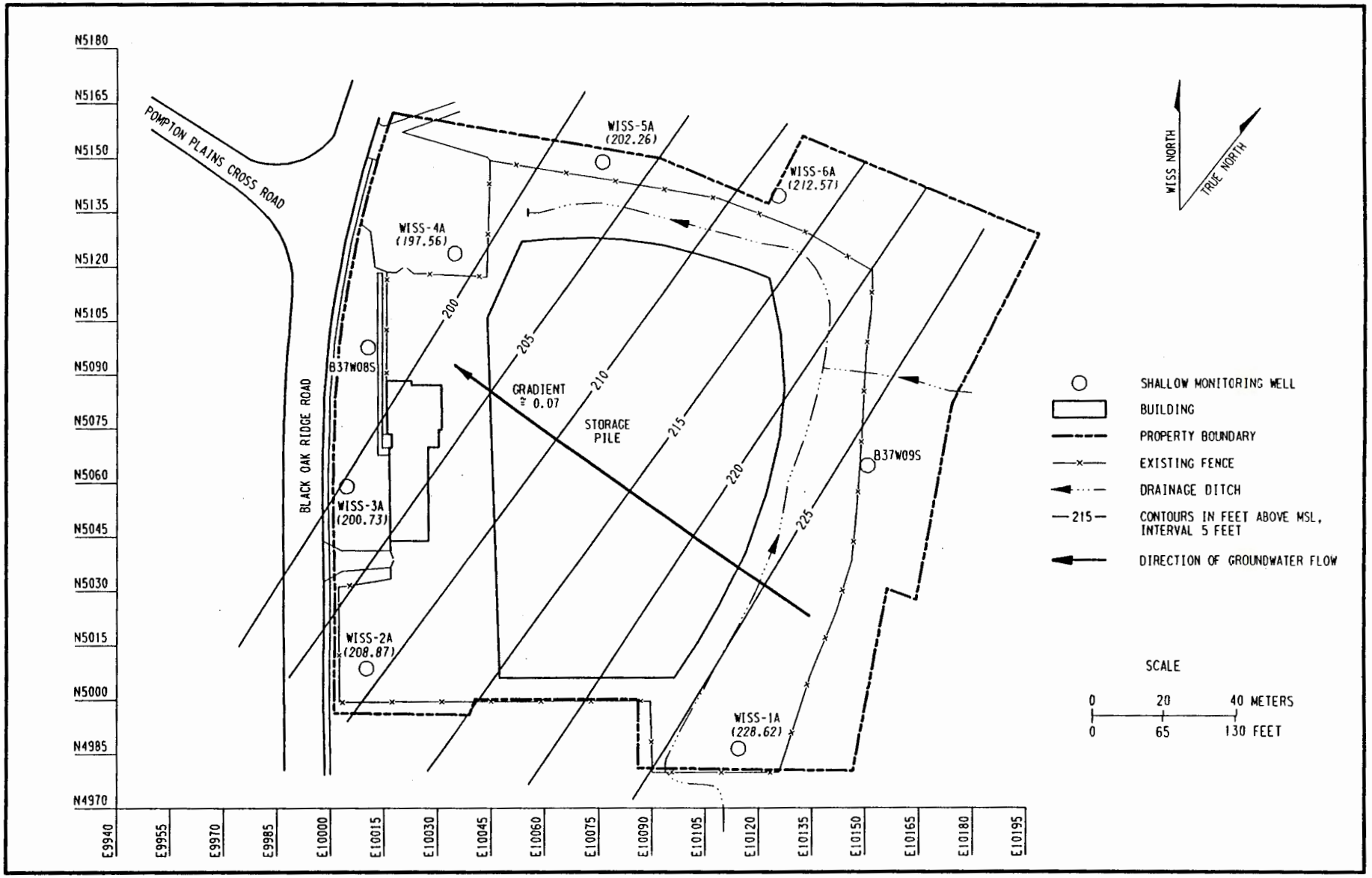

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Figure 6-2
Potentiometric Surface Map of Upper Groundwater System at WISS (3/19/91)

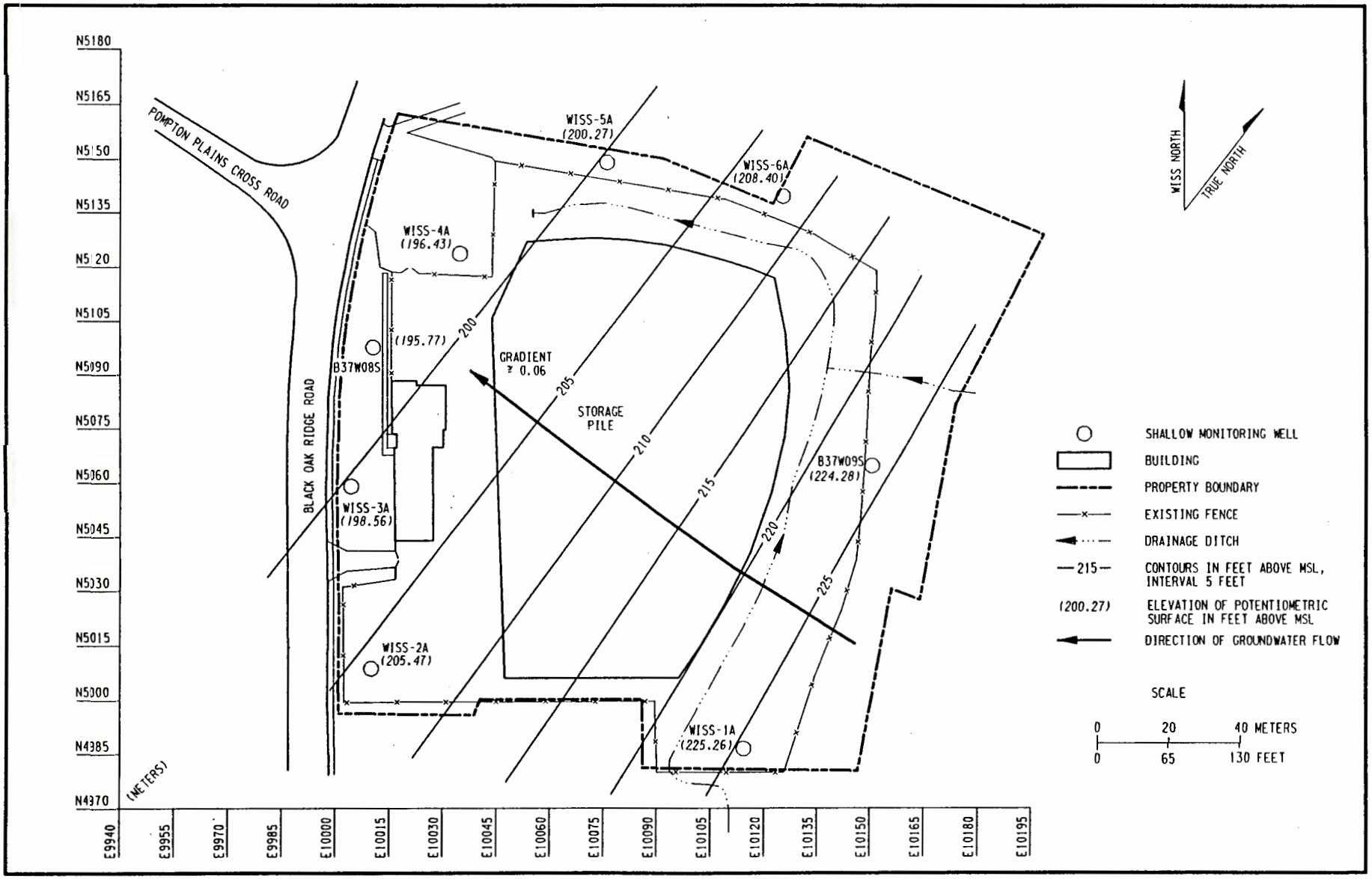

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Figure 6-3
Potentiometric Surface Map of Upper Groundwater System at WISS (9/17/91)

7.0 QUALITY ASSURANCE

7.1 INTRODUCTION

This section summarizes the quality assurance (QA) assessment of environmental surveillance activities at WISS, which were conducted to ensure that onsite contamination is not posing a threat to human health and the environment. Based on this criterion, the overall data quality objective (DQO) for the environmental monitoring program is to provide data of a sufficient quality to allow reliable detection and quantification of any potential release of contaminated material from WISS.

7.2 PROCEDURES

The Quality Assurance Program Plan for the U.S. DOE FUSRAP (QAPmP) (BNI 1990b) addresses the quality requirements for all work being performed as part of FUSRAP. In addition, all subcontractors adhere to or implement a QA system that is compatible with the program. The objectives of the QAPmP are to maintain quality through a system of planned work operations and to verify the preservation of quality standards through a system of checks and reviews.

Established QA procedures are detailed in project procedures and instructions and an instruction guide and are implemented for all field sampling activities. Sampling methodology and techniques are consistent with the methods detailed in A Compendium of Superfund Field Operations Methods (EPA 1987). Laboratory QA procedures, which have been reviewed by BNI, are implemented to control applicable laboratory activities. In addition, various activities (such as data reviews, calculations, and evaluations) are conducted to monitor the information being generated and to prevent or identify quality problems. Quality control (QC) sample requirements, data use information, and QA/QC procedures are provided in project instruction guides.

7.3 QUALITY ASSURANCE SUMMARY

QA/QC activities are an integral part of environmental monitoring activities at WISS. The quality of the data collected for the 1991 monitoring program is considered to be appropriate for these reporting purposes.

The QA/QC program implemented at WISS satisfies the 1991 requirements of DOE Orders 5400.1, 5400.5, and 5700.6B. The programmatic controls in place during the 1991 environmental monitoring program are discussed in the project instruction guide.

The specific methods and formulas used to evaluate the QA/QC program are described in an internal BNI QA document for annual site environmental reports; the QA document also discusses the requirements of precision, accuracy, representativeness, comparability, and completeness (PARCC). This subsection summarizes the results of the QA/QC program at WISS.

7.3.1 Data Usability

To determine data usability, the analytes of interest for WISS were evaluated for the PARCC parameters; Table 7-1 lists each analyte and indicates whether it meets these and other parameters. The following analytes have been determined to satisfy all elements of the PARCC parameters:

- Metals in groundwater, surface water, and sediments
- Radium-226 in surface water and sediments
- Radium-228 in sediments
- Thorium-230 in surface water and sediments
- Total uranium in sediments
- Radon in air

Other analytes were also evaluated, and certain elements did not fully meet PARCC requirements or could not be completely evaluated because some QC data were not retrievable. Corrective actions were initiated for all identified data deficiencies and nonconformances. As part of the ongoing FUSRAP QA program,

Table 7-1

Data Usability Summary

ANALYTE	PRECISION	ACCURACY	REPRESENTATIVENESS	COMPLETENESS	COMPARABILITY	QUANTITATIVE	QUALITATIVE	DQO[1]
Metals	YES[2]	YES	YES	YES	YES	YES	YES	YES
Volatile organics	3	YES	YES	YES	YES	YES	YES	YES
Semivolatiles (BNAEs)	3	YES	YES	YES	4	YES	YES	YES
Pesticides/PCBs	3	YES	YES	YES	YES	YES	YES	YES
Radium-226	YES	YES	YES	YES	YES	YES	YES	YES
Radium-228	3	YES	YES	YES	YES	YES	YES	YES
Thorium-232	YES	YES	5	YES	YES	6	YES	YES
Total Uranium	3	YES	YES	YES	YES	YES	YES	YES
Radon-222	YES	YES	YES	YES	YES	YES	YES	YES
Thoron (Radon-220)	YES	7	5	YES	4	6	YES	YES
External gamma radiation	YES	YES	5	YES	YES	6	YES	YES

Further information on any of the above PARCC parameters can be found in the corresponding summaries of the text.

1 The data quality objective for the environmental monitoring program is to detect and quantify any release from WISS that could be potentially harmful to human health and environment.

2 The term "Yes" indicates that data are usable based on the analyses of the indicated PARCC parameters.

3 Insufficient laboratory duplicate or field duplicate data were reported for this parameter.

4 Comparability factor could not be calculated because precision and/or accuracy information did not meet the 80-percent goal or were not available.

5 Representativeness goal was not met or could not be assessed because of insufficient laboratory blank or insufficient field (rinse) blank data, or because none of the QC elements used to assess representativeness were required for this parameter.

6 Data do not meet quantitative goals because the variation associated with those values could not be adequately assessed.

7 Accuracy goal was not met or could not be assessed because of insufficient laboratory standard reference materials and blank information for this parameter.

appropriate actions have been implemented including root-cause analyses and procedure development and revision.

Results of the evaluation indicate that the data quality for the following analytes did meet the intended end use. After a thorough review of all site information (including non-QC data), the results were determined to be of sufficient quality to achieve reliable detection and quantification of any potential release of contaminated material from WISS.

- Volatile organic compounds (VOCs) in groundwater and surface water
- Semivolatile [base/neutral and acid extractable (BNAE)] organic compounds in groundwater and surface water
- Pesticides/PCBs in groundwater and surface water
- Radium-226 in groundwater
- Radium-228 in groundwater and surface water
- Thorium-232 in groundwater, surface water, and sediments
- Total uranium in groundwater and surface water
- Thoron in air
- External gamma radiation in air

7.3.2 Precision

The precision goal of 80 percent, as measured by analytical results for matrix spike duplicates (MSDs) and field and laboratory duplicates, was met for metals in all matrices at WISS. This goal indicates that a minimum of 80 percent of the QC results fell within acceptable ranges. Calculations for metals indicate that minimal variability was introduced by field sampling. Insufficient field duplicate data were reported for VOCs, BNAEs, and pesticides/PCBs; therefore, analyses for these parameters did not meet the 80-percent goal for precision.

Analytical results for MSD samples, which are used to measure analytical variability, indicate that iron, thallium, cadmium, chromium, lead, and zinc samples (in fourth quarter groundwater samples) exceeded the analytical method's established criteria for acceptable variation. (Data for the first three quarters for

metals in all matrices were derived from Contract Laboratory Program (CLP) data; it is not possible to determine the particular compounds for which analytical variability might exist.) Arsenic and thallium samples (in fourth quarter surface water samples) exceeded the analytical method's established criteria for acceptable variation. No compounds in sediment exceeded the established criteria for acceptable analytical variation. The unacceptable variation in groundwater and surface water samples indicates that matrix effects, which interfere with the analytical determination of variation, may be present at the site. Evaluation of the data usability for all chemical analytes of concern at WISS indicates that the data met their intended end use.

The precision goal of 80 percent was met for radium-226, thorium-230, and thorium-232 in all matrices; for total uranium in groundwater and sediments; for radium-228 in sediments; and for radon, thoron, and external gamma radiation in air. The precision goal was not met for the other radiological analytes because field duplicate and/or laboratory duplicate information was either unavailable or incomplete. Lack of precision information for these parameters does not affect the usability of the data.

Radiological QC data indicate that some degree of variability was present. A high degree of variability was seen in field duplicate results as measured by relative percent differences (RPDs); however, the RPDs were calculated from a very limited data population. (As more data become available, the statistical reliability of these values increases, control limits may become tighter, and data more accurately reflect true site conditions.) The radiological methods used have no defined criteria for RPD values near the method detection limits; therefore, sampling variation cannot be quantitatively separated from laboratory variation. Because the laboratory precision criterion has not been established, the calculated upper control limit from the field duplicates (the mean plus three standard deviations) was used as the standard of data quality.

Values for radiological sediment analyses are considered qualitative because no field duplicate samples were taken and, consequently, total variability could not be quantified.

Qualitative data are useful for estimating the approximate concentration or activity of an analyte, but the amount of variation associated with the data remains unknown.

Data from the FUSRAP radiological laboratory's monthly QC reports indicate that all analytes met the overall laboratory duplicate requirements for precision and met the program's DQOs for precision.

7.3.3 Accuracy

The accuracy goal of 80 percent was met for all chemical analytes of concern at WISS. This goal indicates that a minimum of 80 percent of the QC results fell within acceptable ranges. Control limits were statistically established from the data population for metals in groundwater. Blank contamination was not detected in the third quarter for any of the organic analytes; however, blank contamination was detected in the fourth quarter for the metals chromium and lead. Rinse blanks are not required for either surface water or sediments. Laboratory (method) blank analyses were reported for all metal and organic analyses; the accuracy goal was met or exceeded for each parameter.

The goal for accuracy was met for radium-226, radium-228, and total uranium in surface water and sediments and for radon and external gamma radiation in air. The goal was not met for the aforementioned analytes in groundwater because the reported rinse blank data were insufficient. Accuracy could not be evaluated for thorium-232 in surface water and sediments because none of the elements used in this QC assessment to calculate accuracy were required. Accuracy could not be assessed for thoron because laboratory blank and standard reference material (SRM) information was not available. However, the program has determined that the values associated with these radiological data satisfied the intended end use of the data.

Evaluation of radiological accuracy was limited because it was based on the total reported results for all FUSRAP sites where environmental monitoring was conducted in 1991. Laboratory QC data were summarized in a monthly report that provided an overall

assessment of the laboratory's performance for that period. Because of the summary nature of the reports, WISS QC data may be more accurate than actually reported.

7.3.4 Representativeness

The 80-percent representativeness goal was met for all metals, VOCs, BNAEs, and pesticides/PCBs; for radium-226, radium-228, and total uranium in surface water and sediments; and for radon in air. Radium-226, radium-228, thorium-232, and total uranium in groundwater did not meet the 80-percent goal because of unreported or incomplete field (rinse) blank information. For thorium-232 in surface water and sediments and for thoron and external gamma radiation in air, representativeness could not be assessed because none of the elements used in this QC assessment to calculate representativeness were required. Lack of representativeness information for these parameters does not affect the usability of the data.

7.3.5 Completeness

At WISS, the completeness goal of 80 percent was exceeded for all groundwater, surface water, and sediment samples analyzed for chemical and radiological parameters. Air monitoring was conducted for external gamma radiation, thoron, and radon; all required data were collected.

7.3.6 Comparability

All chemical and radiological analytical methodologies satisfied the program's goals for comparability. In addition, WISS data met the program's comparability requirements, as calculated from precision and accuracy values, for all metals, VOCs, and pesticides/PCBs in groundwater and surface water samples. BNAEs in groundwater and surface water did not meet the comparability goals because the precision component was not met or could not be calculated from the Contract Laboratory Program data.

WISS data met the comparability requirements for radium-226 in all matrices; radium-228 and thorium-232 in surface water and sediments; total uranium in groundwater and sediments; and radon and external gamma radiation in air. The 80-percent goal was not met for the other radiological analytes because precision and/or accuracy requirements were not met or could not be assessed.

7.4 PROGRAMMATIC FACTORS

FUSRAP has also established specific requirements for qualifications and training of personnel, data management and recordkeeping, chain-of-custody procedures, audits, performance reporting, independent data verification, and laboratory certification. These topics are covered in more detail in the QA/QC document.

7.5 DOE LABORATORY QUALITY ASSESSMENT PROGRAM FOR RADIOACTIVE MATERIAL

Results of the radiological laboratory's participation in the DOE Environmental Measurements Laboratory Quality Assessment Program are presented in Table 7-2. The range of ratios presented has been determined to satisfy the requirements of the quality assessment program for radioactive materials.

Table 7-2

Results of the Quality Assessment Program, 1991

Sample Type	Analysis	Results TMA/E[a]	Results EML[b]	Units	Ratio TMA/E:EML
Air Filter	Be-7	63.1	53.0	Bq/filter	1.19
Air Filter	Mn-54	5.90	4.80	Bq/filter	1.23
Air Filter	Sr-90	0.914	0.789	Bq/filter	1.16
Air Filter	Cs-137	5.83	4.53	Bq/filter	1.29
Air Filter	Ce-144	67.3	52.2	Bq/filter	1.29
Air Filter	Pu-239	0.146	0.154	Bq/filter	0.948
Air Filter	Am-241	0.0940	0.101	Bq/filter	0.931
Air Filter	U-234	0.0514	0.0350	Bq/filter	1.47
Air Filter	U-238	0.0444	0.0350	Bq/filter	1.27
Soil	K-40	348	374	Bq/kg	0.931
Soil	Cs-137	154	150	Bq/kg	1.03
Soil	Pu-238	10.8	11.5	Bq/kg	0.939
Soil	Pu-239	3.27	3.40	Bq/kg	0.962
Soil	Am-241	1.48	1.76	Bq/kg	0.841
Soil	U-234	26.7	29.4	Bq/kg	0.908
Soil	U-238	23.0	30.0	Bq/kg	0.767
Vegetation	K-40	492	1150	Bq/kg	0.428
Vegetation	Sr-90	151	186	Bq/kg	0.812
Vegetation	Cs-137	74.4	67.6	Bq/kg	1.10
Vegetation	Pu-238	3.50	4.06	Bq/kg	0.862
Vegetation	Pu-239	0.962	1.40	Bq/kg	0.687
Vegetation	Am-241	0.608	0.829	Bq/kg	0.733
Water	H-3	321	361	Bq/L	0.889
Water	Mn-54	194	213	Bq/L	0.911
Water	Co-57	187	230	Bq/L	0.813
Water	Co-60	178	201	Bq/L	0.886
Water	Sr-90	8.53	8.63	Bq/L	0.988
Water	Cs-137	150	169	Bq/L	0.888
Water	Ce-144	33.2	35.1	Bq/L	0.946
Water	Pu-239	0.665	0.773	Bq/L	0.860
Water	Am-241	1.23	1.19	Bq/L	1.03
Water	U-234	0.236	0.219	Bq/L	1.08
Water	U-238	0.275	0.219	Bq/L	1.26
Air Filter	Be-7	74.7	53.8	Bq/filter	1.39
Air Filter	Mn-54	27.1	24.3	Bq/filter	1.12
Air Filter	Co-57	20.0	16.6	Bq/filter	1.20
Air Filter	Co-60	23.6	23.0	Bq/filter	1.03
Air Filter	Sr-90	0.773	0.663	Bq/filter	1.17
Air Filter	Cs-137	31.6	28.0	Bq/filter	1.13
Air Filter	Ce-144	54.5	50.8	Bq/filter	1.07
Air Filter	Pu-239	0.0704	0.0840	Bq/filter	0.838
Air Filter	Am-241	0.0858	0.104	Bq/filter	0.825
Air Filter	U-234	0.0518	0.0395	Bq/filter	1.31
Air Filter	U-238	0.0585	0.0388	Bq/filter	1.51
Soil	K-40	301	430	Bq/kg	0.700
Soil	Cs-137	240	312	Bq/kg	0.769

Table 7-2

(continued)

Sample Type	Analysis	Results TMA/E[a]	Results EML[b]	Units	Ratio TMA/E:EML
Soil	Pu-239	8.25	7.35	Bq/kg	1.12
Soil	Am-241	1.31	1.58	Bq/kg	0.829
Soil	U-234	25.3	28.9	Bq/kg	0.875
Soil	U-238	26.1	28.9	Bq/kg	0.903
Vegetation	K-40	819	992	Bq/kg	0.826
Vegetation	Sr-90	308	439	Bq/kg	0.702
Vegetation	Cs-137	11.7	27.1	Bq/kg	0.432[c]
Vegetation	Pu-239	0.352	0.365	Bq/kg	0.964
Vegetation	Am-241	0.222	0.266	Bq/kg	0.835
Water	H-3	16.6	100	Bq/L	0.166[c]
Water	Mn-54	91.2	103	Bq/L	0.885
Water	Co-57	154	166	Bq/L	0.928
Water	Co-60	261	291	Bq/L	0.897
Water	Sr-90	8.40	10.1	Bq/L	0.832
Water	Cs-137	42.8	46.0	Bq/L	0.930
Water	Ce-144	201	226	Bq/L	0.889
Water	Pu-239	0.519	0.510	Bq/L	1.02
Water	Am-241	0.620	0.570	Bq/L	1.09
Water	U-234	0.426	0.462	Bq/L	0.922
Water	U-238	0.485	0.478	Bq/L	1.01

[a]TMA/E - ThermoAnalytical/Eberline, the radiological analysis subcontractor for FUSRAP.

[b]EML - the DOE Environmental Measurements Laboratory.

[c]Corrective action request has been issued.

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APPENDIX A
ENVIRONMENTAL STANDARDS

ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr in excess of background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as the use of occupancy factors in determining dose due to 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 using 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

As referenced in Section 2.0, 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 for one year by one exposure mode (e.g., ingestion of water, inhalation), would result in an effective dose equivalent of 100 mrem. The following table provides reference values for conducting radiological environmental protection programs at operational DOE facilities and sites.

Radionuclide	F1 Value[a]	Ingested[b] Water DCG (μCi/ml)	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
" 232	2E-4	5E-8	--	7E-15	1E-14
Uranium-234	2E-3	5E-6	--	--	9E-14
" 235	2E-3	5E-6	--	--	1E-13
" 238	2E-3	6E-6	--	--	1E-13
Radon-222[c]	3E-9	3E-9	--	--	3E-9
" 220[c]	3E-9	3E-9	--	--	3E-9

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

[b]1E-9 μCi/ml = 0.037 Bq/L = 1pCi/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).

[c]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 for releases from DOE facilities.

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.
Other Radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

*Source: U.S. Department of Energy, "Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Surplus Facilities Management Program Sites," Revision 2, March 1987.

APPENDIX B
PARAMETERS FOR ANALYSIS

Parameters for Analysis at WISS, 1991

Medium	Parameter	Technique
Groundwater	Total uranium	Fluorometric
	Radium-226	Emanation/scintillation
	Thorium-232	Alpha spectrometry
	Total organic halides	Carbonaceous analyzer
	Total organic carbon	Coulometric determination
	Total metals: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc	Inductively coupled plasma atomic emission spectrophotometry
		Atomic absorption spectrophometry
	Specific conductivity	Electrometric
	pH	Electrometric
Surface Water	Total uranium	Fluorometric
	Radium-226	Emanation/scintillation
	Thorium-232	Alpha spectrometry
Sediment	Total uranium	Alpha spectrometry
	Radium-226	Gamma spectrometry
	Thorium-232	Alpha spectrometry
Air	Radon-222	Track-etch
	External gamma radiation	Thermoluminescence

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

APPENDIX C
METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

Average annual concentrations are calculated by averaging the results of all four quarters of sampling. When possible, sampling results are compiled in computer spreadsheets and the average values are calculated for all quarters of data.

Thorium-230 Results (pCi/L)

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

Average annual 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 is given below.

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 result is rounded to 9 (number of significant figures is 1). 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

Expected concentration ranges are calculated to provide a basis for trend analysis of the data. These expected ranges are calculated by taking the average of the annual average concentrations for the past five years (when possible) and calculating a standard deviation for these data. The lower expected range is calculated by subtracting two standard deviations from the average value, and the upper range is calculated by adding two standard deviations to the average values. If site conditions do not change, 95 percent of data points would be expected to fall within this range. An example of these calculations is shown below.

Thorium-230 Results (pCi/L)

Sampling Location	Year					Average Value	Standard Deviation
	1986	1987	1988	1989	1990		
1	10	5	14	8	5	8	4

The formula for calculation of the standard deviation of a sample xi, ..., xn is:

$$S = \sqrt{S^2} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

where: S = Standard deviation

x_i = Individual values

$\bar{x}$ = Average of values

n = Number of values

n	x_i	$\bar{x}$	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	10	8	2	4
2	5	8	-3	9
3	14	8	6	36
4	8	8	0	0
5	5	8	-3	9

$$\sum (X_i - \bar{x})^2 = 58$$

$$S = \sqrt{\frac{58}{5 - 1}} = \sqrt{\frac{58}{4}} = \sqrt{14.5} = 3.807,$$

which rounds to 4 because there is only one significant figure.

The calculation for the expected ranges for this example is shown below.

Lower expected range: $8 - 2(4) = 0$
Upper expected range: $8 + 2(4) = 20$ (rounded to one significant figure)

Annual average values for the current year are compared with these ranges to indicate a possible anomaly or trend. If a discernible trend is found from this comparison, the data are presented in the appropriate section of the report.

APPENDIX D

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 given in Subsection 4.2.

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 into 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 maximally exposed individual.

Contamination transported via the atmospheric pathway takes 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 in compliance with concentration requirements for boundaries.

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

Primary Radionuclides of Concern

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

DOSE CALCULATION METHOD

Direct Gamma Radiation Exposure

As previously indicated, direct gamma radiation 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 (described in Section 4.0). These data provide a measure of the amount and energy (in units of mR/yr) of the ionizing radiation at 1.6 m (5 ft) from the fenceline. For the purposes of this report,

Table D-1

Radionuclides of Interest

Radionuclide	Half-life[a]	Dose Conversion Factor[b] for Ingestion (mrem/pCi)
Uranium-238	4.51E+9 years	2.5E-4
Thorium-234	24.1 days	--[c]
Protactinium-234 m	1.17 minutes	--[c]
Protactinium-234	6.75 hours	--[c]
Uranium-234	2.47E+5 years	2.6E-4
Thorium-230	8.0E+4 years	5.3E-4
Radium-226	1602 years	1.1E-3
Uranium-235	7.1E+8 years	2.5E-4
Thorium-231	25.5 hours	--[d]
Protactinium-231	3.25E+4 years	1.1E-2
Actinium-227	21.6 years	1.5E-2
Thorium-227	18.2 days	--[e]
Radium-223	11.43 days	--[e]
Thorium-232	1.41E+10 years	2.8E-3
Radium-228	6.7 years	1.2E-3
Actinium-228	6.13 hours	--[f]
Thorium-228	1.91 years	7.5E-4

[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 (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.

[f]Included in the radium-228 dose conversion factor.

the hypothetical maximally exposed individual is assumed to work 10 m (30 ft) from the southern WISS fenceline for 40 hours per week for an entire year.

The dose to the hypothetical maximally exposed individual can be determined by assuming that the individual is exposed to a line source located along the fenceline. Because the average exposure rate is known from the TETLD for a distance of 1.6 m (5 ft) from the fenceline, the exposure at 10 m (30 ft) from the fenceline can be calculated by using the following equation (Cember 1983).

$$\textit{Exposure at 10 m} = (\textit{Exposure at 1.6 m}) \times \frac{h_1}{h_2} \times \frac{\tan^{-1}(L/h_2)}{\tan^{-1}(L/h_1)}$$

where: h_1 = TETLD distance from the fenceline [1.6 m (5 ft)]
h_2 = Distance to the hypothetical maximally exposed individual [10 m (30 ft)]
L = Half of the length of the southern fenceline [60 m (195 ft)]

The exposure rate at 1.6 m (5 ft) can be calculated by taking the average of the detectors along this portion of the fenceline (9, 11, 7, and 6). The average exposure rate for these detectors was 17.3 mR/yr above background. Using the formula above, the exposure rate at 10 m (30 ft) is approximately 0.6 mR/yr. Because 1 mR/yr is approximately equal to 1 mrem/yr, the resulting dose would be 0.6 mrem/yr, assuming that the individual spent 40 hours per week at this location.

Surface water pathway

Exposures from contaminants in surface water are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the surface water dose calculation consist of measurements of concentrations of contaminants in surface water at the site and of the amount of dilution provided by tributaries or rivers between

the site and the intake. Thus, the dose to the individual can be calculated by the following:

$$D_s = \sum_{i=1}^{N} C_i \times (F_s + F_i) \times U_a \times DCF_i$$

where: D_s = Committed effective dose from surface water
C_i = Concentration of the i^{th} radionuclide in surface water at the site
F_s = Average annual flow of surface water at the site
F_i = Average flow of surface water at the intake
U_a = Annual consumption of liquid (approx. 730 L/yr)
DCF_i = Dose conversion factor for the i^{th} radionuclide (Table D-1)

To determine the dose to the population, the same equation would be used, and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that for the population dose, the intake point is probably not the same as that for the hypothetical maximally exposed individual.

The approach outlined above does not account for radionuclides settling out or for any municipal water treatment.

Groundwater pathway

Exposures from contaminants in groundwater 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. The dose for the individual can be calculated by using the following equation:

$$D_{gw} = \sum_{i=1}^{N} (C_i) \times (D) \times (U_a) \times (DCF_i)$$

where: D_{gw} = Committed effective dose from groundwater
C_i = Concentration of the i^{th} radionuclide in groundwater at the site
D = Estimated dilution factor
U_a = Annual consumption of water (approx. 730 L/yr)
DCF_i = Dose conversion factor for the i^{th} radionuclide (Table D-1)

To determine the dose to the population, the same equation would be used, and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that the population intake point is usually different from that of the hypothetical maximally exposed individual.

The approach given above does not account for any water treatment.

Air pathway (ingestion, air immension, inhalation)

The doses to the hypothetical maximally exposed individual and to the general public from particulate radionuclides transported via the air pathway are calculated using EPA's computer model AIRDOS; results are provided in Subsection 4.2.

The release of particulates was calculated using a model for wind erosion because there are no other mechanisms for releasing particulates from the site. The wind erosion model used was taken from the DOE "Remedial Action Priority System Mathematical Formulation." The input for the model consisted of site-specific average soil concentrations, local meteorological data (see Section 1.0), and areas of contamination.

The site was modeled as three areas: the two grass-covered areas facing Black Oak Ridge Road and a small portion of the drainage area on the eastern side of the storage pile (because

these areas exhibit the highest radionuclide concentrations in subsurface soil).

The average particle size for the soil at WISS is estimated at 0.05 mm for determining the emission factor for windblown material. This greatly overestimates the fraction of the airborne material that is respirable because most particles greater than 0.01 mm in diameter either would not be inhaled or would be quickly removed. Nevertheless, to provide a conservative calculation, all airborne particles were assumed to be respirable with an activity median aerodynamic diameter of 0.001 mm. Because the calculated dose was a small fraction of the NESHAPs standard of 10 mrem/yr, no effort was made to estimate the fraction of the airborne material that would be in the respirable range. Other assumptions used in the model were that the source areas are 99 percent covered by vegetation and that there are very few mechanical disturbances at the site each month.

APPENDIX E
CLEAN AIR ACT COMPLIANCE REPORT FOR WAYNE INTERIM STORAGE SITE

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

CLEAN AIR ACT COMPLIANCE REPORT
(Version 3.0 November 1989)

Facility: Wayne Interim Storage Site
Address: 868 Black Oak Ridge Road
Wayne , NJ. 07470
Annual Assessment for Year: 1991
Date Submitted: 4/16/92

Comments: INPUT DATA IS TAKEN FROM CALCULATION 137-CV-14

Prepared By:

Name: Bechtel National Inc.
Title: FUSRAP
Phone #: (615) 576-1699

Prepared for:
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

CLEAN AIR ACT COMPLIANCE REPORT 4/16/92 2:27 PM

Facility: Wayne Interim Storage Site
Address: 868 Black Oak Ridge Road City: Wayne State: NJ
Comments: INPUT DATA IS TAKEN FROM CALCULATION 137-CV-14
Year: 1991

	Dose Equivalent Rates to Nearby Individuals (mrem/year)
Effective Dose Equivalent	9.68E-05
Highest Organ Dose is to ENDOSTEUM	0.0007

----------EMISSION INFORMATION----------

Radionuclide	Class	Amad	Area #1 (Ci/y)	Area #2 (Ci/y)	Area #3 (Ci/y)
U-238	Y	1.0	6.5E-09	6.7E-09	3.5E-09
U-235	Y	1.0	2.9E-10	3.0E-10	1.6E-10
U-234	Y	1.0	6.5E-09	6.7E-09	3.5E-09
RA-226	Y	1.0	7.2E-10	1.3E-09	2.7E-09
TH-232	Y	1.0	1.2E-08	2.3E-08	5.0E-09
Total Area (m**2)			1.0E+03	1.3E+03	1.8E+02

----------SITE INFORMATION----------

Wind Data	LEA0435.WND	Temperature (C)	13
Food Source	LOCAL	Rainfall (cm/y)	117
Distance to Individuals (m)	300	Lid Height (m)	1000

*NOTE: The results of this computer model are dose estimates. They are only to be used for the purpose of determining compliance and reporting per 40 CFR 61.93 and 40 CFR 61.94.

ORGAN DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL

ORGAN	DOSE EQUIVALENT RATE TO THE ORGAN (mrem/y)
GONADS	4.8E-07
BREAST	5.0E-07
RED MARROW	5.2E-05
LUNGS	5.8E-04
THYROID	4.8E-07
ENDOSTEUM	6.5E-04
REMAINDER	2.9E-06
EFFECTIVE	9.7E-05

Wayne Interim Storage Site

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL
BY PATHWAY FOR ALL RADIONUCLIDES

	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE ENDOSTEUM (mrem/y)
INGESTION	2.6E-06	4.7E-05
INHALATION	9.4E-05	6.0E-04
AIR IMMERSION	4.7E-13	5.8E-13
GROUND SURFACE	1.7E-08	1.8E-08
TOTAL:	9.7E-05	6.5E-04

Wayne Interim Storage Site

DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL
BY RADIONUCLIDE FOR ALL PATHWAYS

RADIONUCLIDE	EFFECTIVE DOSE EQUIVALENT (mrem/y)	DOSE EQUIVALENT TO THE ORGAN WITH THE HIGHEST DOSE ENDOSTEUM (mrem/y)
U-238	1.0E-05	1.1E-05
U-235	4.9E-07	5.6E-07
U-234	1.2E-05	1.3E-05
RA-226	3.5E-06	5.6E-06
TH-232	7.1E-05	6.2E-04
TOTAL :	9.7E-05	6.5E-04

Wayne Interim Storage Site

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF DISTANCE IN THE DIRECTIONS OF THE MAXIMALLY EXPOSED INDIVIDUAL FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTION : NORTH

DISTANCE (meters)	EFFECTIVE DOSE EQUIVALENT (mrem/y)
300	9.7E-05
1000	1.0E-05
3000	1.6E-06
10000	2.4E-07
80000	9.0E-09

Wayne Interim Storage Site

EFFECTIVE DOSE EQUIVALENT AS A FUNCTION
OF ALL DISTANCES AND ALL DIRECTIONS FOR ALL
RADIONUCLIDES AND ALL PATHWAYS

DIRECTIONS:	N	NNE	NE	ENE	E	ESE	SE	SSE
DISTANCE (METERS):								
300	9.7E-05	5.6E-05	5.9E-05	7.5E-05	7.2E-05	4.1E-05	5.0E-05	4.1E-05
1000	1.0E-05	5.9E-06	6.1E-06	7.8E-06	7.5E-06	4.2E-06	5.3E-06	4.3E-06
3000	1.6E-06	9.1E-07	9.4E-07	1.2E-06	1.2E-06	6.6E-07	8.4E-07	6.7E-07
10000	2.4E-07	1.4E-07	1.5E-07	1.9E-07	1.8E-07	1.1E-07	1.3E-07	1.1E-07
80000	9.0E-09	5.6E-09	5.9E-09	7.5E-09	7.0E-09	4.0E-09	5.5E-09	4.3E-09

	S	SSW	SW	WSW	W	WNW	NW	NNW
DISTANCE (METERS):								
300	6.3E-05	4.0E-05	4.9E-05	5.6E-05	6.3E-05	3.4E-05	2.8E-05	2.7E-05
1000	6.6E-06	4.2E-06	5.0E-06	5.7E-06	6.4E-06	3.4E-06	2.9E-06	2.7E-06
3000	1.0E-06	6.5E-07	7.8E-07	8.6E-07	9.7E-07	5.2E-07	4.5E-07	4.2E-07
10000	1.6E-07	1.0E-07	1.2E-07	1.3E-07	1.5E-07	7.8E-08	6.9E-08	6.4E-08
80000	6.4E-09	3.9E-09	4.4E-09	3.8E-09	4.1E-09	2.2E-09	2.3E-09	2.1E-09

Wayne Interim Storage Site

METEOROLOGICAL AND PLANT INFORMATION SUPPLIED TO PROGRAM----

AVERAGE VERTICAL TEMPERATURE GRADIENT OF THE AIR (DEG K/METER)

IN STABILITY CLASS E	0.0728
IN STABILITY CLASS F	0.1090
IN STABILITY CLASS G	0.1455

PLUME DEPLETION AND DEPOSITION PARAMETERS

NUCLIDE	GRAVITATIONAL FALL VELOCITY (METERS/SEC)	DEPOSITION VELOCITY (METERS/SEC)	SCAVENGING COEFFICIENT (1/SEC)	EFFECTIVE DECAY CONSTANT IN PLUME (PER DAY)
U-238	0.000	0.00180	0.117E-04	0.000E+00
U-235	0.000	0.00180	0.117E-04	0.000E+00
U-234	0.000	0.00180	0.117E-04	0.000E+00
RA-226	0.000	0.00180	0.117E-04	0.000E+00
TH-232	0.000	0.00180	0.117E-04	0.000E+00

FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR EACH DIRECTION

SECTOR	FRACTION OF TIME IN EACH STABILITY CLASS						
	A	B	C	D	E	F	G
N	0.0000	0.0300	0.2042	0.6347	0.0890	0.0421	0.0000
NNW	0.0051	0.0224	0.1778	0.6169	0.1039	0.0740	0.0000
NW	0.0000	0.0213	0.1184	0.6929	0.0847	0.0826	0.0000
WNW	0.0000	0.0176	0.0765	0.7082	0.0959	0.1017	0.0000
W	0.0000	0.0259	0.0692	0.6788	0.0969	0.1292	0.0000
WSW	0.0000	0.0295	0.0773	0.6385	0.1043	0.1504	0.0000
SW	0.0029	0.0351	0.0774	0.6372	0.1262	0.1211	0.0000
SSW	0.0000	0.0341	0.1081	0.6200	0.1518	0.0859	0.0000
S	0.0017	0.0229	0.0960	0.6580	0.1492	0.0722	0.0000
SSE	0.0023	0.0181	0.0786	0.6961	0.1634	0.0415	0.0000
SE	0.0000	0.0128	0.0532	0.7688	0.1267	0.0384	0.0000
ESE	0.0000	0.0141	0.0433	0.7504	0.1296	0.0625	0.0000
E	0.0000	0.0189	0.0871	0.6810	0.1317	0.0814	0.0000
ENE	0.0000	0.0199	0.1448	0.5329	0.2053	0.0971	0.0000
NE	0.0000	0.0383	0.1512	0.4917	0.2185	0.1003	0.0000
NNE	0.0000	0.0182	0.1230	0.6261	0.1683	0.0644	0.0000

FREQUENCIES OF WIND DIRECTIONS AND RECIPROCAL-AVERAGED WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
N	0.141	0.00	3.02	4.73	5.11	3.33	1.43	0.00
NNW	0.028	1.19	1.98	4.42	3.91	3.16	1.39	0.00
NW	0.029	0.00	1.98	3.32	3.96	2.98	1.68	0.00
WNW	0.028	0.00	1.95	3.12	3.72	2.94	1.20	0.00
W	0.049	0.00	1.59	2.44	3.91	2.75	1.31	0.00
WSW	0.043	0.00	1.49	2.76	3.95	2.95	1.46	0.00
SW	0.048	1.19	1.63	3.07	4.48	3.26	1.87	0.00
SSW	0.047	0.00	1.84	3.89	4.94	3.77	1.80	0.00
S	0.082	1.19	2.60	3.87	5.59	3.97	1.78	0.00
SSE	0.061	1.19	2.67	3.97	6.17	3.97	1.46	0.00
SE	0.086	0.00	2.74	4.37	6.81	4.07	1.77	0.00
ESE	0.059	0.00	2.00	3.98	6.73	3.97	1.66	0.00
E	0.092	0.00	2.16	3.69	6.02	3.85	1.74	0.00
ENE	0.080	0.00	2.15	3.81	4.66	3.63	1.81	0.00
NE	0.060	0.00	2.48	3.90	4.32	3.39	1.85	0.00
NNE	0.068	0.00	2.16	3.82	4.92	3.48	1.67	0.00

FREQUENCIES OF WIND DIRECTIONS AND TRUE-AVERAGE WIND SPEEDS

WIND TOWARD	FREQUENCY	WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC)						
		A	B	C	D	E	F	G
N	0.141	0.00	3.70	5.36	6.19	3.57	1.96	0.00
NNW	0.028	1.67	3.15	5.05	5.13	3.38	1.91	0.00
NW	0.029	0.00	3.15	4.44	5.02	3.17	2.16	0.00
WNW	0.028	0.00	2.54	4.36	5.12	3.12	1.69	0.00
W	0.049	0.00	2.34	3.44	5.33	2.86	1.83	0.00
WSW	0.043	0.00	2.33	3.42	5.14	3.13	1.98	0.00
SW	0.048	1.67	2.62	3.90	5.61	3.49	2.28	0.00
SSW	0.047	0.00	2.78	4.37	5.71	3.96	2.24	0.00
S	0.082	1.67	3.07	4.27	6.44	4.11	2.23	0.00
SSE	0.061	1.67	3.34	4.38	6.90	4.11	1.98	0.00
SE	0.086	0.00	3.45	4.83	7.58	4.18	2.22	0.00
ESE	0.059	0.00	2.83	4.66	7.42	4.11	2.15	0.00
E	0.092	0.00	3.18	4.38	6.99	4.03	2.20	0.00
ENE	0.080	0.00	3.25	4.10	5.52	3.85	2.25	0.00
NE	0.060	0.00	3.30	4.42	5.22	3.63	2.27	0.00
NNE	0.068	0.00	3.24	4.62	6.00	3.71	2.15	0.00

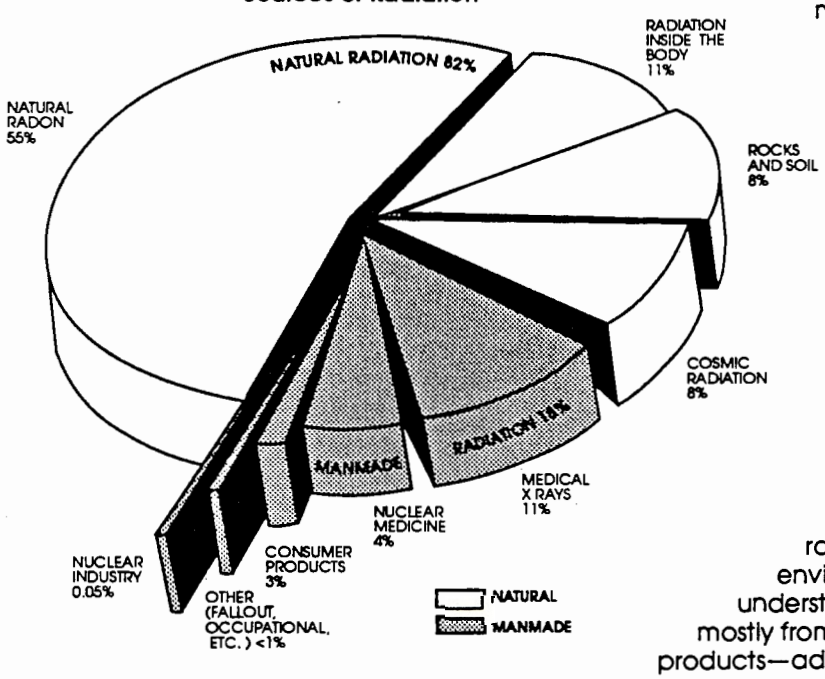
APPENDIX F
RADIATION IN THE ENVIRONMENT

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

TYPES OF IONIZING RADIATION

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

Alpha

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

Beta

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

Gamma

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

Units of Measure

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

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

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

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

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

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/yea
Color Television ..... <1 mrem/yea
Gas Lantern Mantle
(thorium-232) ..... 2 mrem/yea
Highway Construction ..... 4 mrem/yea
Airplane Travel at 39,000 feet
(cosmic) ..... 0.5 mrem/hou
Natural Gas Heating and Cooking
(radon-222) ..... 2 mrem/yea
Phosphate Fertilizers ..... 4 mrem/yea

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.

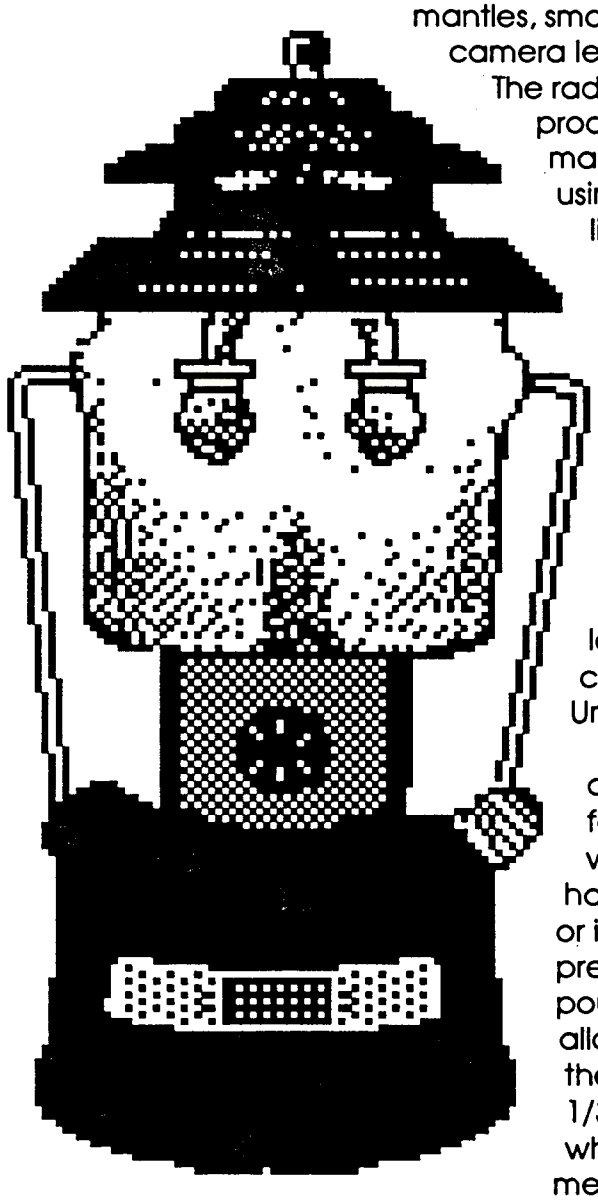
UNIT OF RADIOACTIVITY	SYMBOL	DISINTEGRATIONS PER MINUTE	DOLLAR ANALOGY	EXAMPLES OF RADIOACTIVE MATERIALS
1 Curie	Ci	$2x10^{12}$ or 2 Trillion	2 Times the Annual Federal Budget	Nuclear Medicine Generator
1 Millicurie	mCi	$2x10^{9}$ or 2 Billion	Cost of a New Interstate Highway from Atlanta to San Francisco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

APPENDIX G
METALS DATA

Appendix G

Summary of Metal Concentrations in Groundwater at WISS, 1991

ampling ocation	Metal	Quarter 1	2	3	4	Avg
		(Concentrations are in µg/L)				
1A	Aluminum	123 U	3590	3835.2	200	U1937.1
	Antimony	26.9 BR	19.0 UJ	833.7	60 U	234.9
	Arsenic	2.0 U	2.0 U	2 U	10 U	4.0
	Barium	28.1 B	60.3 B	1205.2	200 U	373.4
	Beryllium	1.0 U	1.0 U	62.5	5 U	17.4
	Boron	182	223	1230	100 U	433.8
	Cadmium	3.0 U	1.0 U	49.7	5 U	14.7
	Calcium	94000	116000	75594	119000	101148.5
	Chromium	3.0 U	3.7 B	130.3	10 U	36.8
	Cobalt	5.0 U	4.3 B	589.2	50 U	162.1
	Copper	7.8 B	12.9 B	294.4	25 U	85.0
	Iron	371	6930	4274.1	198	2943.3
	Lead	3.0 B	11.2 J	11.5 J	3 U	7.2
	Magnesium	27300	34300	27030.6	32700	30332.7
	Manganese	32.3	228	308.5	17.2	146.5
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	1160	100 U	365.0
	Nickel	8.0 U	7.0 U	518.8	40 U	143.5
	Potassium	834 B	1050 B	6174.8	5000 U	3264.7
	Selenium	2.0 U	1.0 U	2.0 UJ	5 U	2.5
	Silver	5.0 UJ	4.0 U	121.6 J	10 U	35.2
	Sodium	40900	49300	32080.4	54000	44070.1
	Thallium	40.0 UR	5.0 UJ	20.0 UJ	100 U	41.3
	Vanadium	32.1 BJ	22.4 BJ	603.6	50 U	177.0
	Zinc	22.1	45.2 J	333.6 J	20 U	105.2
1B	Aluminum	123 U	77.0 U	2564.1	200 U	741.0
	Antimony	20.0 UR	19.0 UJ	701.5	60 U	200.1
	Arsenic	2.0 U	3.9 B	2.8 B	10 U	4.7
	Barium	62.0 B	59.8 B	963.5	348	358.3
	Beryllium	1.0 U	1.0 U	49.9	5 U	14.2
	Boron	144	151	995	100 U	347.5
	Cadmium	3.0 U	4.0 U	47.5	5 U	14.9
	Calcium	9990	13700	24643.1	46200	23633.3
	Chromium	3.0 U	3.0 U	111.1	10 U	31.8
	Cobalt	5.0 U	4.0 U	496.9	50 U	139.0
	Copper	7.7 B	7.0 U	231.2	25 U	67.7
	Iron	12000	8110	2876.1	1510	6124.0
	Lead	3.0 UJ	2.0 J	2.7 BJ	3 U	2.7
	Magnesium	4330 B	6180	13047.4	18100	10414.4
	Manganese	89.6 B	72.9	187	22.8	93.1
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	973	100 U	318.3
	Nickel	8.0 U	7.0 U	434.5	40 U	122.4
	Potassium	1780 B	1010 U	4701.7 B	5000 U	3122.9
	Selenium	2.0 UJ	1.0 U	20.0 UJ	5 U	7.0
	Silver	5.0 UJ	4.0 U	101.5 J	10 U	30.1
	Sodium	13700	14900	12952.5	12000	13388.1
	Thallium	40.0 UR	5.0 UJ	2.0 UJ	10 U	14.3
	Vanadium	17.3 BJ	10.4 BJ	512.2	50 U	147.5
	Zinc	15.6 B	33.1 J	269.6 J	20 U	84.6
2A	Aluminum	16900	14900	38959.8	12100	20715.0
	Antimony	20.0 U	19.0 UJ	18.4 BJ	60 U	29.4
	Arsenic	7.9 B	5.0 B	13.4	10 U	9.1
	Barium	120 B	95.8 B	532.7	200 U	237.1
	Beryllium	1.2 B	1.1 B	4.8 B	5 U	3.0
	Boron	181	189	145	181	174.0
	Cadmium	3.0 U	4.0 U	8.5	5 U	5.1

Appendix G

(continued)

Sampling Location[a]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
2A (cont'd)	Calcium	49400	39900	154366.3	38100	70441.6
	Chromium	9.7 B	10.4	62.0	15.9	24.5
	Cobalt	17.0 B	12.1 B	50.0	50 U	32.3
	Copper	47.1	26.7	171.5	26	67.8
	Iron	31100	26100	71231.4	21900	37582.9
	Lead	22.3	4.7 J	66.9 J	15	27.2
	Magnesium	19600	16100	48161.9	14100	24490.5
	Manganese	1060	643	4871.3	610	1796.1
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U		100 U	75.0
	Nickel	31.9 B	25.3 B	82.3	40 U	44.9
	Potassium	3480 B	2990 B	5941.6	5000 U	4352.9
	Selenium	2.0 U	1.0 U	20.0 UJ	5 U	7.0
	Silver	5.0 U	4.0 U	4.0 UJ	10 U	5.8
	Sodium	10700	11000	12169.5	10600	11117.4
	Thallium	40.0 U	5.0 UJ	2.0 UJ	10 U	14.3
	Vanadium	49.0 B	31.8 BJ	113.6 J	50 U	61.1
	Zinc	83.0 B	77.5 J	657.2 J	68.3	221.5
2B	Aluminum	123 U	77.0 U	84.0 UJ	200 U	121.0
	Antimony	20.0 UR	23.0 BJ	19.4 BJ	60 U	30.6
	Arsenic	2.0 U	3.7 BJ	4.5 B	10 U	5.1
	Barium	267	212	246	219	236.0
	Beryllium	1.0 U	1.0 U	1.0 U	5 U	2.0
	Boron	106	101	100 U	100 U	101.8
	Cadmium	3.0 U	4.0 U	2.0 U	5 U	3.5
	Calcium	42000	40100 J	46607.3 U	45800	43626.8
	Chromium	3.0 U	3.0 U	3.2 BJ	10 U	4.8
	Cobalt	5.0 U	4.0 U	4.4 BJ	50 U	15.9
	Copper	4.0 U	7.0 U	8.6 BJ	25 U	11.2
	Iron	28200	21000	14949.2	5270	17354.8
	Lead	5.1 J	2.0 UJ	2.0 UJ	3 U	3.0
	Magnesium	14400	13800 J	15671.7	14500	14592.9
	Manganese	118	72.4	99.5	21.8	77.9
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U	100 U	100.0
	Nickel	8.0 U	7.0 U	6.0 U	40 U	15.3
	Potassium	815 U	1010 U	955 U	5000 U	1945.0
	Selenium	2.0 U	1.2 BJ	20.0 UJ	5 U	7.1
	Silver	5.0 UJ	4.0 U	4.0 UJ	10 U	5.8
	Sodium	7590	7380	9837.7	7300	8026.9
	Thallium	40.0 UR	5.0 UJ	20.0 UJ	10 U	18.8
	Vanadium	20.9 BJ	8.0 U	29.6 BJ	50 U	27.1
	Zinc	5.7 B	64.2 J	144.3 J	20 U	58.6
3A	Aluminum	123 U	1550	5473.8	1510	2164.2
	Antimony	20.0 UR	19.0 U	18.0 UJ	60 U	26.0
	Arsenic	2.0 B	3.1 BJ	5.1 B	10 U	22.8
	Barium	20.0 B	41.9 B	75.9 B	200 U	84.5
	Beryllium	1.0 U	1.0 U	1.0 U	5 U	2.0
	Boron	123	100 U		139	90.5
	Cadmium	3.0 U	4.0 U	2.0 U	5 U	3.5
	Calcium	46500	77700 J	91438.7	89200	76209.7
	Chromium	3.0 U	3.0 U	11.6 J	10 U	6.9
	Cobalt	5.0 U	4.0 U	6.7 BJ	50 U	16.4
	Copper	4.0 U	7.1 B	18.4 BJ	25 U	13.8
	Iron	1310 U	5060	12041.2	3370	5445.3
	Lead	3.0 UJ	2.0 UJ	3.7 J	3	2.9
	Magnesium	11600	18700	21676.6	20200	18044.2
	Manganese	90.1	731	967.7	358	536.7
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2

Appendix G

(continued)

ampling ocation[a]	Metal	Quarter 1	2	3	4	Avg
3A cont'd)	Molybdenum	100 U	100 U		100 U	75.0
	Nickel	8.0 U	7.0 U	13.7 B	40 U	17.2
	Potassium	815 U	1010 U	1803.4 B	5000 U	2157.1
	Selenium	2.0 U	1.0 UJ	20.0 UJ	5 U	7.0
	Silver	5.0 UJ	4.0 U	4.0 UJ	10 U	5.8
	Sodium	12300	17300	21337.9	19100	17509.5
	Thallium	4.0 UR	5.0 UJ	2.0 UJ	10 U	5.3
	Vanadium	27.5 BJ	16.9 BJ	53.7 J	50 U	37.0
	Zinc	14.3 B	51.9 J	419.2 J	20 U	126.4
3B	Aluminum	123 U	77.0 U	84.0 UJ	200 U	121.0
	Antimony	20.0 UR	19.0 U	18.0 UJ	60 U	29.3
	Arsenic	2.0 U	2.0 UJ	2.0 U	10 U	4.0
	Barium	536	305	388.7	216	361.4
	Beryllium	1.0 U	1.0 U	1.0 U	5 U	2.0
	Boron	100 U	100 U		100 U	75.0
	Cadmium	3.0 U	4.0 U	2.0 U	5 U	3.5
	Calcium	21400	24100 J	51891.3	51700	37272.8
	Chromium	3.0 U	3.0 U	8.9 BJ	10 U	6.2
	Cobalt	6.3 B	4.0 U	6.7 BJ	50 U	16.8
	Copper	7.0 B	7.0 U	8.0 BJ	25 U	11.8
	Iron	12300	65200	113544	24300	53836.0
	Lead	3.0 UJ	2.0 UJ	2.0 UJ	3 U	2.5
	Magnesium	13700	13000 J	16415.1	14700	14453.8
	Manganese	5.1 B	182	291.6	59.5	134.6
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U		100 U	75.0
	Nickel	8.0 U	7.0 U	6.0 U	40 U	15.3
	Potassium	815 U	1010 U	955 U	5000 U	1945.0
	Selenium	2.0 UJ	1.0 UJ	20.0 UJ	5 U	7.0
	Silver	13.3 J	4.0 U	4.0 UJ	10 U	7.8
	Sodium	7660	7530	8216.6 J	7480	7721.7
	Thallium	40.0 UR	50.0 UJ	20.0 UJ	10 U	30.0
	Vanadium	4.0 U	8.0 U	4.0 UJ	50 U	16.5
	Zinc	3.0 U	41.1 J	82.7 J	20 U	36.7
4A	Aluminum	124 U	78.9 BJ	619.4	200 U	255.6
	Antimony	20.4 R	19.0 U	18.0 UJ	60 U	29.4
	Arsenic	2.3 BJ	2.0 U	2.2 BJ	10 U	4.1
	Barium	125 B	109 B	255.4	200 U	172.4
	Beryllium	0.3 BJ	1.0 U	1.0 U	5 U	1.8
	Boron	129	129	151	100 U	127.3
	Cadmium	3.2 U	4.0 U	2.0 U	5 U	3.6
	Calcium	50900	49300	71078.9	42000	53319.7
	Chromium	2.9 U	3.0 U	3.0 U	10 U	4.7
	Cobalt	4.7 U	4.0 U	3.2 BJ	50 U	15.5
	Copper	12.0 B	7.0 U	4.0 BJ	25 U	12.0
	Iron	2560 J	1690 J	14803.9	994	5012.0
	Lead	9.2	2.0 U	2.5 BJ	3 U	4.2
	Magnesium	16300	16000 J	22071.3	13000	16842.8
	Manganese	228	162 J	1379	121	472.5
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U	100 U	100.0
	Nickel	7.7 U	7.0 U	6.0 UJ	40 U	15.2
	Potassium	1510 R	1010 UJ	955 UJ	5000 U	2118.8
	Selenium	2.0 U	1.8 B	2.0 UJ	5 U	2.7
	Silver	11.4 U	4.0 UJ	4.0 U	10 U	7.4
	Sodium	12300 R	13700 J	22605.4	9560	14541.4
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10 U	5.3
	Vanadium	10.2 B	8.0 U	38.9 BJ	50 U	26.8
	Zinc	28.0 J	11.7 BJ	144.5	120	76.1

Appendix G

(continued)

Sampling Location[a]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
4B	Aluminum	124 U	77.0 UJ	84.0 UJ	200 U	121.3
	Antimony	20.4 R	19.0 UJ	18.0 UJ	60 U	29.4
	Arsenic	2.0 UJ	4.2 B	2.0 UJ	10 U	4.6
	Barium	147 B	191 U	271.5	200 U	202.4
	Beryllium	0.3 BJ	1.0 U	1.0 UJ	5 U	1.8
	Boron	122	101	119	100 U	110.5
	Cadmium	3.2	4.0 U	2.0 U	5 U	3.6
	Calcium	42300	44100 J	52699	45300	46099.8
	Chromium	2.9 U	3.0 U	3.0 U	10 U	4.7
	Cobalt	4.7 U	4.0 U	3.0 U	50 U	15.4
	Copper	5.7 B	7.0 U	2.0 U	25 U	9.9
	Iron	2770 J	15500 J	40101.9	8100	16618.0
	Lead	3.0 UJ	2.0 U	2.0 U	3 U	2.5
	Magnesium	14800	14100 J	16329.8	14100	14832.5
	Manganese	43.5	40.1 J	115	24.5	55.8
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U	100 U	100.0
	Nickel	7.7 U	7.0 U	6.0 UJ	40 U	15.2
	Potassium	815 R	1010 UJ	955 UJ	5000 U	1945.0
	Selenium	2.0 UJ	1.0 U	2.0 UJ	5 U	2.5
	Silver	11.4 U	4.0 UJ	4.0 U	10 U	7.4
	Sodium	7820 R	7390 J	8876.5	7680	7941.6
	Thallium	4.0 UJ	50.0 UJ	20.0 UJ	10 U	21.0
	Vanadium	6.6 B	8.0 U	22.6 BJ	50 U	21.8
	Zinc	17.7 BJ	8.2 BJ	147.8	20 U	48.4
5A	Aluminum	124 U	913 J	10931.2 J	203.0	3042.8
	Antimony	20.4 R	25.1 BJ	18.0 UJ		15.9
	Arsenic	2.4 BJ	2.0 U	3.0 BJ		1.9
	Barium	223	19.6 B	95.5 BJ	200.0	134.5
	Beryllium	0.3 UJ	1.0 U	1.0 U		0.6
	Boron	173	100 U	200	185.0	164.5
	Cadmium	3.2 U	4.0 U	2.0 UJ		2.3
	Calcium	35400	22800 J	71994.81 J	54100.0	46073.7
	Chromium	2.9 U	3.0 U	14.2 J	10.0	7.5
	Cobalt	4.7 U	4.0 U	6.4 BJ		3.8
	Copper	4.4 B	7.0 U	35.0 J	25.0	17.9
	Iron	2400 J	1580 J	16967.6 J	396.0	5335.9
	Lead	3.0	2.0 U	5.7 J	42.2	13.2
	Magnesium	15400	8250 J	25005.5 J	18600.0	16813.9
	Manganese	23.4	1420 J	978.5 J	1230.0	913.0
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2	0.2
	Molybdenum	100 U	100 U	100 U		7.8
	Nickel	7.7 U	7.0 U	16.6 BJ	40.0	ERR
	Potassium	883 R	1010 UJ	1240.9 BJ	5000.0	2033.5
	Selenium	2.0 UJ	1.0 U	2.0 UJ		1.3
	Silver	11.4 U	4.0 UJ	4.0 UJ	10.0	6.4
	Sodium	11100 R	4890 BJ	12508.7 J	11500.0	9999.7
	Thallium	4.0 UJ	5.0 UJ	2.0 UJ	10.0	5.3
	Vanadium	5.0 B	8.0 U	49.7 BJ	50.0	28.2
	Zinc	11.5 BJ	12.3 BJ	196.4 J	20.0	60.1
5B	Aluminum	567	77.0 UJ	298.1 J	200.0 U	285.5
	Antimony	20.4 R	19.0 UJ	18.0 UJ		14.4
	Arsenic	2.4 BJ	4.2 B	54.0 J		15.2
	Barium	44.0 B	186 B	944.7 J	200.0 U	343.7
	Beryllium	0.3 UJ	1.0 U	1.0 UJ		0.6
	Boron	179	152	100 U	163.0	148.5
	Cadmium	3.2 U	4.0 U	2.1 BJ		2.3
	Calcium	50600	34300 J	41597.4 J	35100.0	40399.4
	Chromium	2.9 U	3.0 U	3.0 UJ	10.0 U	4.7

Appendix G

(continued)

ampling ocation[a]	Metal	Quarter 1	2	3	4	Avg
5B	Cobalt	4.7 U	4.0 U	7.8 BJ		4.1
cont'd)	Copper	6.9 B	7.0 U	2.0 UJ	25.0 U	10.2
	Iron	940 J	5000 J	127492.4 J	1250.0	33670.6
	Lead	3.0 UJ	2.0 U	2.0 UJ	3.0 U	2.5
	Magnesium	17700	14800 J	16552.6 J	15100.0	16038.2
	Manganese	2040	27.3 J	289.4 J	15.0 U	592.9
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U		75.0
	Nickel	7.7 U	7.0 U	14.7 BJ	40.0 U	17.4
	Potassium	926 R	1010 UJ	955 UJ	5000.0 U	1972.8
	Selenium	2.0 UJ	1.6 B	2.0 UJ		1.4
	Silver	11.4 U	4.0 UJ	7.6 BJ	10.0 U	8.3
	Sodium	10900 R	10600 J	11968.3 J	10900.0	11092.1
	Thallium	4.0 UJ	5.0 UJ	20.0 UJ	10.0 U	9.8
	Vanadium	6.8 B	8.0 U	22.6 BJ	50.0 U	21.9
	Zinc	43.2 J	9.5 BJ	166.8 J	20.0 U	59.9
6A	Aluminum	276	3760 J	2355.1	200.0 U	1647.8
	Antimony	20.4 R	19.0 UJ	18.0 UJ		14.4
	Arsenic	2.0 B	5.3 BJ	2.0 UJ		2.3
	Barium	135 B	244	164 B	200.0 U	185.8
	Beryllium	0.3 BJ	1.0 U	1.0 U		0.6
	Boron	127	164	217	172.0	170.0
	Cadmium	3.2 U	4.0 U	2.0 U		2.3
	Calcium	58700	49000	56582.6	46000.0	52570.7
	Chromium	5.3 B	4.5 B	7.9 B	10.0 U	6.9
	Cobalt	4.7 U	6.2 B	3.0 UJ		3.5
	Copper	6.5 B	19.2 B	9.2 BJ	25.0 U	15.0
	Iron	726 J	7530 J	4371.1	334.0	3240.3
	Lead	3.0 UJ	5.4	2.1 B	16.1	6.7
	Magnesium	18600	17000 J	18655.8	14900.0	17289.0
	Manganese	345	2850 J	745.5	267.0	1051.9
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U		75.0
	Nickel	18.3 B	7.0 U	6.0 UJ	40.0 U	17.8
	Potassium	1060 R	1020 BJ	955 UJ	5000.0 U	2008.8
	Selenium	2.0 UJ	1.0 U	2.0 UJ		1.3
	Silver	11.4 U	4.0 UJ	4.0 U	10.0 U	7.4
	Sodium	11700 R	10000 J	12760.4	14400.0	12215.1
	Thallium	4.0 UJ	50.0 UJ	2.0 UJ	10.0 U	16.5
	Vanadium	8.3 B	9.6 B	39.1 BJ	50.0 U	26.8
	Zinc	17.8 BJ	30.6	162.5	66.0	69.2
6B	Aluminum	124 U	77.0 UJ	84.0 U	200.0 U	121.3
	Antimony	20.4 R	19.0 UJ	18.0 UJ		14.4
	Arsenic	2.1 B	3.3 BJ	2.0 UJ		1.9
	Barium	89.0 B	90.3 B	111.6 B	200.0 U	122.7
	Beryllium	0.3 UJ	1.0 U	1.0 U		0.6
	Boron	197	187	270	214.0	217.0
	Cadmium	3.2 U	4.0 U	2.0 U		2.3
	Calcium	43100	46700 J	57761.7	50500.0	49515.4
	Chromium	2.9 U	3.0 U	3.0 U	10.0 U	4.7
	Cobalt	4.7 U	4.0 U	3.0 UJ		2.9
	Copper	4.2 U	7.0 U	2.0 UJ	25.0 U	9.6
	Iron	883 J	579 J	1041.4	100.0 U	650.9
	Lead	3.0 U	2.0 U	2.0 U	3.0 U	2.5
	Magnesium	14700	15100 J	18413.8	16300.0	16128.5
	Manganese	29.9	3.0 BJ	4.6 BJ	15.0 U	13.1
	Mercury	0.2 U	0.2 U	0.1 UJ	0.2 U	0.2
	Molybdenum	100 U	100 U	100 U		75.0
	Nickel	7.7 U	7.0 U	6.8 BJ	40.0 U	15.4

Appendix G

(continued)

Sampling Location[a]	Metal	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Avg
6B (cont'd)	Potassium	815 R	1010 UJ	955 UJ	5000.0 U	1945.0
	Selenium	2.0 UJ	1.0 U	2.0 UJ		1.3
	Silver	11.4 U	4.0 UJ	4.0 U	10.0 U	7.4
	Sodium	8140 R	7720 J	9523.2	8570.0	8488.3
	Thallium	40.0 UJ	5.0 UJ	2.0 UJ	10.0 U	14.3
	Vanadium	6.8 B	8.0 U	39.0 BJ	50.0 U	26.0
	Zinc	16.8 BJ	8.3 BJ	15.7 BJ	20.0 U	15.2
7A[b]	Aluminum		77.0 UJ	561.5	200 U	209.6
	Antimony		19.0 UJ	18.0 UJ	60 U	24.3
	Arsenic		2.0 U	2.3 BJ	10 U	3.6
	Barium		106 B	255.8	200 U	140.5
	Beryllium		1.0 U	1.0 U	5 U	1.8
	Boron		100 U	141	106	86.8
	Cadmium		4.0 U	2.0 U	5 U	2.8
	Calcium		49100 J	72978.63	47900	42494.7
	Chromium		3.0 U	3.7 B	10 U	4.2
	Cobalt		4.0 U	3.2 BJ	50 U	14.3
	Copper		7.0 U	2.1 BJ	25 U	8.5
	Iron		1720 J	14999.3	1040	4439.8
	Lead		2.0 U	3.7	18.6	6.1
	Lithium				14900	13328.1
	Magnesium		15800 J	22612.5	132	418.4
	Manganese		164 J	1377.4	0.2 U	0.1
	Mercury		0.2 U	0.1 UJ	100 U	75.0
	Molybdenum		100 U	100 U	40 U	13.5
	Nickel		7.0 U	6.8 BJ	5000 U	1741.3
	Potassium		1010 UJ	955 UJ	5 U	2.0
	Selenium		1.0 U	2.0 UJ	10 U	4.5
	Silver		4.0 UJ	4.0 U	10500	11903.7
	Sodium		13500 J	23614.7	10 U	4.3
	Thallium		5.0 J	2.0 UJ	50 U	24.8
	Vanadium		8.0 U	41.1 BJ	20 U	44.2
	Zinc		13.4 BJ	143.2	20.0 U	5.0

[a]Sampling locations shown in Figure 4-12.

[b]Started sampling 2nd quarter.

APPENDIX H

SAMPLE OBSERVATION WELL CONSTRUCTION LOGS AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS

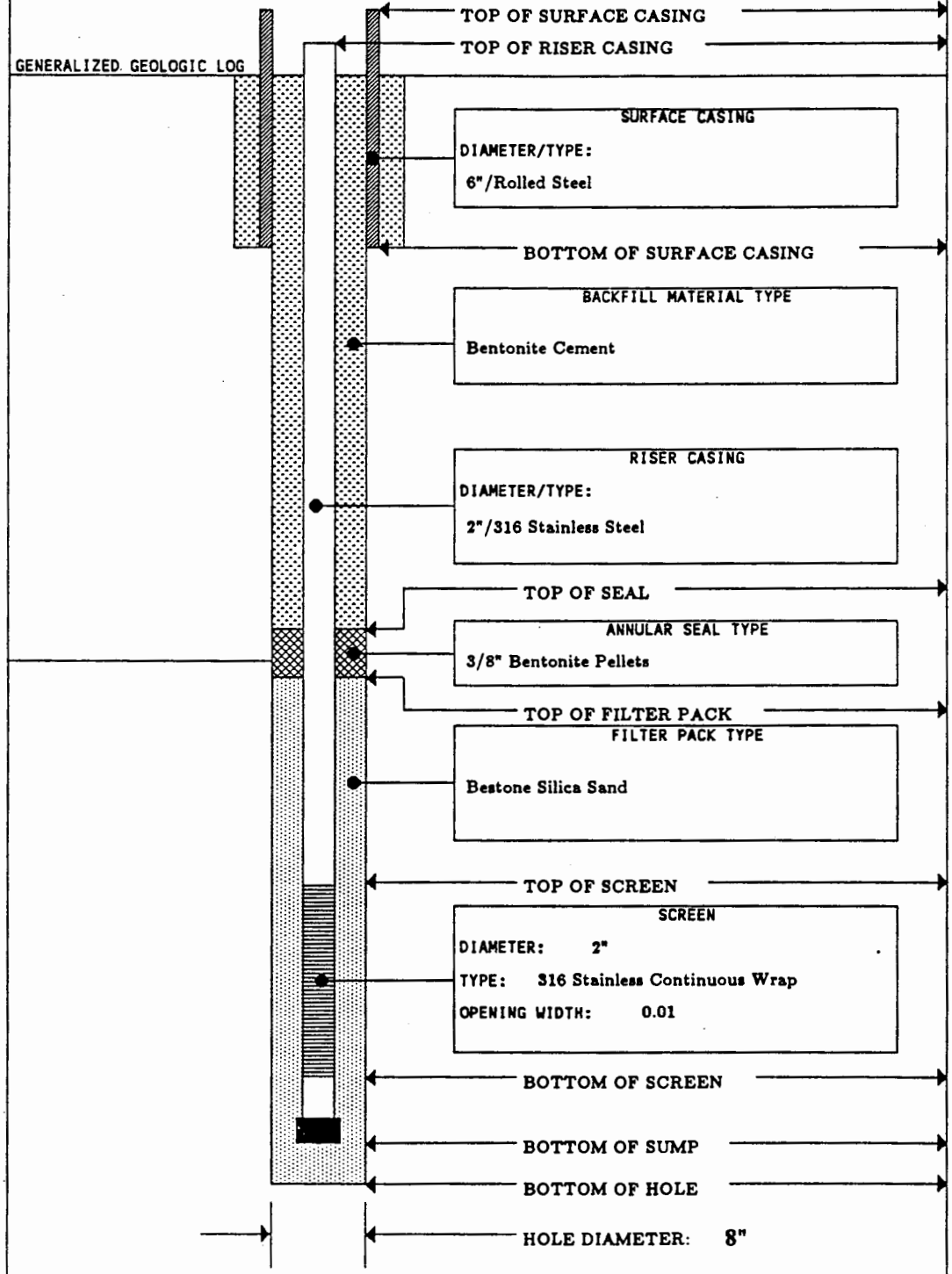
MONITORING WELL

PROJECT	WELL NO.
Wayne Interim Storage Site	B37W09D

JOB NO.	SITE	COORDINATES
14501-137	WISS	N 5,065.4 E 10,153.2

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
11-16-89	11-17-89	C. A. Clark	TOP OF CASING

GENERALIZED GEOLOGIC LOG



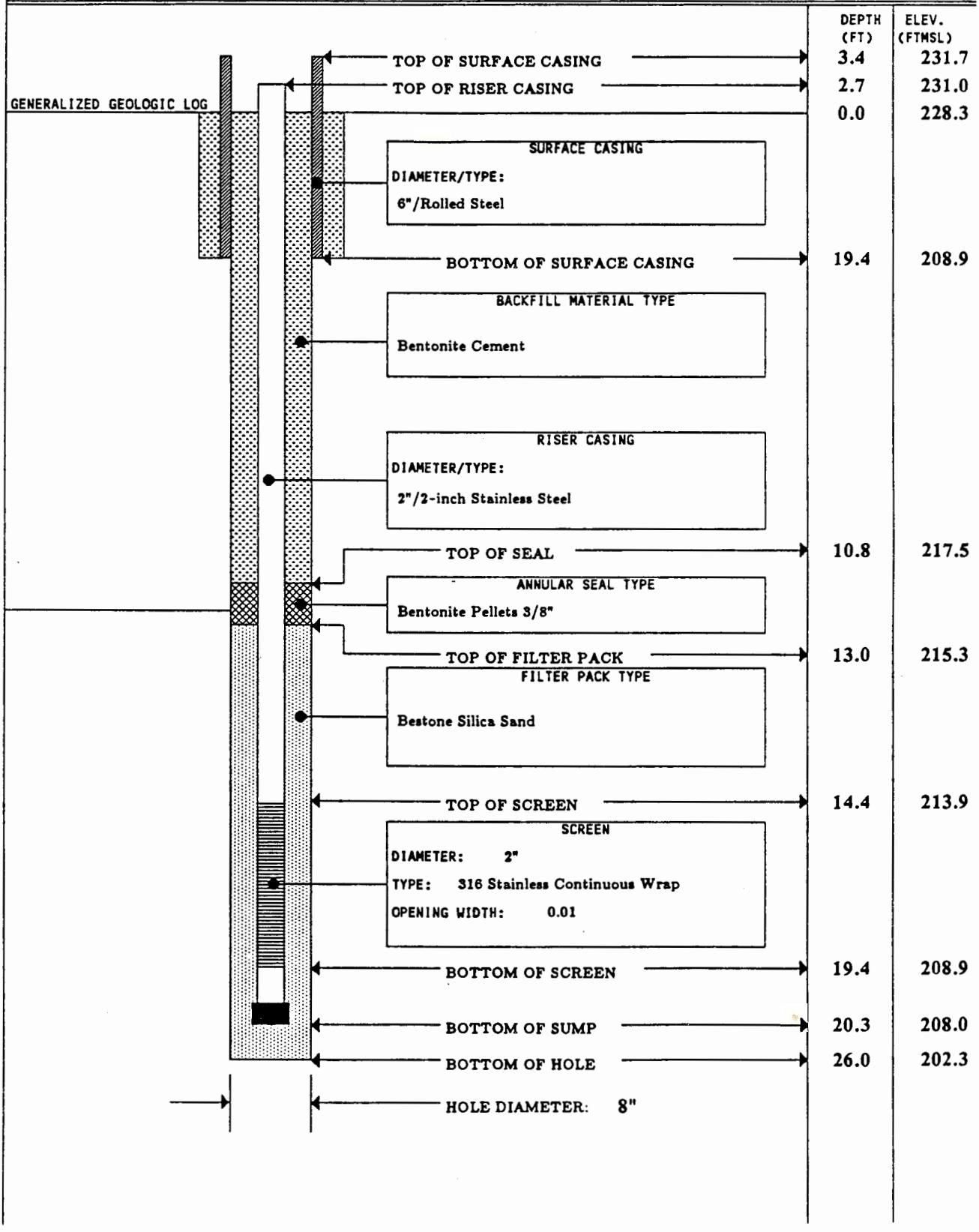
	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	3.5	232.1
TOP OF RISER CASING	2.7	231.3
	0.0	228.6
BOTTOM OF SURFACE CASING	3.0	225.6
TOP OF SEAL	49.4	179.2
TOP OF FILTER PACK	52.3	176.3
TOP OF SCREEN	54.4	174.2
BOTTOM OF SCREEN	64.7	163.9
BOTTOM OF SUMP	80.9	147.7
BOTTOM OF HOLE	81.0	147.6

MONITORING WELL

PROJECT	WELL NO.
Wayne Interim Storage Site	B37W09S

JOB NO.	SITE	COORDINATES
14501-137	WISS	N 5,064.9 E 10,151.5

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
11-17-89	11-18-89	C. A. Clark	TOP OF CASING



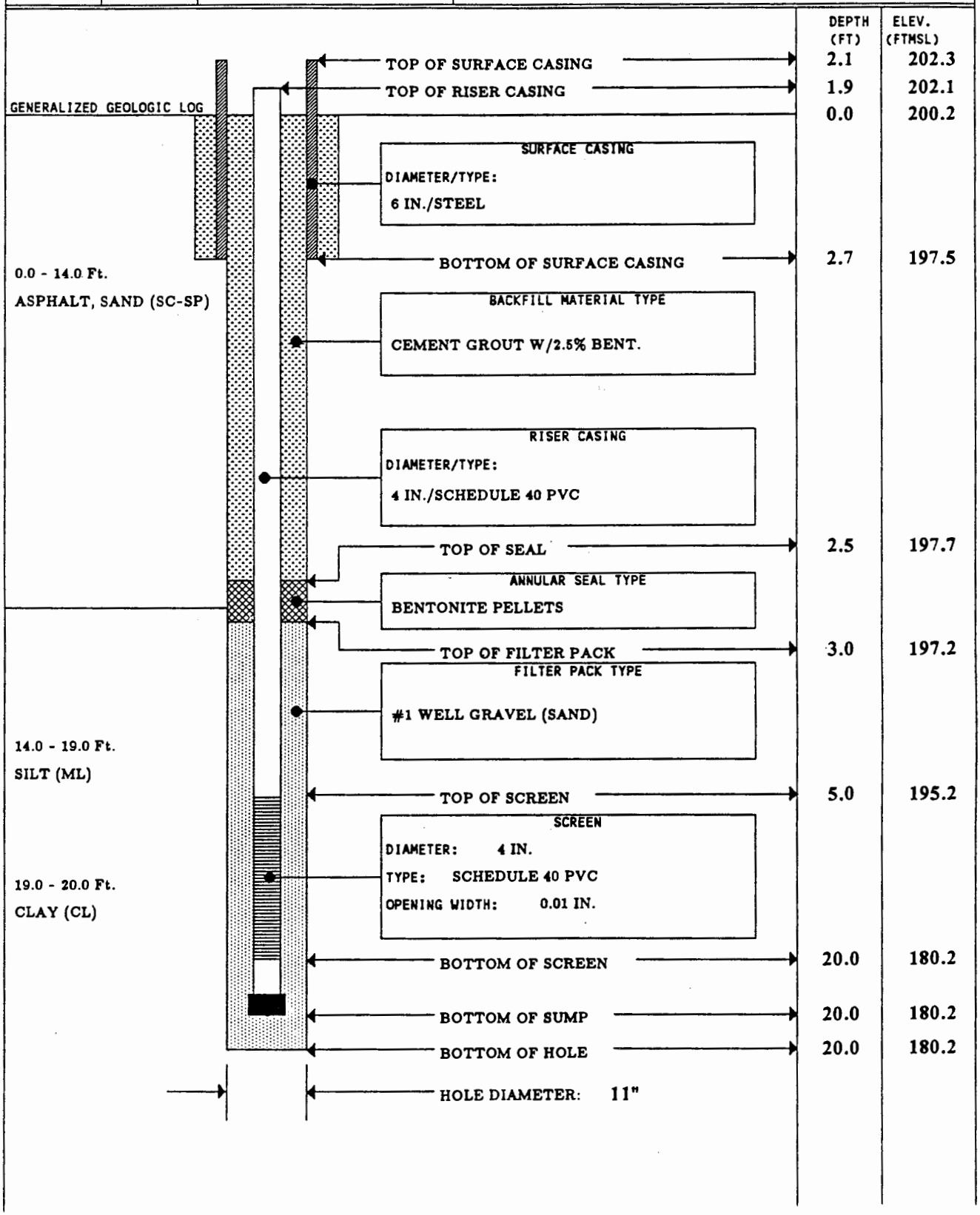
	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	3.4	231.7
TOP OF RISER CASING	2.7	231.0
	0.0	228.3
BOTTOM OF SURFACE CASING	19.4	208.9
TOP OF SEAL	10.8	217.5
TOP OF FILTER PACK	13.0	215.3
TOP OF SCREEN	14.4	213.9
BOTTOM OF SCREEN	19.4	208.9
BOTTOM OF SUMP	20.3	208.0
BOTTOM OF HOLE	26.0	202.3

MONITORING WELL

PROJECT	WELL NO.
Wayne Interim Storage Site	WISS-4A

JOB NO.	SITE	COORDINATES
14501-137	WISS	N 5,125.0 E 10,034.9

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
12-6-84	12-6-84	R. H. Nelson	TOP OF THE RISER PIPE.



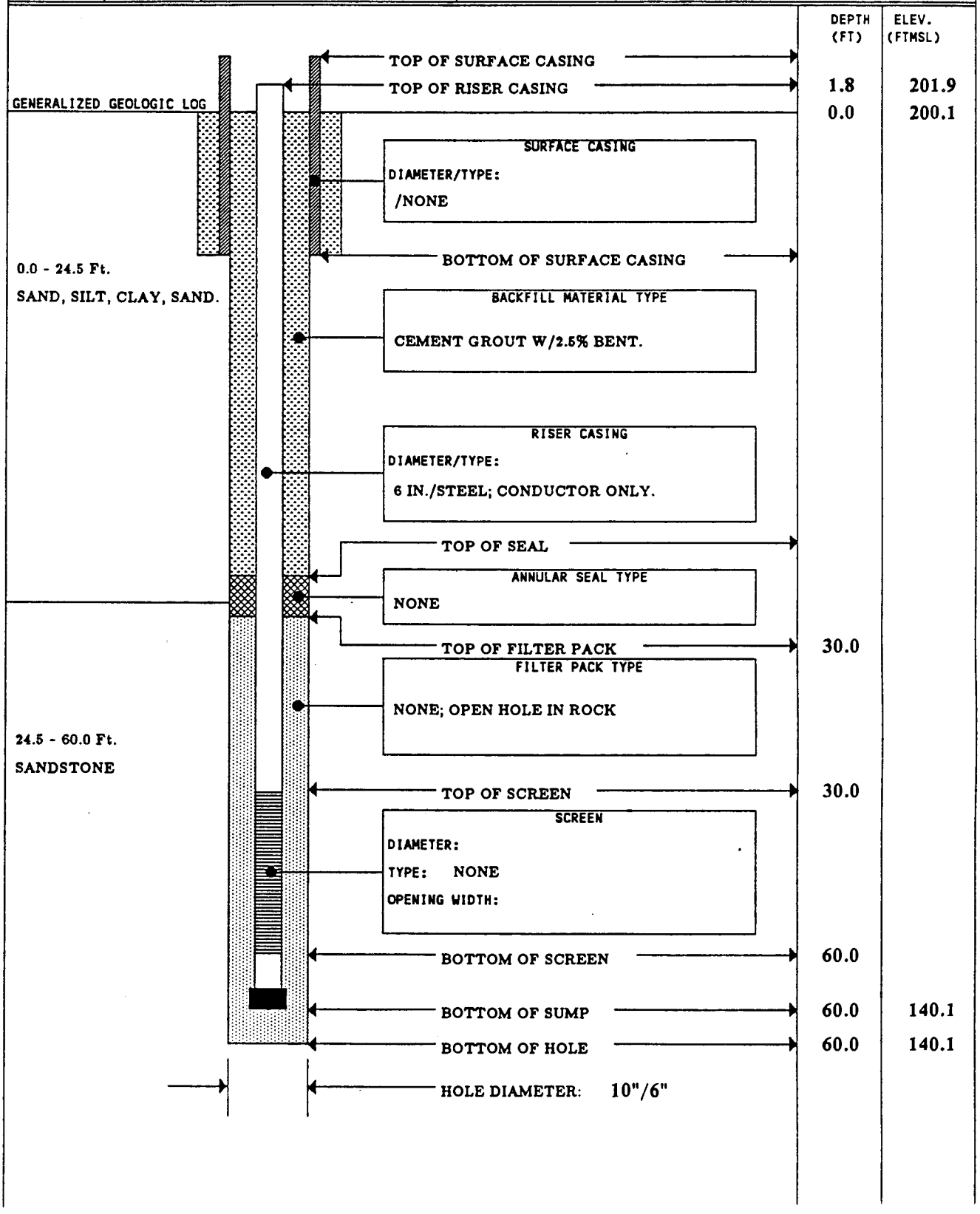
	DEPTH (FT)	ELEV. (FTMSL)
TOP OF SURFACE CASING	2.1	202.3
TOP OF RISER CASING	1.9	202.1
	0.0	200.2
BOTTOM OF SURFACE CASING	2.7	197.5
TOP OF SEAL	2.5	197.7
TOP OF FILTER PACK	3.0	197.2
TOP OF SCREEN	5.0	195.2
BOTTOM OF SCREEN	20.0	180.2
BOTTOM OF SUMP	20.0	180.2
BOTTOM OF HOLE	20.0	180.2

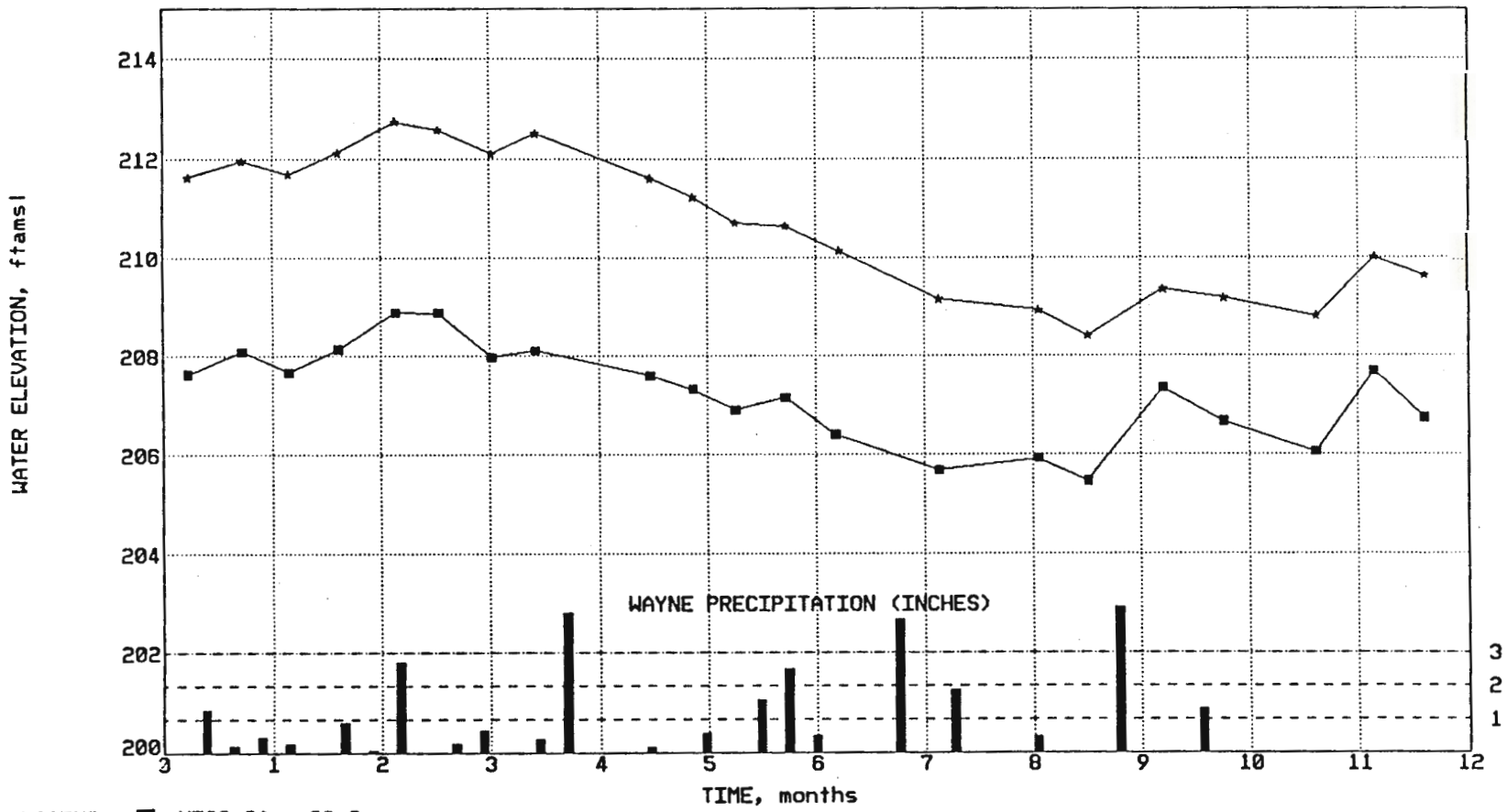
MONITORING WELL

PROJECT	WELL NO.
Wayne Interim Storage Site	WISS-4B

JOB NO.	SITE	COORDINATES
14501-137	WISS	N 5,127.5 E 10,035.3

BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
12-5-84	1-8-85	R. H. Nelson	TOP OF THE RISER PIPE.





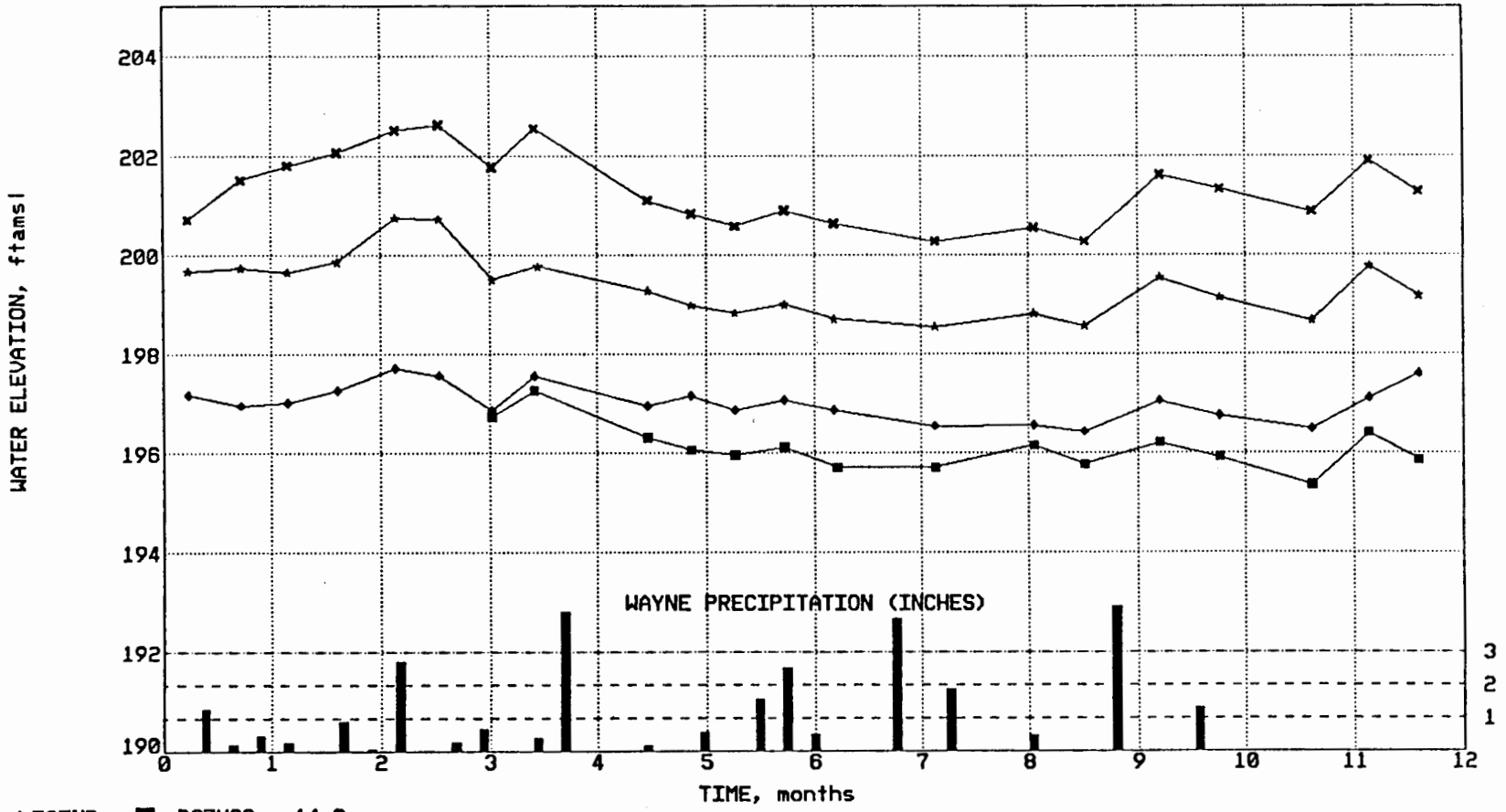
YEAR 1991

Wayne Hydrographs

HYDROGRAPH FOR WISS

Wayne Interim Storage Site PROJECT

BECHTEL JOB 14501-137



YEAR 1991

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HYDROGRAPH FOR WISS

Wayne Interim Storage Site PROJECT

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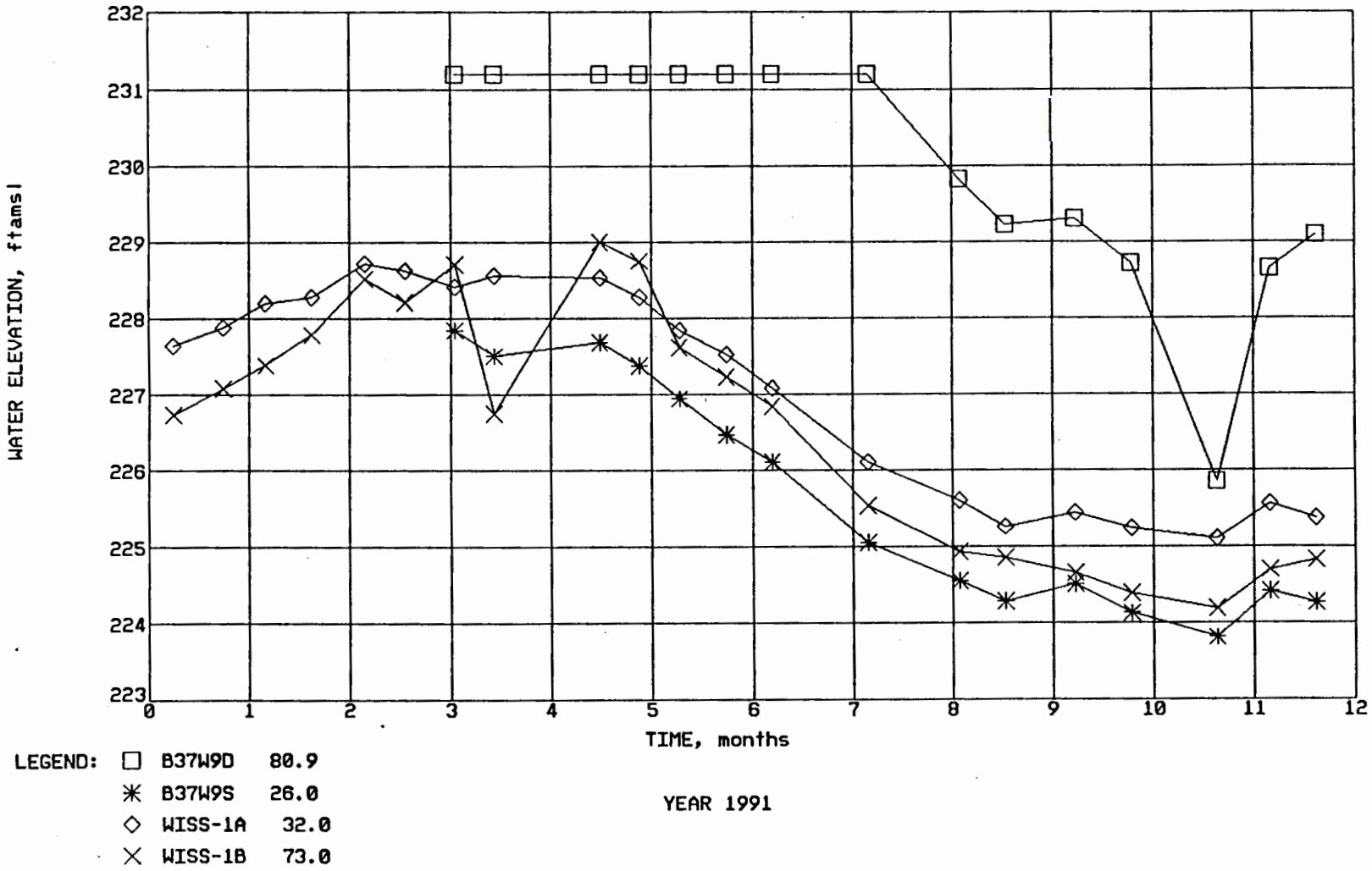

HYDROGRAPH FOR WISS

Wayne Interim Storage Site PROJECT

BECHTEL JOB 14501-137

APPENDIX I
CONVERSION FACTORS

Table I-1
Conversion Factors

1 yr	=	8,760 h
1 L	=	1,000 ml
1 μCi	=	1,000,000 pCi
1 pCi	=	0.000001 μCi
0.037 Bq/L	=	10^{-9} μCi/ml = 1 pCi/L
0.037 Bq/L	=	0.000000001 μCi/ml
1 μCi/ml	=	1,000,000,000 pCi/L
$1E^{-6}$ = 1E-6 = 1E-06	=	0.000001 = 1 x 10^{-6}
$1E^{-7}$ = 1E-7 = 1E-07	=	0.0000001 = 1 x 10^{-7}
$1E^{-8}$ = 1E-8 = 1E-08	=	0.00000001 = 1 x 10^{-8}
$1E^{-9}$ = 1E-9 = 1E-09	=	0.000000001 = 1 x 10^{-9}
$1E^{-10}$ = 1E-10	=	0.0000000001 = 1 x 10^{-10}

APPENDIX J

DISTRIBUTION LIST FOR WAYNE INTERIM STORAGE SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1991

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