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

HAZELWOOD INTERIM STORAGE SITE ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

Hazelwood, Missouri

August 1991

Bechtel National, Inc.

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Department of Energy
Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

August 26, 1991

Distribution

ANNUAL SITE ENVIRONMENTAL REPORT - HAZELWOOD INTERIM STORAGE SITE

Enclosed for your information is a copy of the 1990 Annual Site Environmental Report for the U.S. Department of Energy's Hazelwood Interim Storage Site located in your region. This report is prepared and published annually for distribution to interested local, state, and federal agencies; members of the public; and the press.

If you have any questions on the content of this report or desire additional information, please contact me either directly at (615) 576-9634 or you may call toll-free at (800) 253-9759.

Sincerely,

David G. Adler, Site Manager
Former Sites Restoration Division

Enclosure

DOE/OR/21949-283

HAZELWOOD INTERIM STORAGE SITE

ANNUAL ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1990

HAZELWOOD, MISSOURI

AUGUST 1991

Prepared for

United States Department of Energy

DOE Field Office, Oak Ridge

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

EXECUTIVE SUMMARY

Environmental monitoring of the U.S. Department of Energy's (DOE) Hazelwood Interim Storage Site (HISS) and surrounding area began in 1984. This document describes the environmental monitoring program, the program's implementation, and the monitoring results for 1990.

HISS was assigned to DOE as part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act. DOE placed responsibility for HISS under the Formerly Utilized Sites Remedial Action Program, 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.

It is DOE policy to conduct its operations in an environmentally responsible manner that provides protection of human health and the environment. To that end, DOE is committed to conducting national environmental protection and restoration programs, minimizing risks to the public and the environment, and addressing potential environmental hazards before they pose a threat to public welfare or environmental quality.

Environmental monitoring programs have been established at DOE-managed sites to confirm adherence to DOE environmental protection policies; to monitor the potential effects of site operations on human health and the environment; and to ensure compliance with legal and regulatory requirements imposed by federal, state, and local agencies. Environmental monitoring programs are developed and implemented on a site-specific basis to reflect facility characteristics, applicable regulations, hazard potential, quantities and concentrations of materials released, extent and use of affected land and water, and local public interest or concern. The environmental monitoring program at HISS includes sampling networks for radon concentrations in air; external gamma radiation exposure; and radium-226, thorium-230, and

total uranium concentrations in surface water, sediment, and groundwater. Additionally, several nonradiological parameters are measured in groundwater.

Monitoring results are compared with applicable Environmental Protection Agency (EPA) standards; federal, state, and local applicable or relevant and appropriate requirements (ARARs); and/or DOE derived concentration guidelines (DCGs). Environmental standards, ARARs, and DCGs are established to protect public health and the environment.

Results from the 1990 environmental monitoring program demonstrated that the concentrations of contaminants of concern were all below applicable standards, ARARs, and DCGs. These results are discussed in detail in Sections 4.0 and 5.0; a brief summary is provided below.

During 1990, average annual radon concentrations (including background) in air for each on-site monitoring station along the property boundary ranged from 0.4 to 0.5 pCi/L (0.01 to 0.02 Bq/L), well below the DOE guideline of 3.0 pCi/L. Radon flux measurements were collected to demonstrate that the site was in compliance with the radon flux limit of 20 $pCi/m^2/s$ set forth in 40 CFR Part 61, Subpart Q. The average radon flux rate for the large pile was 10.3 $pCi/m^2/s$ (0.38 $Bq/m^2/s$); the small pile averaged 0.3 $pCi/m^2/s$ (0.01 $Bq/m^2/s$). Although isolated readings on the large pile exceeded the radon flux limit, both piles were in compliance with the averaged value limit of 20 $pCi/m^2/s$. These elevated readings are thought to be taken in areas of weakness in the pile liner; a program will be developed to identify and repair these areas. External gamma radiation exposure levels around HISS averaged 41 mR/yr above background levels at the property line; average background for the area was 78 mR/yr. Average annual radionuclide concentrations in surface water ranged from 0.2E-9 to 0.4E-9, 0.1E-9 to 0.5E-9, and 3E-9 to 4E-9 $\mu Ci/ml$ (0.007 to 0.02, 0.004 to 0.02, and 0.1 to 0.2 Bq/L) for radium-226, thorium-230, and total uranium, respectively. (Note: 1E-n = 1 x 10^{-n}.) These concentrations are below the DOE DCGs of 100E-9, 300E-9, and

600E-9 μCi/ml. Average annual radionuclide concentrations in sediment ranged from 1.3 to 2.7, 0.7 to 11.8, and 1.3 to 2.3 pCi/g (0.048 to 0.10, 0.026 to 0.44, and 0.048 to 0.085 Bq/g) for radium-226, thorium-230, and total uranium, respectively. Six of the quarterly thorium-230 results were above the FUSRAP soil guideline of 5 pCi/g. Average annual concentrations in groundwater ranged from 0.2E-9 to 1.2E-9, 0.2E-9 to 11.1E-9, and 3E-9 to 57E-9 μCi/ml (0.007 to 0.044, 0.007 to 0.41, and 0.11 to 2.1 Bq/L) for radium-226, thorium-230, and total uranium, respectively.

Groundwater was also monitored for the indicator parameters of pH, specific conductance, total organic carbon, and total organic halides; analytical results indicated that levels of these parameters were typical of groundwater in the St. Louis area.

To verify that HISS was in compliance with the DOE radiation protection standard of 100 mrem/yr and to assess the potential effect of the site on public health, the potential radiation dose was calculated for a hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site. Based on the conservative scenario described in Subsection 4.2 of this report, this hypothetical individual would receive an annual exposure excluding background of approximately 0.9 mrem/yr (0.009 mSv/yr). The population within an 80-km (50-mi) radius of HISS would receive a collective dose above background of 1.6 person-rem/yr (0.016 person-Sv/yr). This is an extremely low collective dose; for comparison, the collective population dose due to background gamma radiation would be 2E+5 person-rem/yr (2E+3 person-Sv/yr).

To ensure that HISS was in compliance with 40 CFR Part 61, Subpart H, the EPA AIRDOS computer model was used to calculate the dose to a hypothetical maximally exposed individual resulting from airborne radionuclides transported from the site. The calculated dose was 0.4 mrem/yr (0.004 mSv/yr), which is well below the 10 mrem/yr limit given in the regulation.

During 1990, site activities were limited to the maintenance of contaminated soils in storage piles. HISS was in compliance with all applicable regulations, as has been the case since 1984, when the environmental monitoring program and remedial action began.

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ACRONYMS

AMS	Annotated Missouri Statutes
ARAR	applicable or relevant and appropriate requirement
BNI	Bechtel National, Inc.
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CSR	Code of State Regulations
CWA	Clean Water Act
CX	categorical exclusion
DCG	derived concentration guideline
DOE	Department of Energy
EA	environmental assessment
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
FFA	federal facilities agreement
FR	Federal Register
FUSRAP	Formerly Utilized Sites Remedial Action Program
HISS	Hazelwood Interim Storage site
MoDNR	Missouri Department of Natural Resources
NCP	National Oil and Hazardous Substances Contingency Plan
NEPA	National Environmental Policy Act

ACRONYMS

(continued)

NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PCB	polychlorinated biphenyl
PERALS	photon/electron-rejecting alpha liquid scintillation
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
SLAPS	St. Louis Airport Site
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
TSCA	Toxic Substances Control Act
USC	United States Code

UNITS OF MEASURE

Bq	becquerel
C	Celsius
cm	centimeter
F	Fahrenheit
ft	foot
ft MSL	feet above mean sea level
g	gram
h	hour
ha	hectare
in.	inch
km	kilometer
L	liter
m	meter
mg	milligram
mi	mile
µCi	microcurie
µg	microgram
µmhos	micromhos
ml	milliliter
mm	millimeter
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) Hazelwood Interim Storage Site (HISS) and surrounding area began in 1984. This document describes the environmental monitoring program, the program's implementation, and the monitoring results for 1990.

1.1 DOE INVOLVEMENT

HISS was assigned to DOE as part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act. DOE placed responsibility for HISS under 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.

DOE and the Environmental Protection Agency (EPA) Region VII negotiated a federal facilities agreement (FFA) defining the specific responsibilities and interactions of both agencies regarding DOE's remedial action activities at all the St. Louis FUSRAP sites. The final agreement was signed in June 1990.

The FFA states that the intent of the agreement is to:

- Ensure that the environmental impacts associated with past and present activities at the St. Louis sites are thoroughly investigated and that appropriate remedial action is taken as necessary to protect public health or welfare and the environment

- Establish a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the St. Louis sites in accordance with the Comprehensive Environmental Response, Compensation, and

Liability Act (CERCLA), the National Oil and Hazardous Substances Contingency Plan (NCP), and Superfund guidance and policy

- Facilitate cooperation, exchange of information, and participation of the parties in such actions

1.2 SITE HISTORY

In early 1966, uranium ore residues and uranium- and radium-bearing process wastes that had been stored at the St. Louis Airport Site (SLAPS) were purchased by the Continental Mining and Milling Company, Chicago, Illinois. The wastes had been generated by a St. Louis plant from 1942 through 1957 under contract with the Atomic Energy Commission and its predecessor, the Manhattan Engineer District. The wastes were moved to a storage site at 9200 Latty Avenue, a part of which is the present-day HISS. Between January 1967 and July 1973, the radioactive residues were dried and taken to facilities in Colorado. Much of the remaining material, classified as leached barium sulfate, and 30 to 46 cm (12 to 18 in.) of topsoil were removed and transported to a landfill in St. Louis County. Between 1984 and 1987, contaminated materials along Latty Avenue were excavated and stored at HISS.

1.3 SITE DESCRIPTION

HISS occupies approximately 2.2 ha (5.5 acres) in eastern Missouri within the City of Hazelwood (St. Louis County) (Figure 1-1). The HISS property includes two office trailers, a decontamination pad, and two interim storage piles with surface areas of approximately 6,800 and 1,800 m^2 (73,000 and 19,000 ft^2), respectively (Figure 1-2). HISS is currently being used for storage of radioactively contaminated soil from vicinity properties, and no effluents are generated. The site is entirely fenced, and public access is restricted (BNI 1987a).

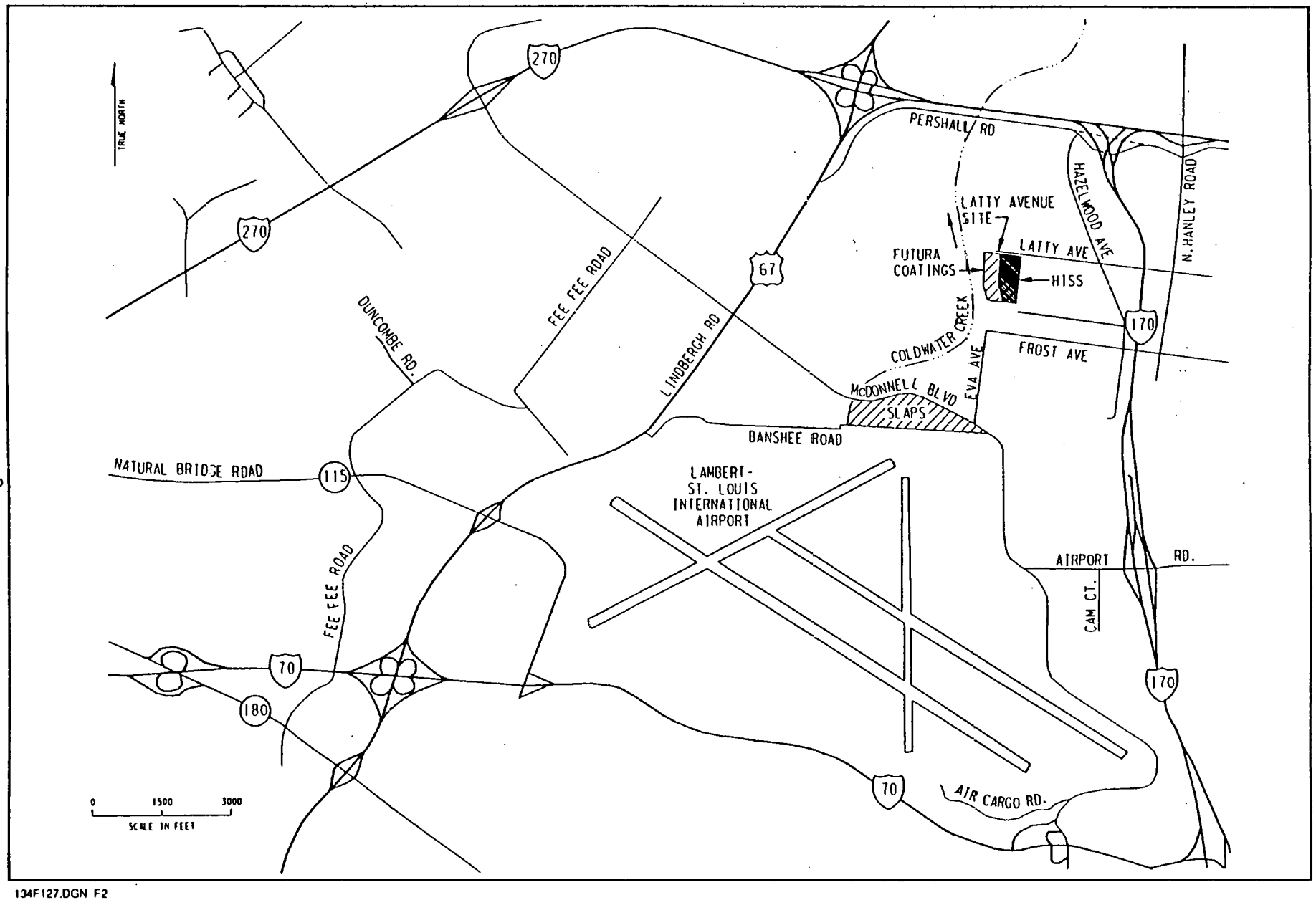

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Figure 1-1
Location of HISS

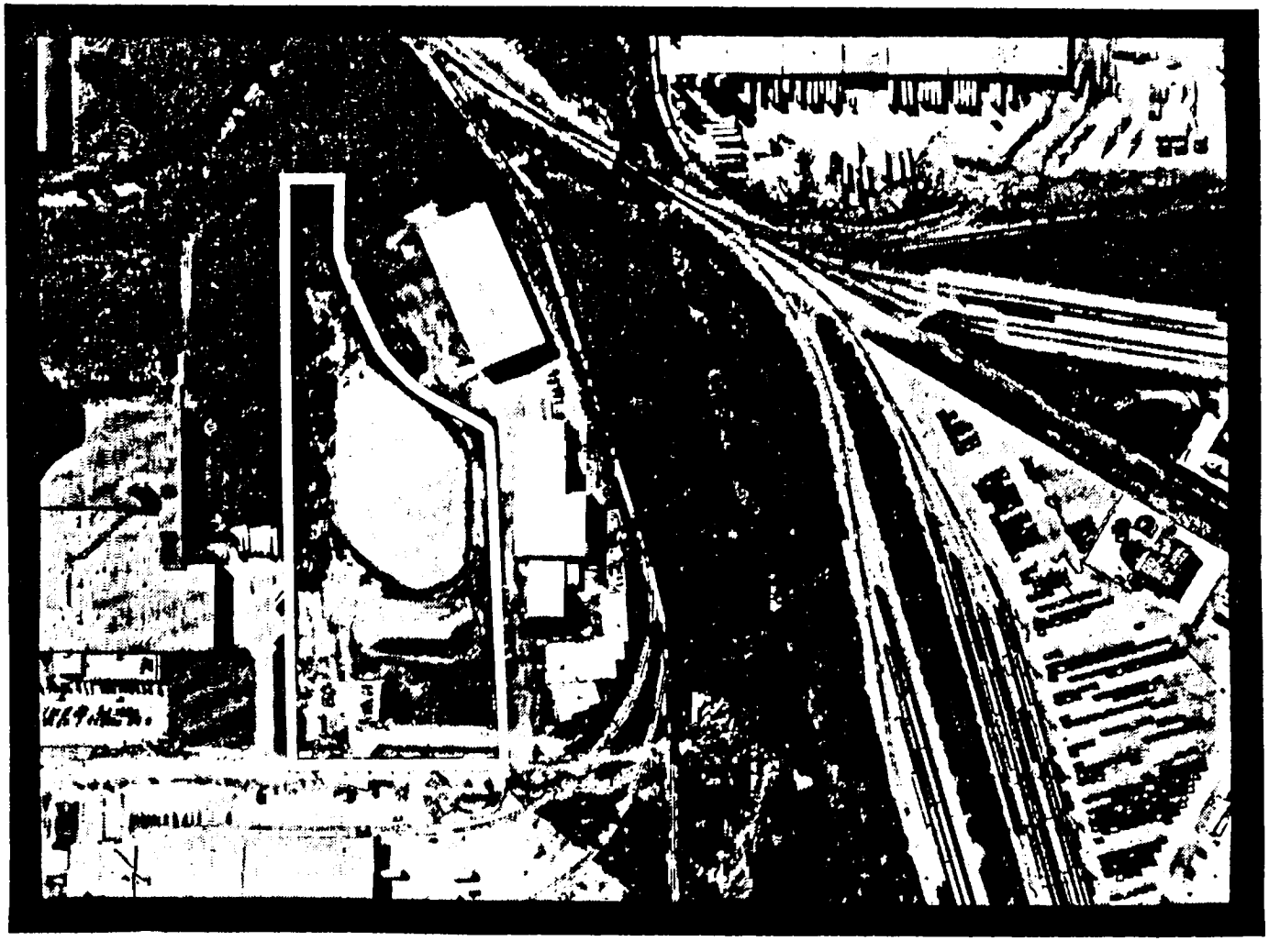

Figure 1-2
Aerial View of HISS and Its Vicinity

1.4 LAND USE

As shown in Figure 1-3, land use in the vicinity of HISS is predominantly industrial and commercial. The site is bordered by manufacturing companies to the north and west, a wooded area and Coldwater Creek to the south, and a warehouse to the east.

The principal source of potable water in the HISS area is treated water from the Mississippi River; approximately 100 percent of the City of Hazelwood uses this source. Water to be treated for public use is taken from the Mississippi River approximately 32 km (20 mi) downstream of HISS (Chain of Rocks Water Treatment Facility). Coldwater Creek (not used as a source of drinking water) empties into the Missouri River, which discharges into the Mississippi River. The nearest potable surface water supply facilities on the Missouri River are Central Plant and Howard Bend Plant.

The nearest residential areas are approximately 0.5 km (0.3 mi) east of HISS in Hazelwood (population 12,800) and 0.8 km (0.5 mi) south in Berkeley (population 20,300). The residences are primarily single-family dwellings. The total population of the area within an 80-km (50-mi) radius of HISS is approximately 2.5 million.

1.5 CLIMATE

Table 1-1 is a summary of climatological data from the National Oceanic and Atmospheric Administration for the St. Louis vicinity for 1990 (BNI 1991). Temperature extremes ranged from -18 to 38.9°C (0 to 102°F). Monthly average wind speeds ranged from 5.0 to 19 km/h (3.0 to 11.4 mph), and the predominant wind direction was from the southwest. Climatological events that could have affected data results were the extremely high precipitation experienced during the second quarter of 1990; monthly rainfall totals in May exceeded 22.9 cm (9 in.), and 11.9 cm (4.7 in.) of this precipitation fell within one 48-h period.

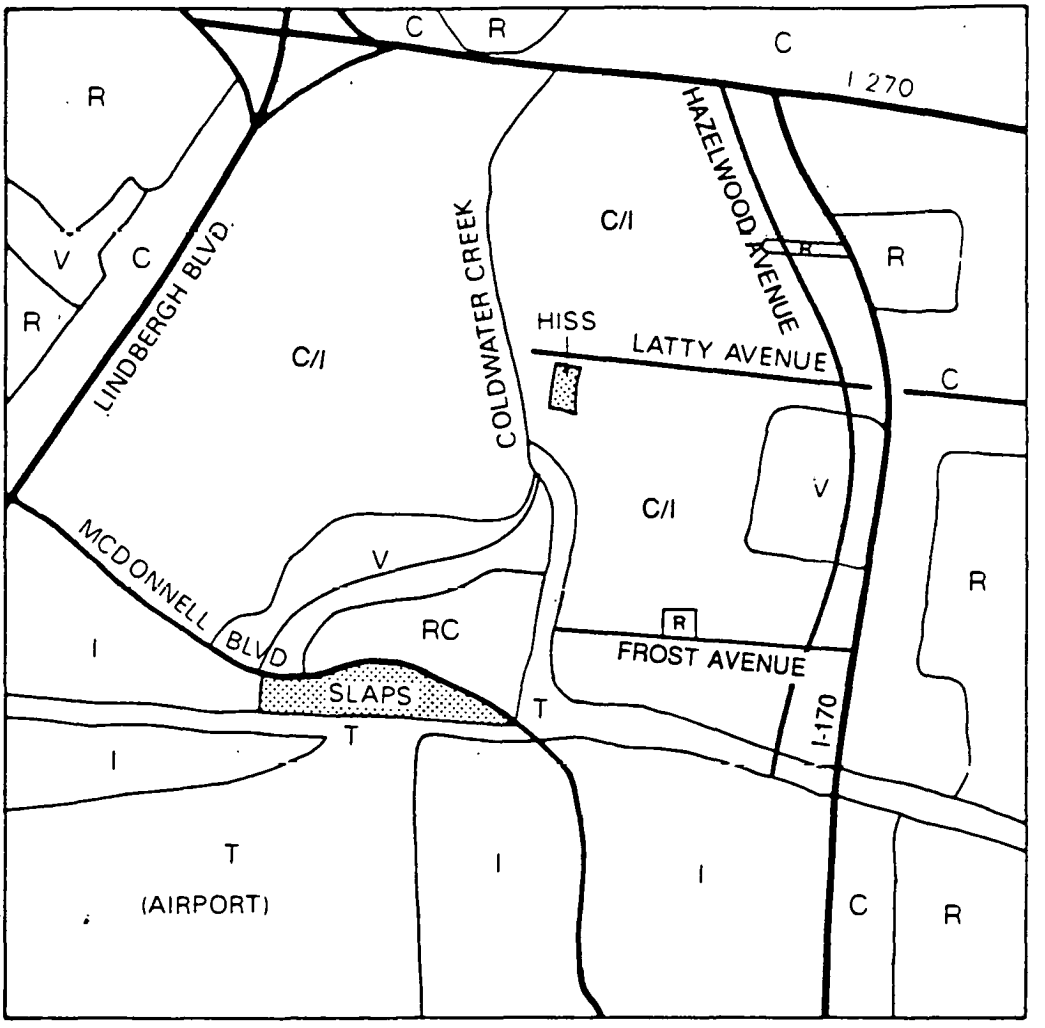

Figure 1-3
Generalized Land Use in the Vicinity of HISS

TABLE 1-1

SUMMARY OF CLIMATOLOGICAL DATA FOR

THE ST. LOUIS VICINITY, 1990

Month	Temperature (°F)			Total Precip (in.)	Wind	
	Min	Max	Avg		Avg Speed (mph)	Resultant Direction
January	19	71	42.9	1.42	11.4	SW
February	17	71	41.3	3.53	9.7	WSW
March	22	84	49.8	2.66	9.6	SSW
April	29	90	55.7	3.07	10.5	SW
May	46	85	63.6	9.59	10.5	SSW
June	51	96	77.2	3.02	10.3	SSW
July	57	102	80.2	3.34	8.9	SSW
August	57	101	77.9	2.84	7.9	SSE
September	45	101	74.1	0.78	9.2	SSW
October	35	87	58.1	4.96	9.4	SW
November	31	80	52.7	3.36	9.9	SW
December	0	67	34.7	6.52	3.0	WSW

Source: BNI 1991.

2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE

Throughout its history, HISS has been subject to evolving federal and state environmental regulations. The primary regulatory guidelines and limits are given in the DOE orders and 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); CERCLA; and the National Environmental Policy Act (NEPA)]. The following summaries describe compliance requirements as they existed in 1990, as well as anticipated regulatory requirements that may affect the site during subsequent years.

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 1988)] that establish quantitative limits, derived concentration guidelines (DCGs), and dose limits for radiological releases from DOE facilities. The applicable guidelines and dose limits are presented in Appendix C. For EPA permitting purposes, DOE orders are treated as legal requirements, and remedial action activities covered by DOE orders conducted at DOE facilities are considered "federally permitted actions" [54 Federal Register (FR) 22524].

A review of environmental monitoring results for calendar year 1990 shows that HISS was in compliance with all 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 [42 United States Code (USC) 7401 et seq.], as amended. Federal

regulations governing air emissions are contained in 40 Code of Federal Regulations (CFR) Parts 50 through 87 and 29 CFR Part 1910.

The only potential sources of air emissions from HISS are radionuclide emissions from the waste piles. To date, HISS does not have or require any state or federal air permits and, because it is a nonoperating DOE facility, only Subpart Q of the National Emission Standards for Hazardous Air Pollutants (NESHAPs) is applicable (DOE 1990a). If the pile is modified in the future, Subpart A (the general construction provisions of NESHAPs) reporting requirements will also be applicable. A strategy for determining compliance with the radon flux standard in Subpart Q was approved by EPA in 1990, and compliance with the EPA-approved strategy was attained and maintained in 1990. Radon flux results collected to demonstrate compliance with Subpart Q are provided in Subsection 4.1.1.

Radionuclide emissions (excluding radon and thoron) from the HISS storage piles have been modeled and the effective dose to members of the public has been calculated for calendar year 1990 using the EPA-approved AIRDOS computer model, as required by 40 CFR Section 61.93. As Subsection 4.2 of this document shows, radionuclide emissions were in compliance with applicable regulations in 1990. A waiver from compliance with the emissions standards for short-term remedial activities at HISS has been granted by the regional EPA office.

Clean Water Act

Waters discharged to navigable waters of the United States are regulated under the federal CWA, as amended (33 USC 1251 et seq.) and its associated EPA regulations (40 CFR Parts 122, 136, 403, and 405 through 471). Missouri has enacted its own Clean Water Law, which is found in Title 12, Annotated Missouri Statutes (AMS), Chapter 204. HISS did not have any state water permits until December 28, 1990.

Missouri Department of Natural Resources (MoDNR) regulates stormwater discharges under its state-authorized National Pollutant

Discharge Elimination System (NPDES) permit program codified in Title 10 Code of State Regulations (CSR), Division 20, Chapters 1 through 7. Stormwater converges at two outfalls at HISS and is conveyed to Coldwater Creek. NPDES permit No. MO-0111252, issued for HISS on December 28, 1990, requires monthly effluent monitoring and quarterly reporting of the results; the first report is due April 28, 1991.

The state regulations have not incorporated the provisions of the federal stormwater regulations promulgated on November 16, 1990. DOE and MoDNR are evaluating the effects of these new federal requirements on existing state stormwater discharge requirements. However, because HISS has been issued a permit, an application for compliance with these new requirements will not have to be submitted until 180 days prior to the expiration of the current permit.

Resource Conservation and Recovery Act

RCRA (40 USC 6901 et seq.) is the principal federal statute governing the management of hazardous waste and radioactive mixed waste that contains hazardous constituents. EPA regulations for implementing RCRA are contained in 40 CFR Parts 260 through 271. Missouri is an authorized state for implementation of the RCRA program; state RCRA requirements can be found in Missouri Hazardous Waste Management Law, AMS, Title 16, Chapter 260. Missouri hazardous waste regulations are contained in Title 10 CSR, Division 25.

Results from characterization studies have indicated that neither RCRA-regulated wastes nor radioactive wastes containing RCRA-regulated wastes are present at HISS. However, since the last characterization activities occurred, the toxicity characteristic leaching procedure (TCLP) has replaced the extraction procedure for testing for the RCRA characteristic of toxicity. The TCLP will be performed on any material to be excavated whenever knowledge of the waste is insufficient. Absent generation of RCRA-regulated waste in the sampling or remediation process, it is anticipated that state hazardous waste regulations will remain inapplicable.

Toxic Substances Control Act

The most common toxic substances regulated by TSCA (15 USC 2601 et seq.) are polychlorinated biphenyls (PCBs) and asbestos. Like RCRA requirements, TSCA requirements will have to be met in CERCLA remedial actions where they are applicable or relevant and appropriate. EPA regulations regarding the production, use, storage, handling, and disposal of PCBs are codified in 40 CFR Part 761. Regulations regarding the production, use, storage, handling, and disposal of asbestos are codified in 40 CFR Part 763.

PCB management (regulated by EPA and MoDNR) involves monitoring of in-service equipment; storage and disposal of equipment removed from service; cleanup and management of spill residues; and recordkeeping and reporting. MoDNR does not list PCBs as hazardous waste, and its regulations governing the management of PCB waste largely incorporate the requirements of 40 CFR Part 761 by reference. These regulations are found in Chapter 13 of the Missouri Hazardous Waste Management Rules (Title 10 CSR, Division 25).

HISS contains only uranium ore residues and uranium- and radium-bearing process wastes. TSCA-regulated waste has not been detected at HISS, and the provisions of TSCA are expected to remain inapplicable (ORNL 1990).

Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA (42 USC 9601 et seq.) is the primary source of statutory authority for the response actions to be conducted at HISS. EPA requlations governing cleanup activities are found in 40 CFR Part 300, which is the NCP. CERCLA Section 121 mandates that CERCLA response actions comply with substantive requirements of other environmental laws when they are applicable or relevant and appropriate.

Because HISS is on the National Priorities List (NPL), an FFA is required for site remedial action. EPA and DOE have entered into an FFA (signed on June 26, 1990) that integrates all response actions at the HISS/Futura Coatings, Inc. site, as well as at other St. Louis FUSRAP sites including SLAPS and vicinity properties.

The FFA integrates the provisions of CERCLA with other applicable and relevant laws. Specifically, the parties to the FFA intend that activities covered by the agreement will achieve compliance with CERCLA and will meet or exceed applicable or relevant and appropriate requirements (ARARs). Potential state and federal ARARs are identified in Appendix C. Compliance with CERCLA during remediation of FUSRAP sites such as HISS is ensured by extensive interactions with EPA and monitoring of compliance by DOE Headquarters.

National Environmental Policy Act

Although a formal NEPA determination has not been made for final cleanup of HISS, completion of an environmental impact statement (EIS) is required as part of the overall effort for the St. Louis FUSRAP sites on the NPL. Preparation of the EIS will be integrated with the preparation of the remedial investigation/ feasibility study (RI/FS) currently being developed for the site (scheduled for completion in 1994). Compliance with NEPA for site remedial actions will be accomplished by incorporating those elements required by an EIS into the format of the CERCLA RI/FS to produce an RI/FS-EIS for the St. Louis FUSRAP sites. This document is scheduled for completion in 1994.

In November 1990, a draft engineering evaluation/cost analysis (EE/CA) that assesses removal alternatives for the SLAPS vicinity properties was submitted to DOE Headquarters. An environmental assessment (EA), for NEPA purposes, will be integrated into the EE/CA to produce an EE/CA-EA addressing a proposed plan to store contaminated soil from vicinity properties at HISS.

On November 2, 1990, DOE proposed regulations to amend its NEPA guidelines in Title 10 CFR Part 1021 (55 FR 46444). Among the

proposed revisions is an expansion of the list of categorical exclusions (CXs) available since September 7, 1990. A CX is a class of actions that normally do not require the preparation of either an EIS or EA. One CX concerns site characterization and environmental monitoring under CERCLA and RCRA. The proposed regulations would streamline the decision-making process when determining the appropriate level of NEPA documentation.

Other Major Environmental Statutes and Executive Orders

In addition to the aforementioned 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; and the National Historic Preservation Act have all been found to impose no current requirements on HISS. In addition, Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands") and state laws and regulations have been reviewed for applicability and compliance. HISS is in compliance with, or not subject to, all applicable environmental statutes, regulations, and executive orders.

2.2 APPLICABLE ENVIRONMENTAL PERMITS

Other than a permit to discharge stormwater from the site, no permits have been identified as necessary for HISS. As regulations change in the future, the need for permits will be reviewed with regard to CERCLA Section 121. Section 121 requires that substantive requirements of applicable regulations be met, but exempts on-site activities at CERCLA sites such as HISS from administrative permitting requirements.

2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

Because the work at HISS will be conducted under an integrated CERCLA/NEPA process, an RI/FS-EIS will be prepared before any final

remedial actions are conducted. There is the possibility of some near-term response actions at the vicinity properties near HISS; any planned response actions will be evaluated using the EE/CA procedure provided by CERCLA. The NEPA process will be integrated into the EE/CA procedure.

2.4 SUMMARY OF COMPLIANCE IN CALENDAR YEAR 1991 (FIRST QUARTER)

During the first quarter of calendar year 1991, there continued to be full regulatory compliance at HISS. Environmental monitoring continues, as does review of potentially applicable federal and state regulations.

3.0 ENVIRONMENTAL PROGRAM INFORMATION

Routine monitoring for radiation, radioactive materials, and chemical substances on and off HISS 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 reducing negative environmental impacts.

The objectives of this report are to:

- Highlight significant programs and efforts
- Describe the environmental monitoring program for the site
- Report the radiological and nonradiological conditions of the site and surrounding areas during 1990
- Provide comparison of monitoring results and applicable regulations
- Provide trend analyses, where applicable, to indicate increases or decreases in environmental impact
- Provide detailed information on the input and assumptions used in all dose calculations

The primary audience for the environmental monitoring results may include the general public; property owners; community interest groups; technical staffs of 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 at all DOE sites. Requirements for environmental monitoring of airborne pollutants are found in NESHAPs; non-radon radionuclide and radon monitoring are required by NESHAPs. Radon monitoring was conducted at the HISS property boundary to ensure compliance with DOE orders.

Requirements for environmental monitoring of nonradiological parameters are found in DOE Order 5400.1 (DOE 1989). Nonradiological parameters were monitored to obtain baseline information on groundwater quality.

3.1.2 Monitoring Networks

The following common criteria were used in establishing the monitoring networks at HISS:

- All radon and gamma exposure rate monitoring stations, except background stations, are on site and only accessible to employees and authorized visitors. For purposes of this report, because site security includes the Futura Coatings property, the boundary of HISS was extended to include this area. "On-site" radon and external gamma radiation monitoring stations are located on the boundary line between HISS and Futura.

- Some radon and gamma exposure rate stations are located on or near the HISS property line to allow determination of exposure at the "fenceline" as required by DOE orders.

- All off-site groundwater wells have locking caps to provide security.

- Background stations are located off site in areas known to be uncontaminated.

The medium-specific networks at HISS include:

- 13 radon monitoring stations [6 on site (HISS/Futura boundary), 5 at the property line, and 2 off site]
- 13 gamma radiation monitoring stations (6 on site, 5 at the property line, and 2 off site)
- 5 surface water monitoring locations (2 off site downstream and 3 off site upstream)
- 5 sediment monitoring locations (2 off site downstream and 3 off site upstream)
- 13 groundwater monitoring locations (11 on site and 2 off site)

Details on the monitoring networks are provided in Sections 4.0 and 5.0.

3.1.3 Summary of Environmental Monitoring Data

The following subsections summarize environmental monitoring results for HISS for calendar year 1990. Detailed discussions of the radiological and nonradiological results are provided in Sections 4.0 and 5.0.

Radon

Annual average radon concentrations on site ranged from 0.4 to 0.5 pCi/L (0.01 to 0.02 Bq/L), including background (Subsection 4.1.1). The radon concentrations at all monitoring locations were below the DOE guideline of 3.0 pCi/L for interim storage sites and remained close to background levels throughout the year.

Radon flux measurements were collected to demonstrate that the site was in compliance with the radon flux limit of 20 $pCi/m^2/s$ set forth in 40 CFR Part 61, Subpart Q. The average radon flux for the large pile was 10.3 $pCi/m^2/s$ (0.38 $Bq/m^2/s$); the small pile averaged 0.3 $pCi/m^2/s$ (0.01 $Bq/m^2/s$).

External gamma radiation exposure

The annual average external gamma radiation exposure level was 5.6 mR/yr on site (HISS/Futura boundary) and 41 mR/yr at the property line, excluding a background level of 78 mR/yr. Detailed information on gamma radiation exposure monitoring can be found in Subsection 4.1.2.

Surface water

Surface water sampling was performed quarterly to determine concentrations of total uranium, radium-226, and thorium-230 and to assess any impact of site discharges to Coldwater Creek (Subsection 4.1.3). Average annual concentrations ranged from 0.2E-9 to 0.4E-9, 0.1E-9 to 0.5E-9, and 3E-9 to 4E-9 $\mu Ci/ml$ (0.007 to 0.02, 0.004 to 0.02, and 0.1 to 0.2 Bq/L) for radium-226, thorium-230, and total uranium, respectively. (Note: 1E-n = 1×10^{-n}.) Radionuclide concentrations at downstream sampling locations were essentially the same as upstream (background) concentrations, and all contaminant levels were below applicable guidelines.

Sediment

Sediment samples were collected in conjunction with surface water samples to check for deposition of the contaminants of interest. Average annual concentrations in sediment ranged from 1.3 to 2.7, 0.7 to 11.8, and 1.3 to 2.3 pCi/g (0.048 to 0.10, 0.026 to 0.44, and 0.048 to 0.085 Bq/g) for radium-226, thorium-230, and total uranium, respectively. With the exception of four quarterly

thorium-230 values, concentrations in downstream sediment did not vary notably from those found in upstream (background) samples (Subsection 4.1.4). There are currently no guidelines in effect for radionuclide concentrations in sediment; however, these concentrations are less than the 5 pCi/g soil guideline for the top 15 cm (6 in.) of soil for radium-226 and thorium-230 and the 50 pCi/g guideline for total uranium (Appendix C). These concentrations are well below the levels of radioactivity found in phosphate fertilizers (Appendix F).

Groundwater

Radionuclide concentrations in groundwater samples from HISS were in the general range of previous monitoring data. Analytical results show that groundwater quality in background wells is essentially the same as that in on-site wells. The groundwater quality is poor, but this is typical for an industrialized urban area.

Average annual radionuclide concentrations in groundwater ranged from 0.2E-9 to 1.2E-9, 0.2E-9 to 11.1E-9, and 3E-9 to 57E-9 μCi/ml (0.007 to 0.044, 0.007 to 0.41, and 0.11 to 2.1 Bq/L) for radium-226, thorium-230, and total uranium, respectively. Radionuclide concentrations in all samples were below applicable guidelines. With the exception of three wells (HISS-5, HISS-6, and HISS-16), all total uranium values were near measured background levels (Subsection 4.1.5). Thorium-230 concentrations were marginally above background levels, except for one elevated sample from HISS-15 [30E-9 μCi/ml (1.1 Bq/L)]. Annual average background levels for radium-226 were comparable to on-site levels.

Groundwater was also monitored for nonradiological parameters; samples were analyzed for specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX). Specific conductance values ranged from 673 to 12,600 μmhos/cm; pH ranged between 6.1 and 7.6. TOC results ranged from 1.2 to 62.6 mg/L, and TOX ranged from 20 to 130 μg/L.

3.2 APPLICABLE ENVIRONMENTAL PERMITS

The FFA for the St. Louis FUSRAP sites provides, in conjunction with DOE policy, that all applicable permit conditions will be met even though no permit applications are required. CERCLA Section 121 provides the statutory authority for an exemption to permitting requirements for on-site CERCLA remedial actions.

MoDNR regulates stormwater discharges from point sources under its NPDES permit program. DOE was issued a discharge permit (MO-0111252) for HISS on December 28, 1990. Under the conditions of the permit, which expires December 31, 1991, monthly effluent monitoring and quarterly reporting of the results are required.

3.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

As stated in Section 2.0, two NEPA documents are being generated for all the St. Louis sites; the first of these is the EA, which will be integrated into the EE/CA pursuant to CERCLA. This document will address interim removal actions taken prior to final site remedial action.

The second document to be produced is an EIS that will be integrated with the RI/FS. The RI/FS-EIS, scheduled for completion in fiscal year 1994, will satisfy the requirements of both NEPA and CERCLA.

3.4 SUMMARY OF ENVIRONMENTAL ACTIVITIES

In October a one-time sampling study was conducted to evaluate the need for expanding the isotopic analyses currently performed. Twenty percent of the surface water, sediment, and groundwater samples taken for routine analyses were also analyzed for gross alpha and beta. Table 3-1 is a summary of these data. In general, the gross alpha and beta results and the current sampling program results are in agreement. Even though the sum of the results of the primary analyses conducted (total uranium, radium-226, and thorium-230) does not always exactly equal the values of the gross radioanalyses, the data are consistent overall.

TABLE 3-1

SUMMARY OF GROSS ALPHA AND GROSS BETA

RESULTS FOR HISS, 1990

Sampling Location[a]	Gross Alpha	Gross Beta	Sum of Isotopic Results
Surface Water[b]			
3	2	3	3.5
Sediment[c]			
3	46	23	12.7
Groundwater[b]			
HISS-13	21	8	7.5
HISS-14	39	19	8.5
HISS-15	6	10	8.2
HISS-16	43	34	38.8

[a]Sampling locations are shown in Figures 4-3 and 4-4.

[b]Concentrations are given in E-9 μCi/ml.
Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[c]Concentrations are given in pCi/g.
Note: 1 pCi/g is equivalent to 0.037 Bq/g.

Factors contributing to differences between the data are (1) the contribution of alpha-emitting daughters in the decay chain that are not included in the analyses listed above, (2) poor counting statistics for gross alpha and beta results when analyzing samples with very low concentrations of radionuclides, and (3) the presence of potassium-40. Potassium-40, a beta emitter, is one of the Earth's most abundant naturally occurring radionuclides. Because gross alpha and gross beta values did not vary a large amount (e.g., an order of magnitude), there is no indication of a need to expand the isotopic analyses performed for the current program.

3.5 SELF-ASSESSMENTS

During 1990, DOE conducted two major self-assessments of the FUSRAP environmental monitoring program: one in June by the DOE-Oak Ridge Operations Environmental Protection Division, the second in November by DOE Headquarters Office of Environmental Audits. Findings from these two self-assessments focused on monitoring techniques, field documentation of monitoring events, and planning of environmental monitoring locations and events. As a result of the June assessment, corrective actions were developed and implemented prior to the next quarter's environmental monitoring. Actions remaining consist of developing environmental monitoring plans [required by DOE Order 5400.1 (DOE 1989)] to document the logic behind the environmental monitoring networks for FUSRAP sites. Work on these plans is currently under way; they are scheduled to be published by December 1991.

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

HISS is not an active site and produces no effluents; thus, the only possibility for contamination to be released from the site would be through contaminant migration.

Radiological environmental monitoring at HISS in 1990 included sampling for:

- radon concentrations in air
- on-site external gamma radiation exposure
- total uranium, radium-226, and thorium-230 concentrations in surface water, sediment, and groundwater

The monitoring systems included on-site, property-line, and off-site stations to provide sufficient information on the site's potential effects on human health and the environment.

The information contained in this section of the report includes the quarterly radiological data for each sampling point, yearly averages, and trend information. The methodology for calculating the averages and standard deviations is provided in Appendix A. All quarterly data are reported as received from the laboratory; all calculated values (i.e., averages and standard deviations) have been rounded off using standard rules for significant figures. Where appropriate, data are presented using powers of ten. The number following the "E" denotes the exponent (e.g., 3.2×10^{-1} is given as 3.2E-1).

Some of the quarterly results are reported using a "less than" (<) sign. This notation is used to denote specific sample analysis results that are below the limit of sensitivity of the analytical method, based on a statistical analysis of parameters. For 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 monitoring program for possible radioactive contaminant migration and results for 1990.

4.1 ENVIRONMENTAL MONITORING FOR RADIOLOGICAL CONTAMINANTS

4.1.1 Radon Monitoring

One pathway of radiation exposure from the uranium-238 decay series arises from inhalation of the short-lived radon and radon daughter products. Radon is a radioactive (alpha-emitting) gas that is very mobile in air. Radon monitoring was conducted at HISS to assess the impacts of the contaminants at the site on radon levels near the site and to ensure compliance with environmental regulations.

Program description

Quarterly radon concentrations were measured using monitors that contain a piece of alpha-sensitive film enclosed in a small plastic two-piece cup. Radon diffuses through a seam or membrane (depending on the manufacturer of the detector) of the cup until the radon concentrations inside and outside the cup reach equilibrium. Alpha particles from the radioactive decay of radon and its daughters in the cup create tiny tracks when they collide with the film. After the cups are collected, the films are placed in a caustic etching solution to enlarge the tracks; under strong magnification, the tracks are counted. The number of tracks per unit area (i.e., tracks/mm^2) is related through calibration to the radon concentration in air.

Radon detectors are maintained at six on-site (HISS/Futura boundary), five property-line, and two off-site locations (Figure 4-1). Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions.

To determine the radon flux from the storage piles, 70 charcoal canisters were placed on the large pile and 20 were placed on the small pile. The piles were covered with plastic sheeting while the radon flux was measured. The canisters remained on the piles for

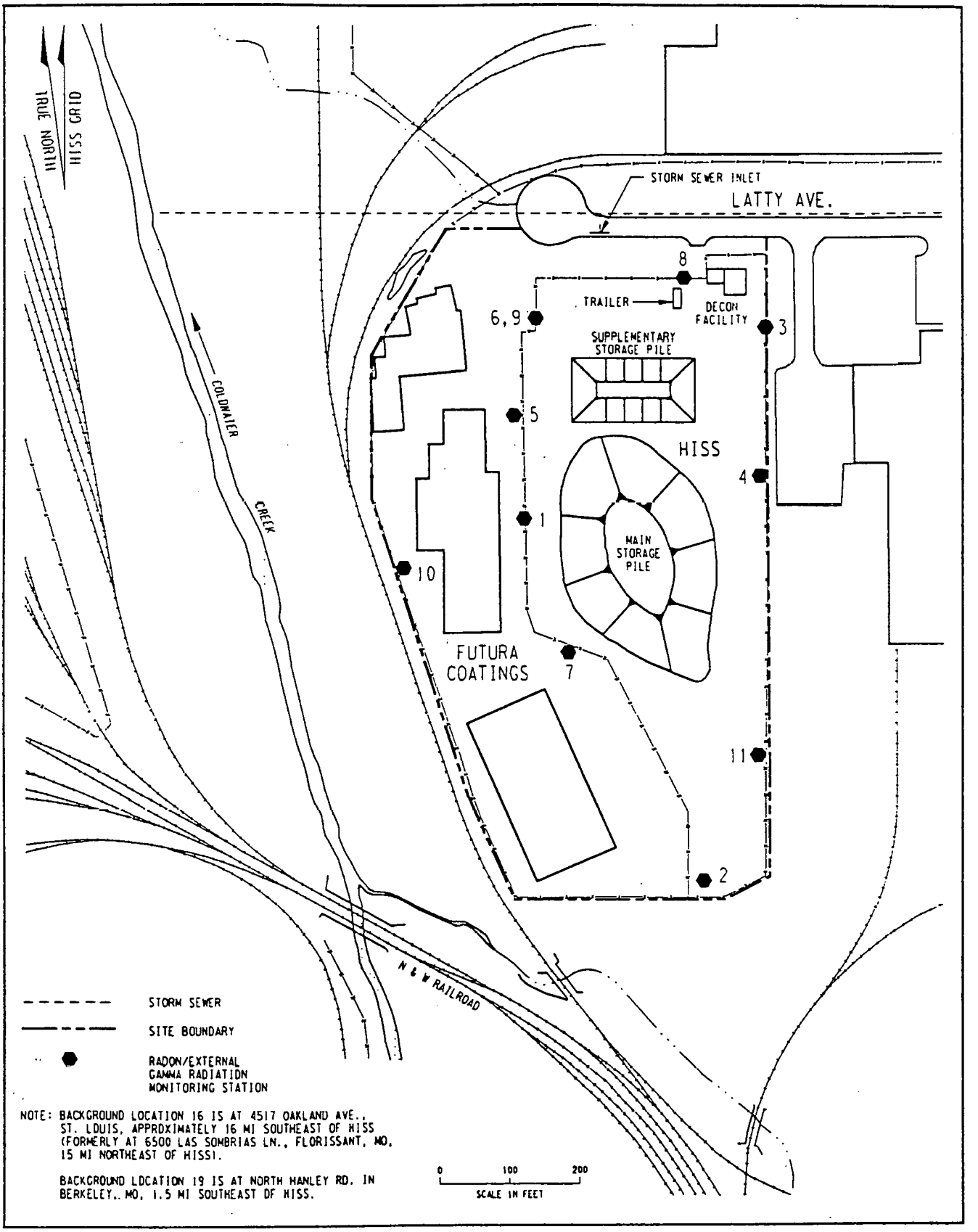

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Figure 4-1
Radon and External Gamma Radiation
Monitoring Locations at HISS

24 hours and were then removed, sealed, and shipped for analysis. No significant weather event that could conceivably affect the sampling occurred in the three days before or during the sampling event. Because radon is a gas, rain or snow could inhibit the normal radon flux rate and cause the resulting measurements to be lower than average.

Data and discussion

The maximum ambient air radon level detected was 1.1 pCi/L (0.04 Bq/L), at background location 16; annual average concentrations at the site ranged from 0.4 to 0.5 pCi/L (0.01 to 0.02 Bq/L) (see Table 4-1). No annual average at the boundary was greater than 30 percent of the DOE interim storage site guideline of 3.0 pCi/L.

Monitoring results demonstrated that the larger (main storage) pile had an average flux rate of 10.3 $pCi/m^2/s$ (0.38 $Bq/m^2/s$) and minimum and maximum values of 0.002 and 198 $pCi/m^2/s$ (7E-5 to 7.3 $Bq/m^2/s$), respectively. The smaller (supplementary storage) pile had an average flux rate of 0.3 $pCi/m^2/s$ (0.01 $Bq/m^2/s$) and minimum and maximum values of 0.05 and 0.44 $pCi/m^2/s$ (0.0017 to 0.016 $Bq/m^2/s$), respectively. Both piles were in compliance with the limit of 20 $pCi/m^2/s$ (an averaged value) specified in 40 CFR Part 61, Subpart Q. The isolated high readings are thought to be in areas of weakness in the pile liner; a program will be developed to identify and repair these areas.

Trends

Trends for concentrations of radon in air measured from 1986 through 1990 are presented in Table 4-2. The expected value ranges shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently

TABLE 4-1

CONCENTRATIONS[a,b] OF RADON

AT HISS, 1990

Sampling Location[c]	Quarter 1	2	3	4	Min	Max	Avg
Property Line (HISS and Futura)							
2	0.5	<0.3	<0.4	<0.3	<0.3	0.5	0.4
3	0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
4	0.9	<0.3	<0.4	<0.3	<0.3	0.9	0.5
10	<0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
11	0.6	<0.3	<0.4	<0.3	<0.3	0.6	0.4
On Site (HISS/Futura Boundary)							
1	<0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
5	<0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
6	<0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
7	0.7	<0.3	<0.4	<0.3	<0.3	0.7	0.4
8	<0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4
Quality Control							
9[d]	0.6	<0.3	<0.4	<0.3	<0.3	0.6	0.4
Background							
16[e]	0.5	<0.3	<0.4	1.1	<0.3	1.1	0.6
19[f]	0.4	<0.3	<0.4	<0.3	<0.3	0.4	0.4

[a]Concentrations are given in pCi/L. Note: 1 pCi/L is equivalent to 0.037 Bq/L.

[b]Background has not been subtracted from the values reported for property-line and on-site locations. Note: Concentrations at some stations were below values at background stations.

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

[d]Station 9 is a quality control for station 6.

[e]Station relocated during fourth quarter to 4517 Oakland Avenue, St. Louis, approximately 26 km (16 mi) southeast of HISS. Formerly located in Florissant, MO, approximately 24 km (15 mi) northeast of HISS.

[f]Located at North Hanley Road, Berkeley, MO, approximately 2.5 km (1.5 mi) east of HISS.

TABLE 4-2

TREND ANALYSIS FOR CONCENTRATIONS[a,b] OF RADON AT HISS, 1986-1990

Sampling Location[c]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[d]
Property Line (HISS and Futura)								
2	0.8	0.7	0.7	0.9	0.4	0.7	0.2	0.3 - 1.1
3	0.3	0.6	0.6	0.5	0.4	0.5	0.1	0.3 - 0.7
4	1.3	1.5	1.3	0.9	0.5	1	0.4	0.2 - 1.8
10	0.2	0.4	0.4	0.5	0.4	0.4	0.1	0.2 - 0.6
11	1.8	1.2	0.8	0.6	0.4	1	0.6	0 - 2.1
On Site (HISS/Futura Boundary)								
1	0.9	1	0.9	0.8	0.4	0.8	0.2	0.4 - 1.2
5	0.6	0.3	0.9	0.5	0.4	0.5	0.2	0.1 - 0.9
6	0.6	0.8	0.7	0.5	0.4	0.6	0.1	0.4 - 0.8
7	1.1	1.8	0.6	0.6	0.4	0.9	0.6	0.0 - 2.1
8	0.2	0.3	0.6	0.5	0.4	0.4	0.1	0.2 - 0.6
Quality Control								
9[e]	0.5	0.3	0.9	0.5	0.4	0.5	0.2	0.1 - 0.9
Background								
16[f]	0.3	0.4	0.4	0.5	0.6	0.4	0.1	0.2 - 0.6
19[g]	--	--	0.7	0.5	0.4	0.5	0.1	0.3 - 0.7

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

[a]Concentrations are given in pCi/L. Note: 1 pCi/L is equivalent to 0.037 Bq/L.

[b]Measured background has not been subtracted from the values reported for property-line and on-site locations.

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

[d]Average value ±2 standard deviations.

[e]Station 9 is a quality control for station 6.

[f]Background station located approximately 24 km (15 mi) northeast of HISS. During fourth quarter, relocated to approximately 26 km (16 mi) southeast of HISS.

[g]Background station located approximately 2.5 km (1.5 mi) east of HISS; established April 1988.

falls outside the expected range, then a trend could be present. Average annual radon concentrations for 1990 fell within the expected value range for background locations near the site. This is a good indication that there is no upward trend in radon concentrations at HISS, which is to be expected because there have been no recent activities that would disturb the source of the radon.

4.1.2 External Gamma Exposure Monitoring

External gamma radiation levels were measured as part of the routine environmental monitoring program to confirm that direct radiation from HISS was not significantly increasing radiation levels above natural background levels and to ensure compliance with environmental regulations.

Program description

Since 1988, the external gamma radiation monitoring system has used tissue-equivalent thermoluminescent dosimeters (TETLDs) to provide realistic values of radiation exposure to the tissues of the body. When exposed to penetrating radiation (such as gamma or cosmic radiation), thermoluminescent materials absorb and store a portion of the energy. If the material is heated, the stored energy is released as light, and the light is measured and used to calculate an equivalent exposure.

Each dosimetry station contains a minimum of four dosimeters. One dosimeter in each station will have been exposed for a full year at the end of each quarter. Quarterly, the fully exposed dosimeter is exchanged with a new dosimeter. Each dosimeter contains five individual lithium fluoride chips that were preselected on the basis of having a reproducibility of ±3 percent across a series of laboratory exposures. The responses are averaged, and the average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent). The

corrected value is then converted to milliroentgen per year (mR/yr). (In determining dose, 1 mR/yr is approximately equal to 1 mrem/yr.)

External gamma radiation levels are measured at six on-site (HISS/Futura boundary), five property-line, and two off-site locations, as indicated in Figure 4-1. Background radiation level detectors are stationed at the same locations as the background radon detectors.

Data and discussion

The results of external gamma radiation monitoring are presented in Table 4-3. Although TETLDs are state of the art, the dosimeter accuracy is approximately ±10 percent at levels between 100 and 1,000 mR/yr and ±25 percent at radiation levels in the range from 0 to 70 mR/yr.

The annual average gamma radiation exposure levels at HISS in 1990 were 5.6 mR/yr on site and 41 mR/yr at the property line. These values do not include a background value of 78 mR/yr. The highest annual average external gamma levels at the property line was 107 mR/yr at location 2. The external gamma levels at on-site stations were lower than those at the property line because the levels of contamination vary across the site. A hypothetical individual standing at this location for the entire year would receive a dose over 100 mrem/yr in excess of background, which is the DOE long-term radiation protection standard; this guideline includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). Information on public exposure can be found in Subsection 4.2.

The background external gamma radiation value for a given location is not constant because the value is affected by a combination of both natural terrestrial and cosmic radiation sources and factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil. Detectors are also influenced by site

TABLE 4-3

EXTERNAL GAMMA RADIATION LEVELS[a,b] AT HISS, 1990

Sampling Location[c]	Quarter 1	2	3	4	Average
Property Line (HISS and Futura)					
2	117	104	--[d]	101	107
3	0[e]	0[e]	0[e]	0[e]	0[e]
4	72	60	58	57	62
10	0[e]	0[e]	0[e]	0[e]	0[e]
11	45	34	27	35	35
				Average	41
On Site (HISS/Futura Boundary)					
1	0[e]	0[e]	--[d]	0[e]	0[e]
5	0[e]	0[e]	0[e]	0[e]	0[e]
6	0[e]	0[e]	0[e]	0[e]	0[e]
7	35	23	25	28	28
8	0[e]	0[e]	0[e]	0[e]	0[e]
				Average	5.6
Quality Control					
9[f]	0[e]	2	0[e]	0[e]	0.5
Background					
16[g]	63	63	55	56	59
19[h]	93	107	95	90	97
				Annual Average	78

[a]Levels are given in units of mR/yr. Dosimeters evaluated each quarter have been in place for 1 yr.

[b]Annual average measured background of 78 mR/yr has been subtracted from the readings taken at the site boundary and on-site sampling stations.

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

[d]TETLD missing.

[e]The 0 indicates no measurable difference from the annual average measured background.

[f]Station 9 is a quality control for station 6.

[g]Station relocated during fourth quarter to approximately 26 km (16 mi) southeast of HISS. Formerly located approximately 24 km (15 mi) northeast of HISS.

[h]Located at North Hanley Road, Berkeley, MO, approximately 2.5 km (1.5 mi) east of HISS; established April 1988.

altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Eisenbud 1987).

Because of these factors, the background radiation level is not constant from one location to another even over a short time. Thus it is normal for some stations at the boundary of a site to have an external gamma radiation value less than the background level measured some distance from the site.

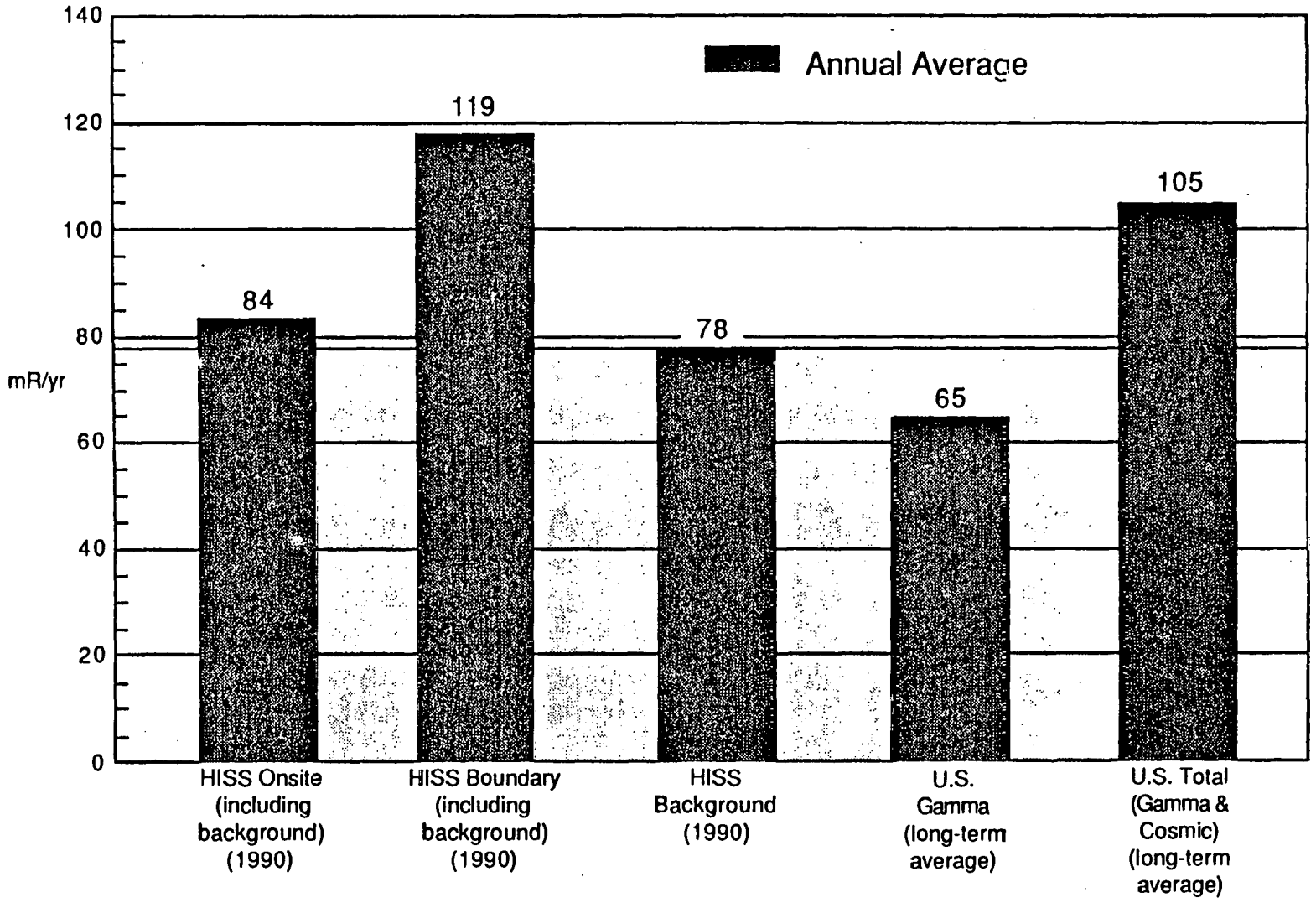
For comparison, Figure 4-2 shows the average annual external radiation levels for locations on site, at the site boundary, off site, and the nation. Based on these data, the radioactive waste stored at HISS does not present a threat to the public from external gamma radiation because the levels are so low and access to the material is restricted.

Trends

Trends in external gamma exposure levels measured from 1986 through 1990 are presented in Table 4-4. The expected value ranges shown are based on calculation of the average and standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present. Since 1986, several of the annual average radiation levels at HISS have shown a significant decrease, probably because of shielding (fill dirt) that was placed along the western edge of the site in 1987. There do not appear to be any upward trends in the data.

4.1.3 Surface Water Monitoring

Surface water monitoring is conducted to ensure compliance with environmental regulations and to determine whether runoff from HISS contributes to surface water contamination in the area.



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

Source: Martin Marietta Energy Systems, Inc., 1989. *Portsmouth Gaseous Diffusion Plant Site Environmental Report for 1988*, ES/ESH-8/V4, Oak Ridge, Tenn.

Figure 4-2
External Gamma Radiation Exposure Rates

TABLE 4-4

TREND ANALYSIS FOR EXTERNAL GAMMA RADIATION LEVELS[a,b]

AT HISS, 1986-1990

Sampling Location[c]	Annual Average Levels 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[d]
Property Line (HISS and Futura)								
2	68	113	116	129	107	107	21	65 - 149
3	23	20	14	2	0[e]	10	9	0 - 30
4	71	74	83	68	62	72	7.0	58 - 84
10	21	17	13	1	0[e]	10	9	0 - 30
11	15	45	56	36	35	37	15	7 - 68
On Site (HISS/Futura Boundary)								
1	34	44	40	6	0[e]	30	20	0 - 70
5	77	46	51	5	0[e]	40	30	0 - 100
6	179	29	44	5	0[e]	50	70	0 - 190
7	46	50	61	61	28	49	12	25 - 73
8	17	27	11	0[e]	0[e]	11	10	0 - 31
Quality Control								
9[f]	151	61	49	6	0.5	50	50	0 - 150
Background								
16[g]	99	77	73	61	59	74	16	42 - 106
19[h]	--	--	--	92	96	94	2.0	90 - 98

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

[a]Levels are given in units of mR/yr.

[b]Measured background has been subtracted.

[c]Property-line and on-site sampling locations are shown in Figure 4-1.

[d]Average value ±2 standard deviations.

[e]The 0 indicates no measurable difference from the annual average measured background.

[f]Station 9 is a quality control for station 6.

[g]Located approximately 24 km (15 mi) northeast of HISS.

[h]Located approximately 8 km (5 mi) east of HISS; established April 1988.

Program description

Surface water samples were collected quarterly at sampling locations established on the basis of potential contaminant migration and discharge routes from the site. Sampling points were located both upstream (locations 2 and 6), to establish background conditions; and downstream (locations 3 and 5), to determine the effect of runoff from the site on the surface waters in the vicinity (Figure 4-3). Sampling location 4 is downstream of SLAPS and upstream of HISS and provides information on whether any contaminants in Coldwater Creek originated from SLAPS or HISS. Contamination at location 5 could have come from either SLAPS or HISS; however, if location 4 is not contaminated, the source is probably HISS.

Surface water samples were analyzed for total uranium, radium-226, and thorium-230. Total uranium in surface water is typically measured using the fluorometric method, which has been proven to be a very sensitive and dependable method for determining trace concentrations of uranium. The first step in the method is dispensing a measured aliquot (typically 0.1 ml) of sample onto a flux pellet made of sodium fluoride (98 percent) and lithium fluoride (2 percent). The flux pellet is dried, and the uranium is then fused to the pellet by a rotary fusion burner. After cooling, the fluorescence of the fused pellet is measured by a fluorometer. The measured fluorescence of the pellet is directly proportional to the concentration of total uranium in the sample as compared with spikes, standards, and blanks.

Radium-226 concentrations were determined by radon emanation, a method that consists of precipitating radium-226 as sulfate and transferring the treated sulfate to a radon bubbler, where the radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then withdrawn into a scintillation cell and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.

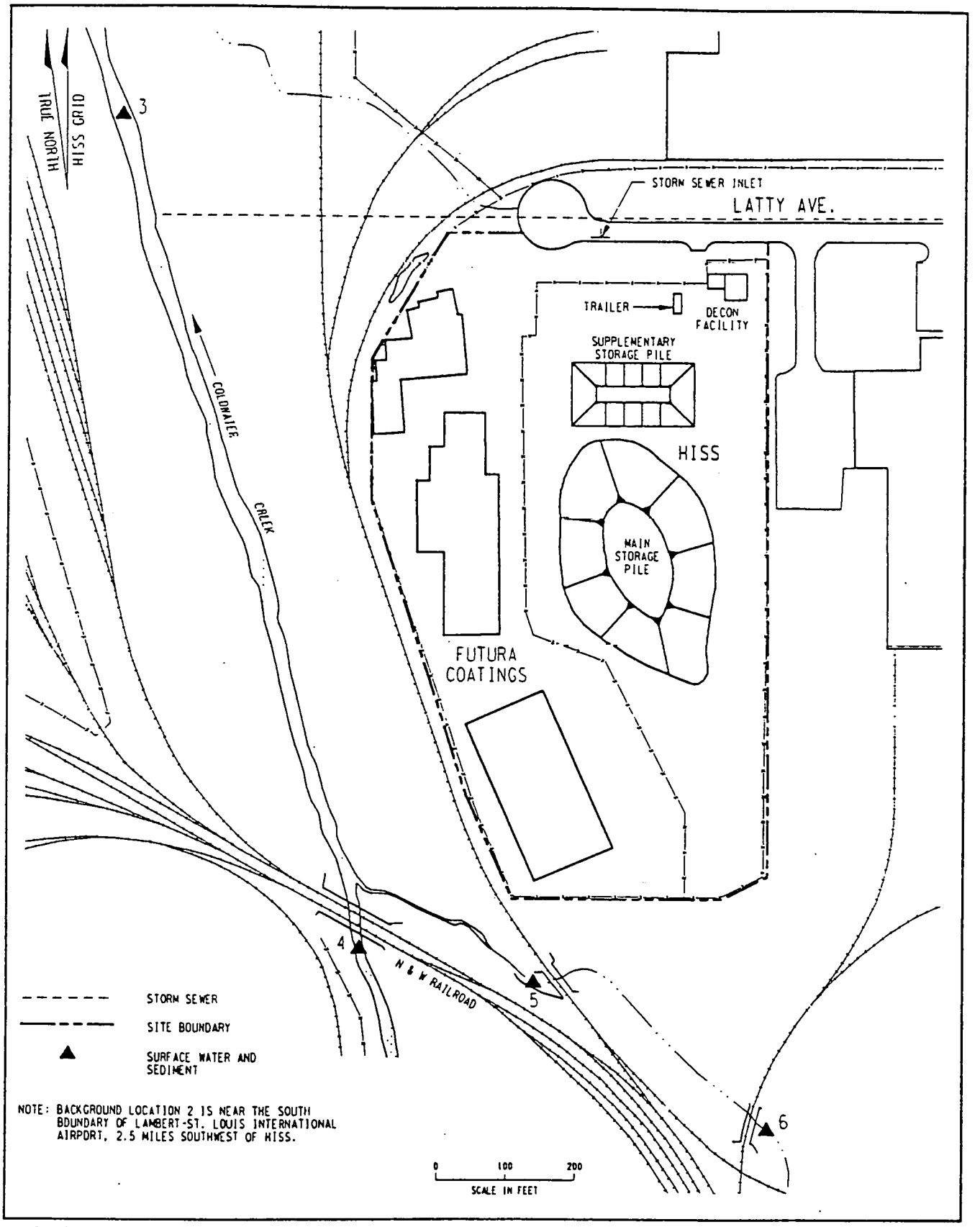


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Figure 4-3
Surface Water and Sediment Sampling Locations at HISS

Thorium-230 concentrations were determined by the photon/electron-rejecting alpha liquid scintillation (PERALS) method. This method begins with the coprecipitation of radionuclides from a sample by using lead sulfate. Radium is separated onto barium sulfate and precipitated with diethylene-triamine-pentaacetate solution. Thorium is then separated sequentially from barium sulfate supernate by extraction into di(2-ethylhexyl)phosphoric acid. The thorium is then counted on the PERALS instrument. This method has approximately a 95 percent recovery rate for thorium.

Data and discussion

Table 4-5 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in surface water. Annual concentrations of total uranium averaged 3E-9 μCi/ml (0.1 Bq/L) at both upstream and downstream locations. Downstream sampling locations potentially affected by the site showed no elevated levels, which may indicate that uranium is not migrating from the site via surface water. During the second quarter, location 4 showed slightly elevated levels of uranium [5E-9 μCi/ml (0.2 Bq/L)]. Total uranium concentrations were well below the DOE DCG of 600E-9 μCi/ml (22 Bq/L).

Annual average concentrations of radium-226 ranged from 0.2E-9 to 0.3E-9 μCi/ml (0.007 to 0.01 Bq/L) at upstream (background) locations and averaged 0.3E-9 μCi/ml (0.01 Bq/L) at downstream locations. Results from location 4 (between SLAPS and HISS) averaged 0.4E-9 μCi/ml (0.02 Bq/L). Radium-226 concentrations remained close to background throughout the year and were well below the DOE DCG of 100E-9 μCi/ml (3.7 Bq/L).

Annual concentrations of thorium-230 ranged from 0.1E-9 to 0.2E-9 μCi/ml (0.004 to 0.007 Bq/L) at upstream (background) locations and ranged from 0.1E-9 to 0.5E-9 μCi/ml (0.004 to 0.02 Bq/L) at downstream locations. Results from location 4 averaged 0.2E-9 μCi/ml (0.007 Bq/L). Thorium-230 concentrations remained close to background throughout the year and were well below the DOE DCG of 300E-9 μCi/ml (11 Bq/L).

TABLE 4-5

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF HISS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
Total Uranium[c]							
2[d,e]	4	<3	<3	<3	<3	4	3
3	<3	<3	<3	<3	<3	<3	3
4[f]	<3	5	<3	4	<3	5	4
5	<3	<3	<3	<3	<3	<3	3
6[e]	<3	<3	<3	<3	<3	<3	3
Radium-226							
2	0.3	0.3	0.2	0.4	0.2	0.4	0.3
3	0.2	0.3	0.4	0.4	0.2	0.4	0.3
4	0.3	0.3	0.4	0.7	0.3	0.7	0.4
5	0.1	0.6	0.3	0.3	0.1	0.6	0.3
6	0.1	0.2	0.3	0.1	0.1	0.3	0.2
Thorium-230							
2	0.1	0.1	0.1	0.3	0.1	0.3	0.2
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.2	0.1	0.2	0.1	0.2	0.2
5	0.1	1.5	0.2	0.1	0.1	1.5	0.5
6	0.1	0.2	0.1	0.1	0.1	0.2	0.1

[a]Concentrations are given in units of E-9 μCi/ml.
Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

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

[c]Total uranium concentrations were determined by using the fluorometric method.

[d]Location 2 serves as a background surface water sampling station for both HISS and SLAPS. Located south of runway 6 at Lambert Airport, upstream of any influence from SLAPS or HISS.

[e]Upstream location.

[f]Located between SLAPS and HISS.

Trends

Trends in annual average radionuclide concentrations measured in surface water from 1986 through 1990 are presented in Table 4-6. The expected value ranges shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. In general, the ranges were fairly consistent between data sets and quarterly results for 1990 fell within the expected range of values. There were a few exceptions; however, these were isolated occurrences and do not represent a trend in the results.

4.1.4 Sediment Monitoring

Sediment monitoring is conducted to determine whether contaminants are collecting in on-site and/or off-site sediment and to ensure compliance with environmental regulations.

Program description

Sediment samples were collected quarterly at surface water sampling locations where sediment is present. Sampling points were located upstream (locations 2 and 6), to establish background conditions; downstream (locations 3 and 5), to determine the effect of the site on the sediment in the vicinity; and between SLAPS and HISS (location 4), to distinguish between the impacts of these two sites (Figure 4-3).

Addressing the impact of the site on Coldwater Creek is difficult because the creek contains low-level sediment contamination and sediment migrates during large storm events. Therefore, changes in the radionuclide concentrations may not be due to the influx of sediment from HISS into the creek.

TABLE 4-6

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230 CONCENTRATIONS[a] IN SURFACE WATER AT HISS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
				Total Uranium[d]				
2[e]	3	3	4	3	3	3	0.4	2 - 4
3	4	4	4	4	3	4	0.5	3 - 5
4	4	5	4	5	4	4	0.6	3 - 5
5	3	3	4	4	3	3	0.6	2 - 4
6	3	3	3	4	3	3	0.5	2 - 4
				Radium-226				
2	0.3	0.3	0.5	0.3	0.3	0.3	0.08	0.1 - 0.5
3	0.3	0.2	0.3	0.4	0.3	0.3	0.06	0.2 - 0.4
4	0.3	0.2	0.3	0.3	0.4	0.3	0.06	0.2 - 0.4
5	0.2	0.3	0.3	0.3	0.3	0.3	0.04	0.2 - 0.4
6	0.2	0.2	0.3	0.3	0.2	0.2	0.05	0.1 - 0.3
				Thorium-230				
2	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1 - 0.3
3	0.4	0.3	0.2	0.2	0.1	0.2	0.1	0 - 0.4
4	0.2	0.4	0.3	0.2	0.2	0.3	0.08	0.1 - 0.5
5	0.4	0.3	0.1	0.1	0.5	0.3	0.2	0 - 0.7
6	0.2	0.1	0.3	0.1	0.1	0.2	0.08	0 - 0.4

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

[a]Concentrations are given in units of E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

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

[c]Average value ±2 standard deviations.

[d]Total uranium concentrations were determined by using the fluorometric method.

[e]Location 2 serves as a background surface water sampling station for both HISS and SLAPS. Located south of runway 6 at Lambert Airport, upstream of any influence from HISS or SLAPS.

Sediment samples were analyzed for total uranium, radium-226, and thorium-230. Isotopic uranium, radium-226, and thorium-230 were eluted in solution, organically extracted, electroplated to a stainless steel disc, and counted by alpha spectrometry. Total uranium concentrations were calculated by summing the results of the isotopic uranium analyses.

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

Data and discussion

Table 4-7 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in sediment. Annual average concentrations of total uranium ranged from 1.5 to 1.6 pCi/g (0.056 to 0.059 Bq/g) at upstream (background) locations and 1.3 to 1.5 pCi/g (0.048 to 0.056 Bq/g) at downstream locations. Location 4 (between SLAPS and HISS) results averaged 2.3 pCi/g (0.085 Bq/g). Total uranium concentrations remained close to background levels.

Annual average concentrations of radium-226 ranged from 1.3 to 2.7 pCi/g (0.048 to 0.10 Bq/g) at upstream (background) locations and averaged 1.4 pCi/g (0.052 Bq/g) at downstream locations. Location 4 results for radium-226 averaged 2.0 pCi/g (0.074 Bq/g). Radium-226 levels remained close to background throughout the year and were below the FUSRAP soil guideline of 5 pCi/g.

Annual average concentrations of thorium-230 ranged from 0.7 to 1 pCi/g (0.03 to 0.04 Bq/g) at upstream (background) locations and 5.9 to 11.8 pCi/g (0.22 to 0.44 Bq/g) at downstream locations. One elevated quarterly level [34 pCi/g (1.3 Bq/g)] at location 3 was detected during the first quarter. Location 4 results averaged 4.9 pCi/g (0.18 Bq/g). Six of the quarterly thorium-230 results were above the FUSRAP surface soil guideline of 5 pCi/g.

TABLE 4-7

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SEDIMENT IN THE VICINITY OF HISS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
			Total Uranium[c]				
2[d,e]	1.2	1.6	1.8	1.8	1.2	1.8	1.6
3	2	0.8	1.1	1.3	0.8	2	1
4[f]	1.4	2.4	3.2	2.1	1.4	3.2	2.3
5	1	1.4	1.5	1.9	1	1.9	2
6[e]	1.3	1.3	1.5	1.8	1.3	1.8	1.5
			Radium-226				
2	1	2.7	2.4	4.7	1	4.7	3
3	1.7	1.3	1.3	1.4	1.3	1.7	1.4
4	0.9	2.3	2.6	2	0.9	2.6	2
5	0.7	1.3	1	2.4	0.7	2.4	1
6	0.8	1.4	1.2	1.9	0.8	1.9	1
			Thorium-230				
2	0.5	0.7	0.8	0.9	0.5	0.9	0.7
3	34	0.2	3	10	0.2	34	12
4	2.1	0.1	11	6.2	0.1	11	5
5	1	0.7	7.7	14	0.7	14	6
6	1.2	0.1	0.9	1.6	0.1	1.6	1

[a]Concentrations are given in units of pCi/g.
Note: 1 pCi/g is equivalent to 0.037 Bq/g.

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

[c]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[d]Location 2 serves as a background sampling station for both HISS and SLAPS. Located south of runway 6 at Lambert airport, upstream of any influence from SLAPS or HISS.

[e]Located upstream of HISS.

[f]Located between SLAPS and HISS.

Trends

Trends in annual average radionuclide concentrations measured in sediment from 1986 through 1990 are presented in Table 4-8. The expected value ranges shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. All average annual concentrations for radionuclides in sediment for 1990 fell within the expected ranges. Radium-226 and total uranium concentrations have remained fairly consistent since monitoring began. The lack of discernible trends for thorium-230 may be due to the fact that contaminated sediment along Coldwater Creek could migrate, re-collect elsewhere, and thus influence the sampling results without an obvious trend.

4.1.5 Groundwater Monitoring

Groundwater monitoring is conducted to provide information on potential migration of contaminants through the groundwater system and to ensure compliance with environmental regulations.

Program description

The monitoring well system is designed to provide sufficient indication of area groundwater conditions. Off-site sampling points (wells B53W01S and B53W01D) were used to establish background conditions; these wells are 0.8 km (0.5 mi) southwest of HISS. The highest potentiometric surface is a central area next to the western edge of the storage pile, which makes all on-site wells downgradient (Figure 4-4).

Quarterly groundwater samples were analyzed for total uranium, radium-226, and thorium-230 by the same methods used for surface water samples.

TABLE 4-8

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230 CONCENTRATIONS[a] IN SEDIMENT AT HISS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986[c]	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[d]
				Total Uranium[e]				
2[f]	--	1.6	1.7	1.9	1.6	1.7	0.14	1.4 - 2.0
3	--	2.0	1.4	2.1	1	2	0.5	1 - 3
4[g]	--	2.1	2.2	1.9	2.3	2.1	0.15	1.8 - 2.4
5	--	1.8	2.1	1.9	2	2	0.1	2 - 2
6	--	1.5	1.4	1.9	1.5	1.6	0.19	1.2 - 2.0
				Radium-226				
2	--	1.0	1.5	1.2	3	2	0.9	0 - 4
3	--	1.2	1.0	2.3	1.4	1.5	0.50	0.5 - 2.5
4	--	1.2	1.2	1.2	2	1	0.4	0.2 - 2
5	--	1.4	1.6	1.4	1	1	0.3	0.4 - 1.6
6	--	1.2	0.8	1.4	1	1	0.3	0.4 - 1.6
				Thorium-230				
2	--	1.6	1.3	0.8	0.7	1	0.4	0.3 - 2
3	--	2.7	5.8	44.4	12	16	19	0 -54
4	--	0.9	4.3	2.2	5	3	2	0 - 7
5	--	2.9	7.5	2.1	6	5	3	0 -10
6	--	20.0	1.5	2.0	1	6	9	0 -25

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

[a]Concentrations are given in units of pCi/g. Note: 1 pCi/g is equivalent to 0.037 Bq/g.

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

[c]No sediment samples taken for 1986 at these locations due to excavation.

[d]Average value ±2 standard deviations.

[e]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[f]Location 2 serves as a background sampling location for both HISS and SLAPS. Located south of runway 6 at Lambert Airport, upstream of any influence from SLAPS or HISS.

[g]Located between SLAPS and HISS.

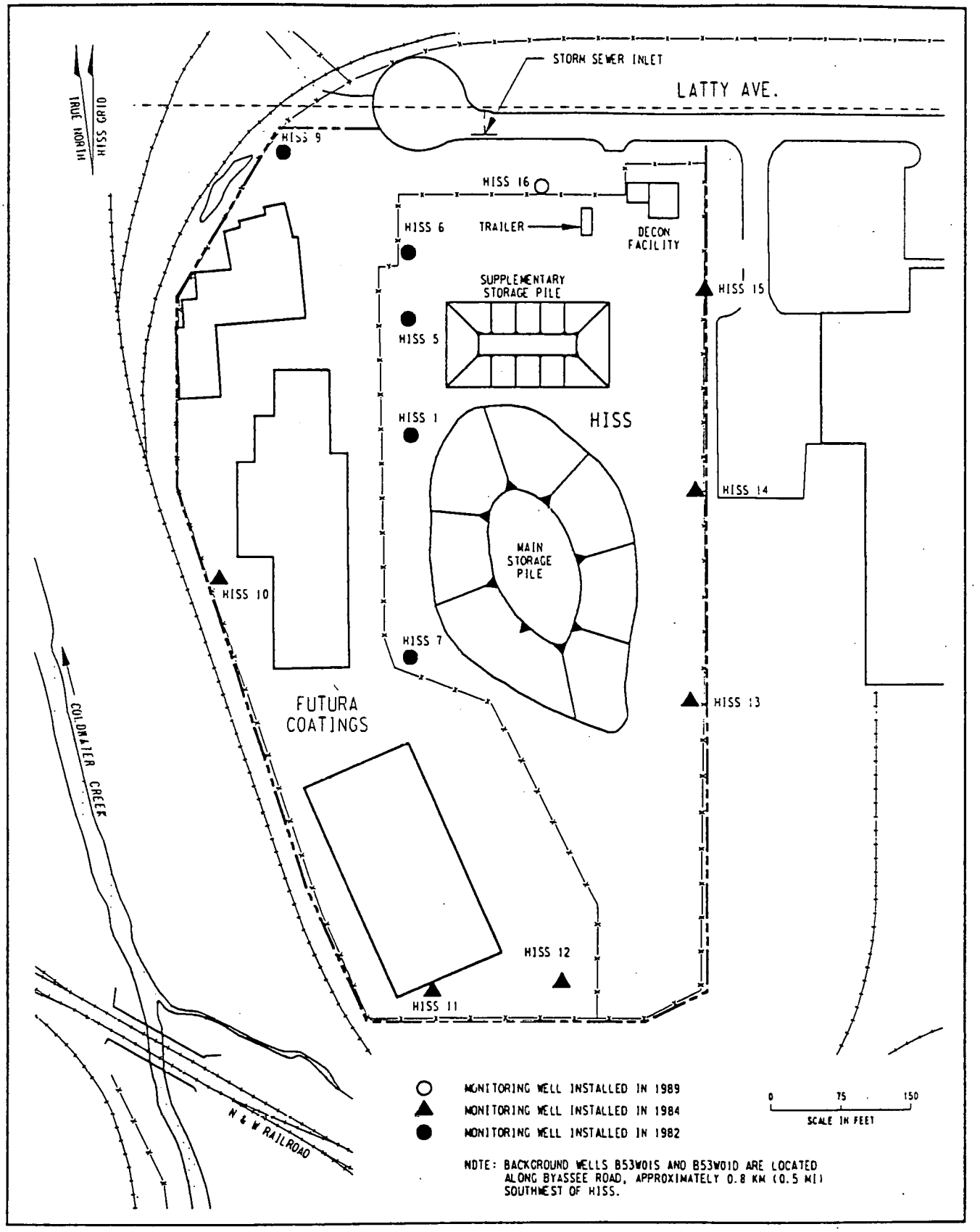

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Figure 4-4
Groundwater Wells Monitored for Radiological and Chemical Contamination at HISS in 1990

Data and discussion

Table 4-9 presents 1990 concentrations of total uranium, radium-226, and thorium-230 in groundwater. Annual concentrations of total uranium averaged 3E-9 μCi/ml (0.1 Bq/L) at background locations and ranged from 3E-9 to 57E-9 μCi/ml (0.1 to 2.1 Bq/L) at on-site locations. Except in HISS-5, HISS-6, and HISS-16, total uranium concentrations averaged at and slightly above background levels. The elevated levels in HISS-5, HISS-6, and HISS-16 reflect the elevated levels of contaminants in soils near the area of the wells. Measurements from HISS-9, located downgradient of HISS-6, are used to ensure that contaminants from the area of HISS-6 are not migrating. Results from HISS-9 show that contaminant levels are at background levels. Total uranium concentrations in all wells were below the DCG of 600E-9 μCi/ml (22 Bq/L).

Annual average concentrations of radium-226 ranged from 0.4E-9 to 1E-9 μCi/ml (0.02 to 0.04 Bq/L) at background locations and 0.2E-9 to 1.2E-9 μCi/ml (0.007 to 0.044 Bq/L) at on-site locations. Radium-226 concentrations were comparable to background levels and much lower than the DCG of 100E-9 μCi/ml (3.7 Bq/L).

Annual average concentrations of thorium-230 ranged from 0.2E-9 to 0.4E-9 μCi/ml (0.007 to 0.02 Bq/L) at background locations and 0.2E-9 to 11.1E-9 μCi/ml (0.007 to 0.41 Bq/L) at on-site locations. Thorium-230 concentrations only slightly exceeded background, with one exception: 30E-9 μCi/ml (1.1 Bq/L), from HISS-15. Thorium-230 concentrations in all wells were below the DCG of 300E-9 μCi/ml (11 Bq/L).

Trends

Trends in annual average radionuclide concentrations in groundwater measured from 1986 through 1990 are presented in Table 4-10. The expected value ranges shown are based on calculation of the standard deviation of the yearly mean. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside

TABLE 4-9

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER IN THE VICINITY OF HISS, 1990

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
			Total Uranium[c]				
HISS-5	28	104	63	33	28	104	57
HISS-6	35	79	50	27	27	79	48
HISS-7	<3	5	<3	<3	3	5	4
HISS-9	<3	<3	<3	<3	3	3	3
HISS-10	<3	<3	<3	<3	3	3	3
HISS-11	<3	<3	<3	<3	3	3	3
HISS-12	<3	5	5	<3	3	5	4
HISS-13	<3	4	6	6	3	6	5
HISS-14	6	5	6	7	5	7	6
HISS-15	<3	<3	<3	<3	3	3	3
HISS-16	29	41	19	37	19	41	22
Background							
B53W01S[d]	<3	<3	<3	<3	3	3	3
B53W01D[d]	<3	<3	<3	<3	3	3	3
			Radium-226				
HISS-5	0.5	0.7	0.5	0.5	0.5	0.7	0.6
HISS-6	1.1	0.9	1.8	1.1	0.9	1.8	1
HISS-7	0.3	0.1	2.4	1.5	0.1	2.4	1
HISS-9	0.2	0.5	0.4	0.5	0.2	0.5	0.4
HISS-10	0.1	0.2	0.2	0.2	0.1	0.2	0.2
HISS-11	0.4	0.3	0.6	0.6	0.3	0.6	0.5
HISS-12	0.5	0.7	0.7	0.5	0.5	0.7	0.6
HISS-13	0.5	0.8	0.6	0.5	0.5	0.8	0.6
HISS-14	0.7	0.7	0.8	0.8	0.7	0.8	0.8
HISS-15	0.5	1	0.8	0.7	0.5	1	0.8
HISS-16	0.2	0.4	0.5	0.6	0.2	0.6	0.4
Background							
B53W01S[d]	0.2	0.2	0.9	0.2	0.2	0.9	0.4
B53W01D[d]	0.9	0.5	1.1	1.6	0.5	1.6	1

TABLE 4-9
(continued)

Sampling Location[b]	Quarter 1	2	3	4	Min	Max	Avg
			Thorium-230				
HISS-5	1	0.3	0.3	0.3	0.3	1	0.5
HISS-6	4.9	2.5	3.6	3.9	2.5	4.9	3.7
HISS-7	0.7	0.5	0.4	1.2	0.4	1.2	0.7
HISS-9	0.1	0.2	0.1	0.2	0.1	0.2	0.2
HISS-10	0.1	0.3	0.1	0.1	0.1	0.3	0.2
HISS-11	0.6	0.4	0.4	0.2	0.2	0.6	0.4
HISS-12	1.0	3.2	0.6	1.5	0.6	3.2	2
HISS-13	0.6	0.8	1.0	0.4	0.4	1.0	0.7
HISS-14	0.8	1.4	0.4	0.7	0.4	1.4	0.8
HISS-15	5.0	30.0	4.9	4.5	4.5	30.0	11
HISS-16	0.2	0.3	0.2	1.2	0.2	1.2	0.5
Background							
B53W01S[d]	0.2	0.2	0.1	0.2	0.1	0.2	0.2
B53W01D[d]	0.8	0.4	0.2	0.3	0.2	0.8	0.4

[a]Concentrations are given in units of E-9 μCi/ml.
Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are indicated in Figure 4-4.

[c]Total uranium concentrations were determined by using the fluorometric method.

[d]Located at Byassee Road, approximately 0.8 km (0.5 mi) southwest of the site.

TABLE 4-10

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-230 CONCENTRATIONS[a] IN GROUNDWATER AT HISS, 1986-1990

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
Total Uranium[d]								
HISS-5[e]	--	--	--	--	57	--	--	--
HISS-6	33	40	50	82	48	51	19	13 - 88
HISS-7[e]	--	--	--	--	4	--	--	--
HISS-9	3	3	3	3	3	3	0	3 - 3
HISS-10	6	4	4	5	3	4	1	2 - 7
HISS-11	5	4	5	6	3	5	1	2 - 7
HISS-12	4	5	6	4	4	5	1	3 - 6
HISS-13	8	8	8	5	5	7	2	4 - 10
HISS-14[e]	--	--	--	--	6	--	--	--
HISS-15	5	3	6	5	3	4	1	2 - 7
HISS-16[e]	--	--	--	--	22	--	--	--
Background								
B53W01S[f]	--	--	3	3	3	3	0	3 - 3
B53W01D[f]	--	--	4	3	3	3	0.6	2 - 5
Radium-226								
HISS-5	--	--	--	--	0.6	--	--	--
HISS-6	0.7	1.2	1.8	1.6	1	1	0.4	0.2 - 2
HISS-7	--	--	--	--	1	--	--	--
HISS-9	0.2	0.2	0.6	0.6	0.4	0.4	0.2	0 - 0.8
HISS-10	0.1	0.2	0.4	0.3	0.2	0.2	0.1	0 - 0.4
HISS-11	0.4	0.2	1.0	0.7	0.5	0.5	0.3	0 - 1
HISS-12	0.4	0.5	1.3	0.7	0.6	0.7	0.3	0.1 - 1
HISS-13	0.3	0.3	0.6	0.7	0.6	0.5	0.2	0.1 - 0.9
HISS-14	--	--	--	--	0.8	--	--	--
HISS-15	0.4	0.4	0.8	1.2	0.8	0.7	0.3	0.1 - 1
HISS-16	--	--	--	--	0.4	--	--	--

TABLE 4-10

(continued)

Sampling Location[b]	Annual Average Concentration 1986	1987	1988	1989	1990	Average Value	Standard Deviation	Expected Range[c]
				Radium-226 (cont'd)				
Background								
B53W01S	--	--	0.6	0.7	0.4	0.6	0.1	0.4 - 0.8
B53W01D	--	--	1.1	1.0	1	1	0.05	1 - 1
				Thorium-230				
HISS-5	--	--	--	--	0.5	--	--	--
HISS-6	2.6	2.9	24	5	3.7	8.0	8.0	0.0 - 24.0
HISS-7	--	--	--	--	0.7	--	--	--
HISS-9	0.6	0.2	0.2	0.2	0.2	0.3	0.2	0.0 - 0.7
HISS-10	0.7	0.3	0.7	0.1	0.2	0.4	0.3	0.0 - 1.0
HISS-11	1.3	0.8	1.5	0.7	0.4	0.9	0.4	0.1 - 2.0
HISS-12	2	0.8	2.3	2.3	2.0	2.0	0.6	0.8 - 3.0
HISS-13	1	0.3	0.6	0.9	0.7	0.7	0.2	0.3 - 1.0
HISS-14	--	--	--	--	0.8	--	--	--
HISS-15	1.3	0.8	5.7	8.6	11.0	6.0	4.0	0.0 - 14.0
HISS-16	--	--	--	--	0.5	--	--	--
Background								
B53W01S	--	--	0.2	0.3	0.2	0.2	0.05	0.1 - 0.3
B53W01D	--	--	0.2	0.4	0.4	0.3	0.09	0.1 - 0.5

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

[a]Concentrations are given in units of E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

TABLE 4-10

(continued)

[b]Sampling locations are indicated in Figure 4-4.

[c]Average value ±2 standard deviations.

[d]Total uranium concentrations were determined by using the fluorometric method.

[e]Environmental monitoring for this well began in first quarter 1990.

[f]Located at Byassee Road, approximately 0.8 km (0.5 mi) southwest of the site; added to the monitoring program in July 1988.

the expected range, then a trend could be present. Even though values tended to fall within these ranges, there is one possible trend that the data seem to indicate for thorium-230 in HISS-15: concentrations have increased over the past three years. The cause of the elevated levels will be investigated; the investigation will probably include installation of a downgradient well to monitor potential contaminant migration from the area of HISS-15. Also, HISS-6 showed increased levels of total uranium from 1986 through 1989, but levels decreased during 1990.

4.2 POTENTIAL DOSE TO THE PUBLIC

This section contains information on exposures to the general public and the hypothetical maximally exposed individual from the radioactive materials at HISS. As expected for a relatively stable site such as HISS, all calculated doses were 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. The distinction is important because external exposures occur only when a person is near the external radionuclides, but internal exposures continue as long as the radionuclides reside in the body.

To assess the potential health effects of the materials stored at HISS, radiological exposure pathways were evaluated and radiation doses were calculated for a hypothetical maximally exposed individual and for the population within 80 km (50 mi) of the site. The combined effect from all pathways (surface water, groundwater, air, and direct exposure) from all DOE sources can then be compared with DOE guidelines. Exposures from radon and radon daughters are not considered in these calculations because radon exposure is controlled through compliance with concentration requirements for boundaries (Appendix B). All doses presented in this section are estimated and do not represent actual doses. A summary is provided in Table 4-11.

TABLE 4-11

SUMMARY OF CALCULATED DOSES[a] FOR HISS, 1990

Type	Dose to Hypothetical Maximally Exposed Individual (mrem/yr)[b]	Collective Dose for Population Within 80 km of Facility (person-rem/yr)[b]
Direct gamma radiation[c]	0.5	--[d]
Drinking water	--[d]	--[d]
Ingestion	--[d]	--[d]
Air immersion	--[d]	--[d]
Inhalation[e]	0.4	1.6
Total	0.9	1.6
Background[f]	78	2.0E+5[g]
DOE guideline[h]	100	--[i]
Percent of guideline (excluding background)	1	--[i]

[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).

[f]Direct gamma exposure only.

[g]Calculated by the following: 78 mrem/yr x 2.5E+6 people.

[h]Source: DOE 1990b.

[i]No DOE guideline.

4.2.1 Maximally Exposed Individual

The hypothetical maximally exposed individual is assumed to be an individual who lives near the site and works at Futura Coatings (next to HISS); using these assumptions, the following doses have been calculated.

Direct exposure

The calculated yearly dose to a hypothetical worker at Futura Coatings can be calculated by using the equation in Appendix B for direct exposure. The calculated dose for the hypothetical maximally exposed individual is 0.5 mrem/yr (0.005 mSv/yr), well below the DOE guideline of 100 mrem/yr. This approach is conservative because it is unlikely that an individual would work outside at Futura Coatings for an entire year.

Drinking water pathway

Only one pathway, either groundwater or surface water, is used to determine the committed dose to the hypothetical maximally exposed individual. Maximally exposed individuals would obtain 100 percent of their drinking water from either surface water or groundwater in the vicinity of the site. Groundwater concentrations of total uranium, radium-226, and thorium-230 in the vicinity of HISS are barely detectable above normal background levels. Because there are no wells within 3.2 km (2 mi) of the site, groundwater is not a credible exposure pathway; therefore, the dose contribution from these radionuclides in groundwater to the maximally exposed individual was not calculated. There was also no credible exposure from surface water. Radionuclide concentrations at sampling locations upstream and downstream of HISS are essentially equivalent to the background levels measured at location 2.

Air pathway

The hypothetical maximally exposed individual would work adjacent to and live near HISS throughout the year. It is assumed that this individual's average distance from the site would be 300 m (980 ft). Air doses determined using the AIRDOS computer model, version 3.0, were found to be negligible, 0.4 mrem/yr, which is well below the limit of 10 mrem/yr given in 40 CFR 61 Subpart H. The 1990 AIRDOS compliance report is provided in Appendix H; the appendix also gives the calculated amount of each primary radionuclide of concern released to the air in 1990.

Total dose

The total dose for the hypothetical maximally exposed individual would be the sum of the doses calculated for each exposure pathway. When these doses are added together, the total dose is 0.9 mrem/yr (0.009 mSv/yr). These exposures are less than the exposure a person receives during one flight from New York City to Los Angeles because of greater amounts of cosmic radiation at higher altitudes (see Appendix F).

4.2.2 Population Dose

The collective dose to the general population living within 80 km (50 mi) of the site is calculated as follows.

Direct exposure

HISS is located in an industrial area and thus is remote from the general population. Both distance from the site and intervening structures reduce direct gamma exposure from HISS (see Table 4-12). Therefore, it is assumed that there is no detectable exposure to the general public.

TABLE 4-12

MAXIMUM EFFECTIVE DOSE TO THE GENERAL PUBLIC FROM HISS, 1990

Distance from the Site (m)	Effective Dose Equivalent (mrem/yr)[a,b]	Population Dose (person-rem/yr)[c,d]
0 - 1,000	4.0E-01[e]	0.16
1,000 - 3,000	3.4E-02	0.11
3,000 - 10,000	4.2E-03	0.15
10,000 - 80,000	4.7E-04	1.2
	Total Dose	1.6

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

[b]Values were obtained using AIRDOS (Appendix B).

[c]A population density of 1.24E-4 person/m^2 was used in the calculation.

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

[e]Effective dose equivalent for 300 m.

Drinking water pathway

There are no wells within 3.2 km (2 mi) downgradient of the site (see Subsection 6.1.2), and there is a significant distance [32 km (20 mi)] to a drinking water intake point on the Mississippi River; therefore, it is reasonable to assume that the general public would not receive a committed dose in drinking water from radionuclides from HISS.

Air

The AIRDOS model provides an effective dose equivalent for contaminants transported via the atmospheric pathway at different distances from the site (Table 4-12). The collective dose for the general population within 80 km (50 mi) of HISS was calculated using these effective dose equivalents and the population density. The calculated collective population dose was 1.6 person-rem/yr (0.016 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 potential contribution to the collective population dose is the atmosphere, the total population dose is equal to that calculated for the atmospheric pathway [1.6 person-rem/yr (0.016 person-Sv/yr)].

5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM

Site characterization has shown that nonradiological contamination of the soil at HISS is not substantially different from background levels and does not pose a potential threat to human health or the environment via an airborne pathway (e.g., resuspension of soil) or a surface water pathway (e.g., runoff from site and/or collection in sediments). Monitoring of airborne particulates is conducted during site construction operations to evaluate worker health hazards (e.g., inhalation of dust) and to monitor any unexpected releases. Nonradiological parameters in groundwater at HISS are monitored to collect baseline information on groundwater quality in the area. HISS is not an active site; therefore, the only "effluents" would be contaminant migration.

Program description

Groundwater samples were collected from the same locations as those in the radiological groundwater monitoring system (Figure 4-4). Monitoring points were both off site (wells B53W01S and B53W01D), to establish background conditions; and on site, to determine the effect of the site on groundwater in the vicinity. Quarterly groundwater samples were analyzed for the indicator parameters specific conductance, pH, TOC, and TOX. These parameters indicate changes in the inorganic and organic composition of the groundwater.

Specific conductance and pH readings indicate changes in inorganic composition. Specific conductance measures the capacity of water to conduct an electrical current; generally, conductivity increases with an elevated concentration of dissolved solids or salinity. Acidity or alkalinity of the water is expressed as pH. A change in pH affects the solubility and mobility of chemical contaminants in water.

Groundwater is analyzed for TOC and TOX to determine organic content. TOC measures the total organic content of the groundwater but is not specific to a given organic contaminant, and TOX

measures organic compounds containing halogens (e.g., halogenated hydrocarbons).

Data and discussion

Analytical results for indicator parameters show that groundwater at HISS is generally of poor quality, which is typical in industrial/urban areas. Annual average specific conductance levels ranged from 697 to 7,213 μmhos/cm (Table 5-1); the wide range of levels indicates that the amount of dissolved solids in the groundwater is not constant across the site. As shown in Table 5-1, annual average pH varied from slightly acidic to slightly basic (6.6 to 7.5).

Annual average TOC levels varied from 2.4 to 20 mg/L, and annual average TOX levels ranged from 28 to 130 μg/L (Table 5-2). The elevated TOC level from first-quarter sampling of well HISS-14 (62.6 mg/L) and the elevated TOX level from fourth-quarter sampling of well HISS-16 (130 μg/L) are not considered high for these parameters. Because results from the same wells for the other three quarters of sampling are much lower and correlate well with other data, it is probable that an external factor such as sampling or analytical error is responsible for the elevated results for these samples. Overall, TOC and TOX average results remain relatively stable when compared with 1989 results.

Trends

Indicator analyses such as TOC and TOX are used as gross indicators for the presence of organics. These indicator parameters can fluctuate greatly between sampling events; therefore, trend analysis is not feasible. In cases where broad-screen organic analyses are performed to support a site characterization or remedial investigation, the data will be presented in the annual environmental report, but trend analyses will not be performed.

TABLE 5-1

ANALYTICAL RESULTS FOR INORGANIC INDICATOR PARAMETERS IN GROUNDWATER AT HISS, 1990

Sampling Location[a]	Quarter[b] 1	2	3	4	Min	Max	Avg
Specific Conductance (μmhos/cm)							
HISS-5	1,060	882	910	889	882	1,060	935
HISS-6	3,820	2,180	5,200	1,579	1,579	5,200	3,195
HISS-7	3,260	12,600	1,200	1,055	1,055	12,600	4,529
HISS-9	865	862	859	923	859	923	877
HISS-10	737	701	673	675	673	737	697
HISS-11	1,340	1,340	1,280	1,353	1,280	1,353	1,328
HISS-12	3,230	2,940	2,540	2,540	2,540	3,230	2,813
HISS-13	7,140	7,030	6,500	6,710	6,500	7,140	6,845
HISS-14	7,550	7,370	7,040	6,890	6,890	7,550	7,213
HISS-15	926	939	898	842	842	939	901
HISS-16	3,660	3,680	3,710	4,160	3,660	4,160	3,803
Background							
B53W01S[c]	860	808	873	800	800	873	835
B53W01D[c]	1,050	1,020	941	950	941	1,050	990
pH (standard units)							
HISS-5	7.1	7.0	7.0	7.2	7.0	7.2	7.1
HISS-6	6.8	7.4	6.7	6.9	6.7	7.4	7.0
HISS-7	6.6	6.6	6.6	6.6	6.6	6.6	6.6
HISS-9	7.3	7.6	7.5	7.4	7.3	7.6	7.5
HISS-10	7.4	7.2	7.3	7.4	7.2	7.4	7.3
HISS-11	7.1	6.9	7.0	6.1	6.1	7.1	6.8
HISS-12	6.8	6.7	6.7	6.1	6.1	6.8	6.6
HISS-13	6.6	6.5	6.6	6.5	6.5	6.6	6.6
HISS-14	6.8	6.6	6.8	7.0	6.6	7.0	6.8
HISS-15	7.0	6.9	6.7	6.7	6.7	7.0	6.8
HISS-16	6.8	6.7	6.8	6.8	6.7	6.8	6.8
Background							
B53W01S[c]	7.0	7.4	7.0	6.3	6.3	7.4	6.9
B53W01D[c]	6.3	7.2	7.3	7.0	6.3	7.3	7.0

[a]Sampling locations are shown in Figure 4-4.
[b]First three quarters' results based on laboratory measurement of parameters; fourth-quarter measurements were taken in the field.
[c]Located at Byassee Road, approximately 0.8 km (0.5 mi) southwest of HISS.

TABLE 5-2

CONCENTRATIONS OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDES IN GROUNDWATER AT HISS, 1990

Sampling Location[a]	Quarter 1	2	3	4	Min	Max	Avg
Total Organic Carbon (mg/L)							
HISS-5	4.8	4.5	4.6	2.1	2.1	4.8	4.0
HISS-6	3.7	5	4.9	3.9	3.7	5	4
HISS-7	3.1	8.3	2.8	2	2	8.3	4
HISS-9	2.1	3.1	4.3	1.2	1.2	4.3	2.7
HISS-10	4	2.2	2.1	1.5	1.5	4	3
HISS-11	3.9	1.7	2.5	1.6	1.6	3.9	2.4
HISS-12	3.8	2.3	2.5	1.8	1.8	3.8	2.6
HISS-13	5.6	4.2	2.6	2.3	2.3	5.6	3.7
HISS-14	62.6	7.6	1.5	5	1.5	62.6	20
HISS-15	5.1	24.6	4.6	4.3	4.3	24.6	9.7
HISS-16	10.2	5.6	5.6	5.5	5.5	10.2	6.7
Background							
B53W01S[b]	4.1	3.7	3.7	1.2	1.2	4.1	3.2
B53W01D[b]	7.4	5.4	5.4	6.1	5.4	7.4	6.1
Total Organic Halides (μg/L)							
HISS-5	<20	54	<20	56	20	56	38
HISS-6	28	40	<20	70	20	70	40
HISS-7	<20	<20	<20	<20	20	20	20
HISS-9	43	<20	57	49	20	57	42
HISS-10	<20	<20	<20	44	20	44	26
HISS-11	80	<20	<20	31	20	80	38
HISS-12	<20	76	<20	38	20	76	39
HISS-13	<20	<20	29	<20	20	29	22
HISS-14	<20	56	72	<20	20	72	42
HISS-15	100	<20	<20	<20	20	100	40
HISS-16	<20	68	48	130	20	130	67
Background							
B53W01S[b]	71	<20	<20	<20	20	71	33
B53W01D[b]	<20	<20	<20	91	20	91	38

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

[b]Located at Byassee Road, approximately 0.8 km (0.5 mi) southwest of HISS.

[c]20 μg/L is the detection limit for TOX.

6.0 GROUNDWATER PROTECTION PROGRAM

6.1 HYDROGEOLOGICAL CHARACTERISTICS

6.1.1 Site Hydrogeology

HISS is located within a shallow subsurface depression in bedrock known as the Florissant Basin, the site of a glacial lake that was filled with more than 30 m (100 ft) of silts, clays, and fine-grained sand. The bedrock underlying these lacustrine deposits at HISS is believed to be limestone of Mississippian geologic age. Because of the relatively shallow depth of the observation wells installed at HISS, bedrock was not encountered during drilling.

Groundwater at the site occurs as an unconfined system characterized by radial flow away from a central area next to the western edge of the main storage pile (Figure 6-1). The water table is in a zone approximately 1.0 to 5.0 m (3.5 to 16.5 ft) below the ground surface. The HISS wells are screened in unconsolidated silty clays and clayey silts at depths of 3.7 to 7.9 m (12 to 26 ft).

6.1.2 Groundwater Quality and Usage

A well canvass of the combined HISS and SLAPS areas conducted in 1987 and 1988 yielded records for eight wells, four of which had been drilled to obtain water for irrigation. No wells are known to have been drilled or used to furnish drinking water or for public water supply. Water needs are met by using treated Mississippi River water.

6.2 GROUNDWATER MONITORING

6.2.1 Methods

The hydrogeological interpretations presented here are based on groundwater levels measured in monitoring wells during 1990;

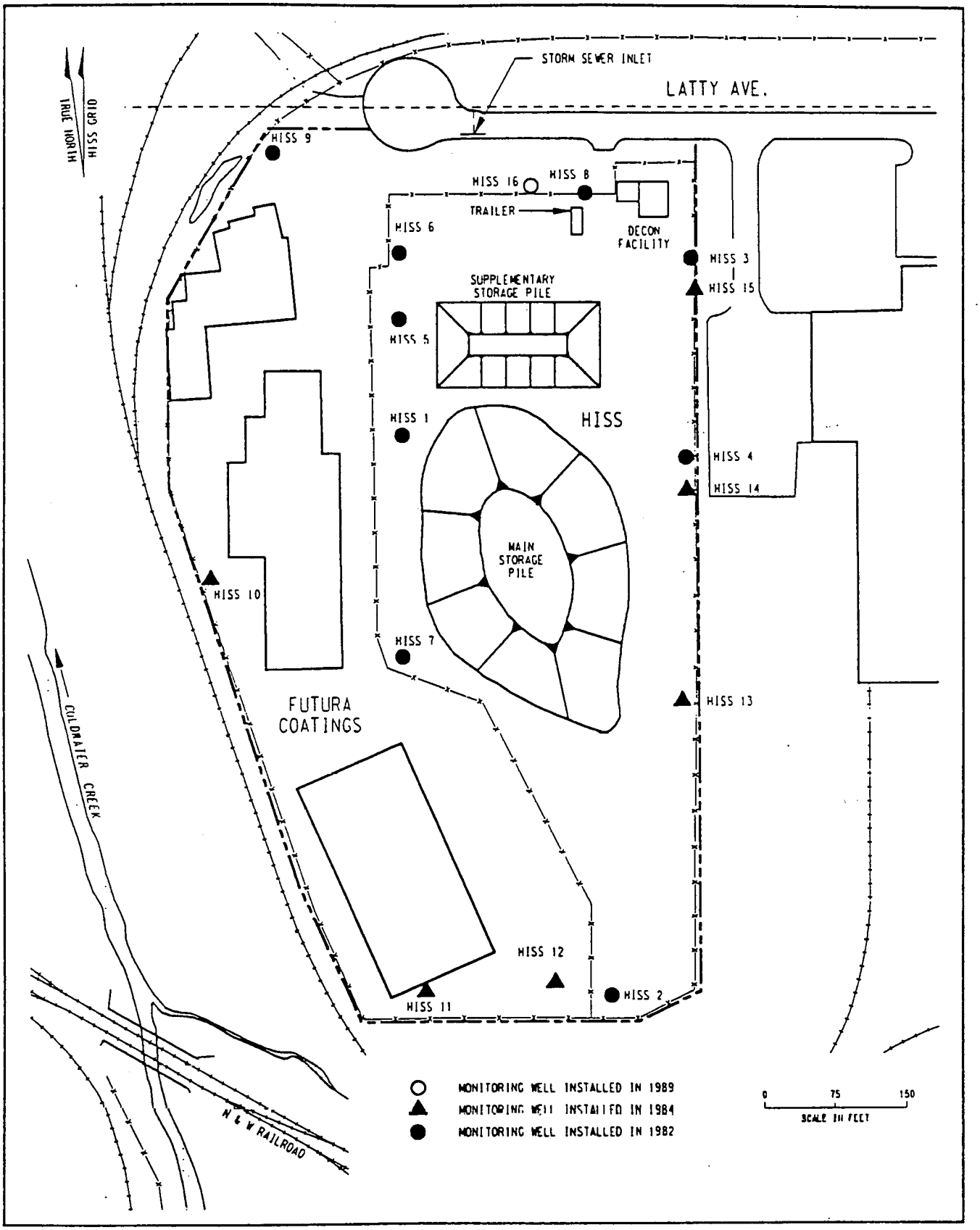

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Figure 6-1
Monitoring Wells Used for Water Level Measurements at HISS in 1990

these levels are measured at weekly intervals using an electric downhole probe water level indicator.

Groundwater monitoring wells (Figure 6-1) were installed at HISS in two phases. Eight first-phase wells (HISS-1 through HISS-8) were installed in 1982 as part of the radiological site assessment program conducted by Oak Ridge Associated Universities. Details of the geology and construction methods for the first-phase wells are not available. Seven second-phase wells (HISS-9 through HISS-15) were installed by Bechtel National, Inc. (BNI) in late 1984. An additional well (HISS-16) was installed in June 1989 to supplement readings from HISS-8, which was permanently closed in August 1990. A summary of well construction information is presented in Table 6-1, and an example of well construction details is included in Appendix E. Further background information on site geology, hydrogeology, and well construction details can be found in the Report on Drilling and Observation Well Installations at the Hazelwood Interim Storage Site, St. Louis County, Missouri (BNI 1985).

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 (Appendix E). The HISS hydrographs also include bar graphs of U.S. Weather Service precipitation records for the St. Louis area as an aid in evaluating the influence of precipitation on water level behavior.

The amount of slope (gradient) and the flow direction of the HISS groundwater system are determined from potentiometric surface (water level) maps (Figures 6-2 through 6-5). These maps are prepared by plotting water level measurements for selected dates (representative of each season) on a base map and contouring the values.

TABLE 6-1

HISS MONITORING WELL CONSTRUCTION SUMMARY

Well Number	Completion Date	Total Depth [m (ft)]	Monitored or Screened Interval Below Ground [m-m (ft-ft)]	Construction Material
HISS-2	Jan. 1982	9.8 (32.2)	No Documentation	PVC[a]
HISS-3	Jan. 1982	6.6 (21.6)	No Documentation	PVC
HISS-4	Jan. 1982	6.8 (22.2)	No Documentation	PVC
HISS-5	Jan. 1982	6.4 (21.1)	No Documentation	PVC
HISS-6	Jan. 1982	4.6 (15.1)	No Documentation	PVC
HISS-7	Jan. 1982	5.2 (17.0)	No Documentation	PVC
HISS-8[b]	Jan. 1982	6.4 (21.0)	No Documentation	PVC
HISS-9	Dec. 1984	8.7 (28.5)	5.9-8.7 (19.4-28.5)	PVC
HISS-10	Dec. 1984	7.6 (25.0)	4.3-7.2 (14.1-23.5)	PVC
HISS-11	Dec. 1984	7.3 (23.8)	3.9-6.8 (12.7-22.3)	PVC
HISS-12	Dec. 1984	6.1 (20.0)	3.1-5.6 (10.0-18.5)	PVC
HISS-13	Dec. 1984	7.6 (25.0)	3.1-7.2 (10.0-23.5)	PVC
HISS-14	Dec. 1984	9.2 (30.0)	2.8-8.7 (9.3-28.5)	PVC
HISS-15	Dec. 1984	6.3 (20.5)	3.1-5.8 (10.3-19.0)	PVC
HISS-16	June 1989	6.7 (22.0)	3.2-6.3 (10.4-20.6)	Enco Fiberglass Epoxy
B53WO1S[c]	Nov. 1987	8.4 (27.5)	5.2-8.4 (17.0-27.5)	316 Stainless Steel
B53WO1D[c]	Nov. 1987	28.5 (93.5)	24.3-28.5 (79.7-93.5)	316 Stainless Steel

[a]PVC - polyvinyl chloride.

[b]Well closed in August 1990.

[c]Background well located at Byassee Road, approximately 0.8 km (0.5 mi) southwest of HISS.

NOTE: Water level elevations for wells monitored in 1990 are shown as hydrographs in Appendix E.

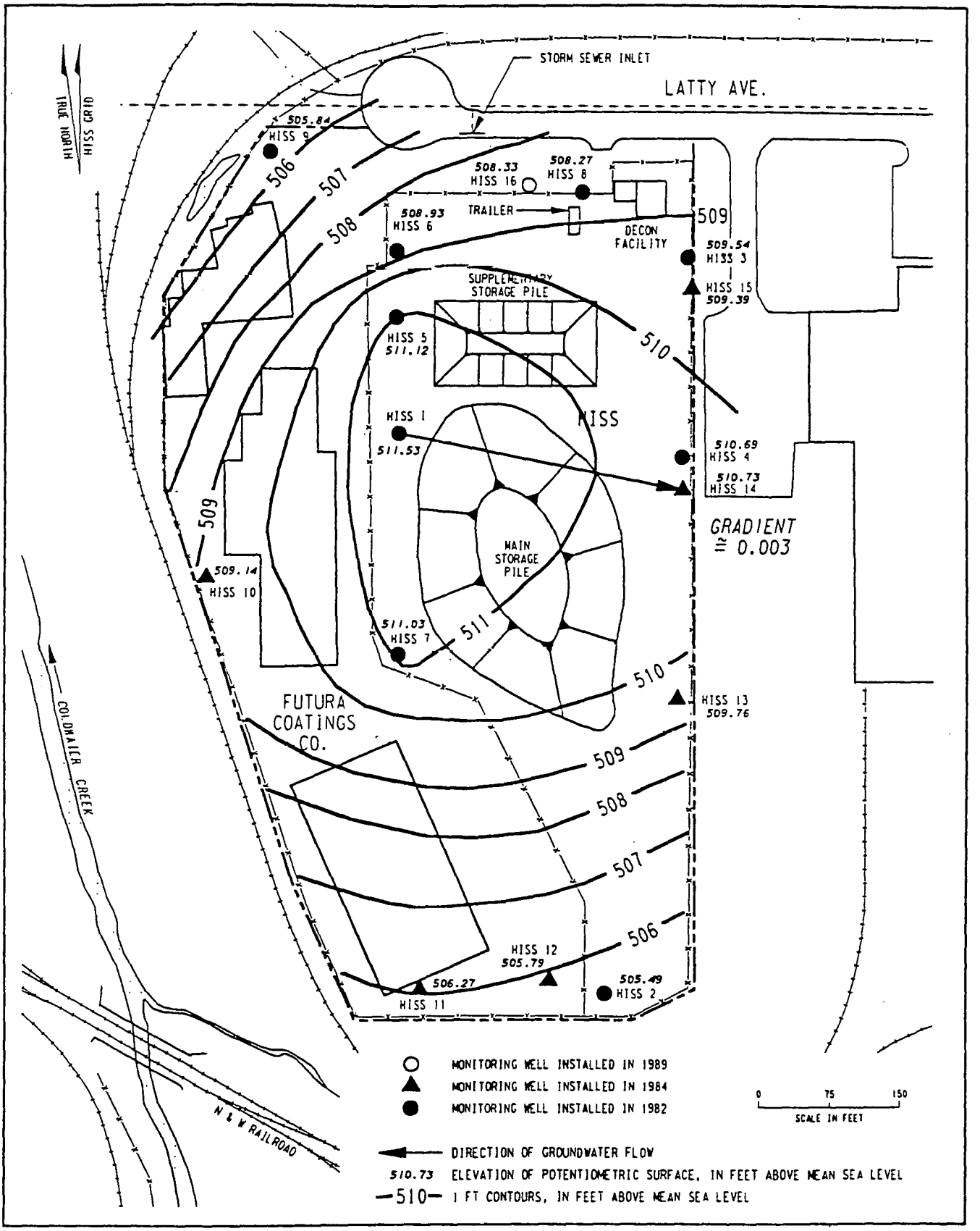

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Figure 6-2
HISS Potentiometric Surface Map (1/19/90)

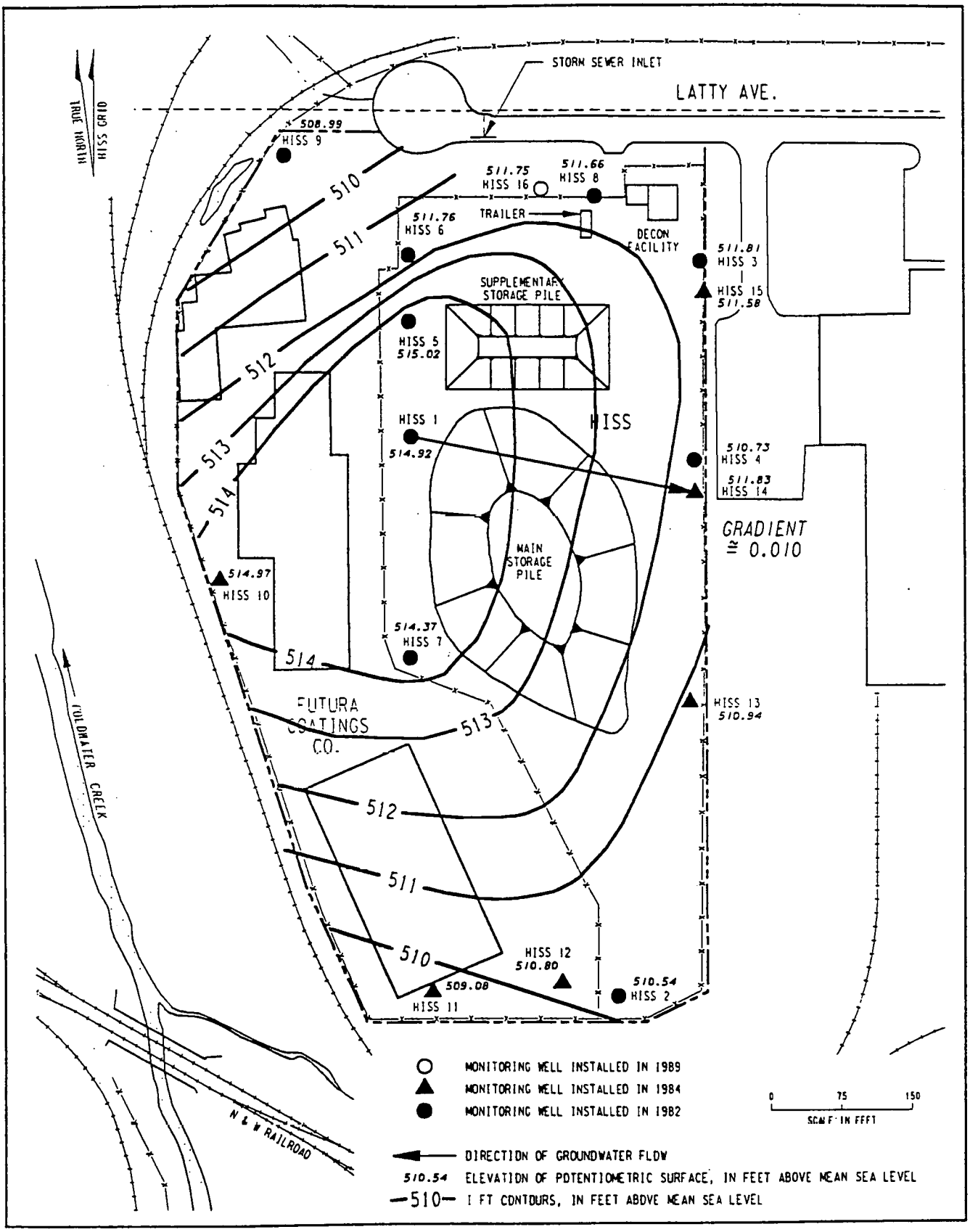

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Figure 6-3
HISS Potentiometric Surface Map (4/12/90)

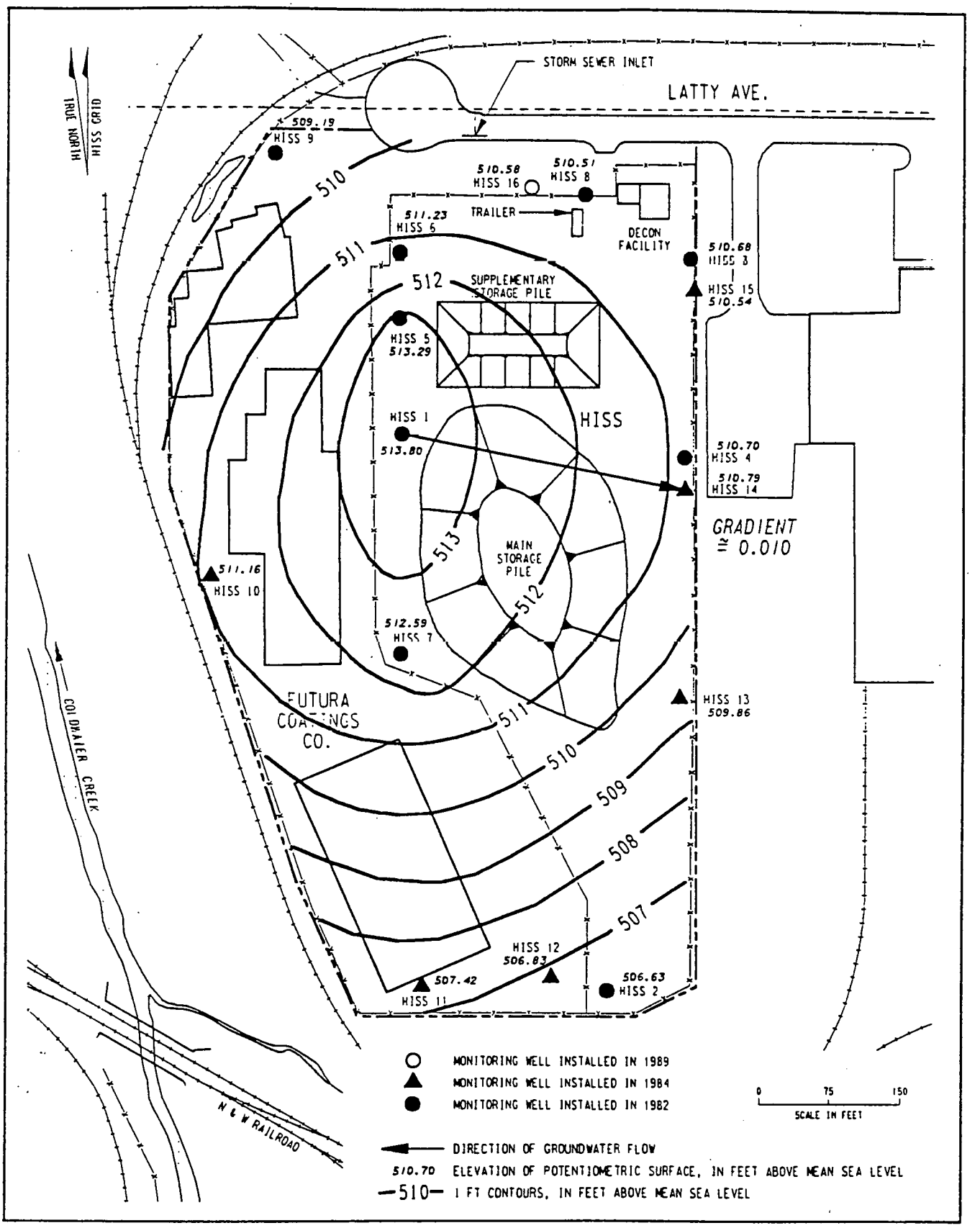

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Figure 6-4
HISS Potentiometric Surface Map (8/17/90)

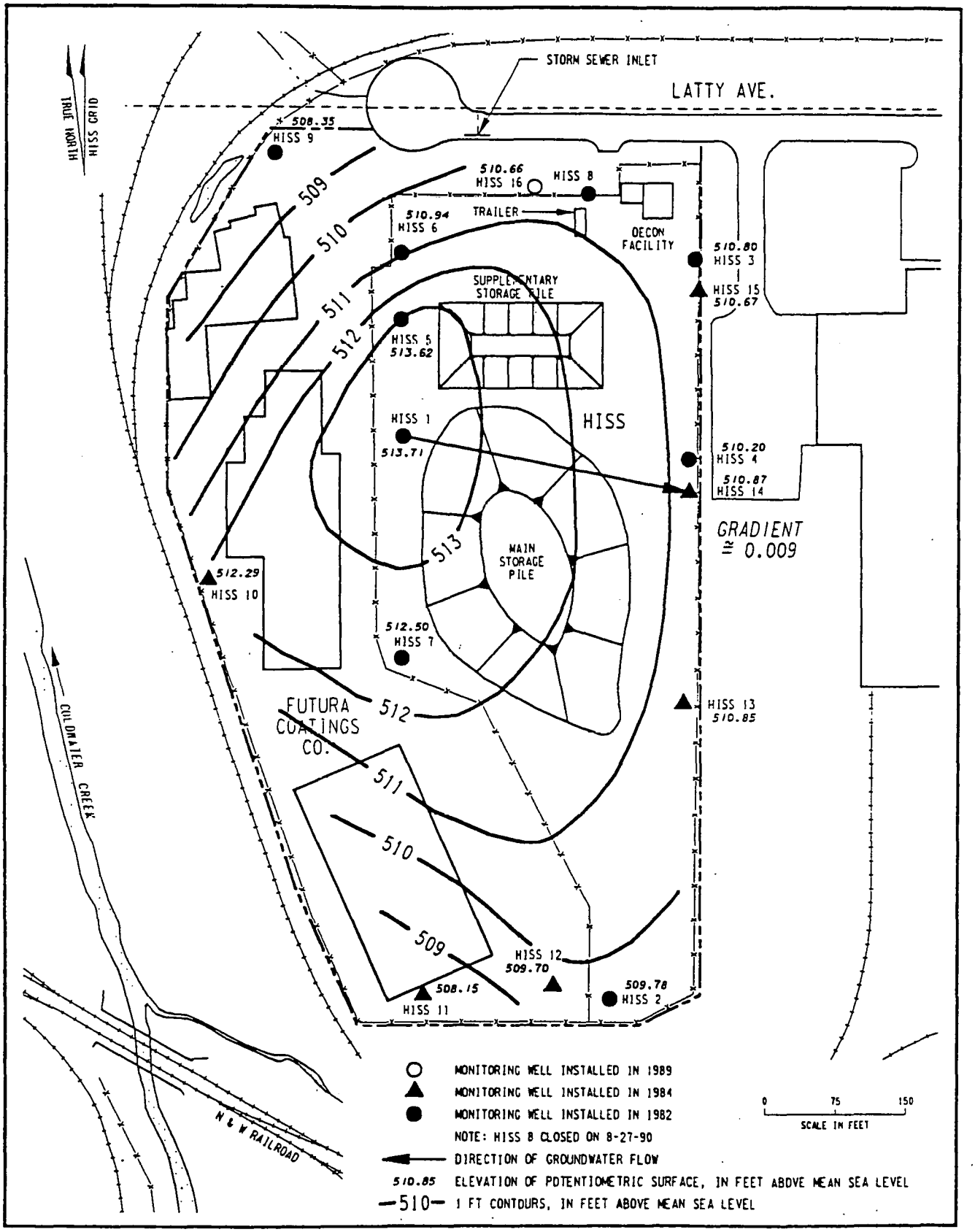

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Figure 6-5
HISS Potentiometric Surface Map (12/14/90)

6.2.2 Results and Conclusions

Hydrographs prepared for water levels measured in 1990 (shown in Appendix E) show slight seasonal fluctuations in groundwater levels. During the spring, groundwater levels rose several feet, a slight amount, or not at all. This may have been due to differences in spring thaw conditions from well to well. The lowest water levels were in the fall, repeating the seasonal fluctuation pattern seen in 1988 and 1989 (BNI 1989, 1990). Comparison of water levels with precipitation events shown on the hydrographs reveals an apparent correlation between the two in many of the wells, which indicates that the area around many of the wells is experiencing rapid recharge from precipitation events.

The general flow pattern is radial, with the groundwater flowing outward primarily from the area around wells HISS-1 and HISS-5 toward the other wells. The slope for the water table surface for 1990 was calculated using the southeastern flow direction. This direction gave a flow gradient beneath the HISS pile and was also consistent with results from previous years. The flow direction was to the southeast in 1988 and 1989. With the exception of winter, calculated flow gradients for 1990 are similar to those for 1988 and 1989 (BNI 1989, 1990). The 1990 gradients are 0.003 for winter (1/19/90; Figure 6-2), 0.010 for spring (4/12/90; Figure 6-3), 0.010 for summer (8/17/90; Figure 6-4), and 0.009 for fall (12/14/90; Figure 6-5). The flow gradient calculated for winter 1990 is sightly lower than that calculated for previous years.

The apparent slight seasonal variations from spring to winter shown on the hydrographs do not affect the slope of the potentiometric surface or the direction of groundwater flow (Figures 6-2 through 6-5). In all seasons the slope of the potentiometric surface and the direction of flow are radial, away from HISS-1 and HISS-5, which are located in an area of greater surface recharge. To detect any leachate that might come from the HISS pile through increased recharge, groundwater is sampled and

analyzed for radiological contaminants downgradient of wells HISS-1 and HISS-5. Results of radiological groundwater monitoring for 1990 are reported in Subsection 4.1.5.

Preliminary investigation of radial flow in the area around these wells has revealed that they are underlain by soils yielding high conductivity values. The highest of these values occur where standing water is occasionally present, suggesting that the soils may be saturated. Water accumulates in a drainage ditch along the western edge of the HISS pile. The amount and occurrence of standing water in this ditch is currently being examined in a surface water study for the HISS site.

7.0 QUALITY ASSURANCE

A comprehensive quality assurance (QA) program involving sampling, data management, and analysis is maintained to ensure that the data reported are representative of actual concentrations in the environment. The QA program meets the requirements of DOE Order 5700.6B and ANSI/ASME NQA-1.

QA sampling requirements are ensured through the following:

- Samples at all locations are collected using established procedures as outlined in the FUSRAP Integrated Environmental Monitoring Instruction Guide, 191-00-IG-003

- The sampling program design provides for trip blanks, matrix spike and spike duplicates, field blanks (daily), and quality control (QC) duplicate sampling (minimum of 1 in 20)

- Chain-of-custody procedures are performed to maintain traceability of samples and corresponding analytical results

Data management QA is achieved through:

- Completion and recording of parameter-specific data review checklists for each analysis report

- Use of calculation sheets for documenting computations

- Double checking and concurrence on calculations
  - By the originator
  - By an independent, equally qualified second party

- Report preparation and presentations

System QA audits are conducted by BNI FUSRAP project QA personnel to verify adherence to laboratory procedures and to

evaluate the appropriateness and effectiveness of the procedures. Audit team leaders and auditors are trained and certified in accordance with project procedures. Technical specialists participate as auditors under the direction of the audit team leader when warranted by the nature of the activities being audited. Audit reports are prepared for each audit conducted, and audit findings that require corrective action and followup are documented, tracked, and resolved, as verified by the project QA supervisor.

Routine radioanalyses are performed under subcontract by Thermo Analytical/Eberline (TMA/E), Albuquerque, New Mexico. This laboratory participates in the collaborative testing and interlaboratory comparison program with EPA at Las Vegas, Nevada. In this program, samples of various environmental media (water, milk, air filters, and soil) containing one or more radionuclides in known amounts are prepared and distributed to participating laboratories. After analysis, results are forwarded to EPA for comparison with known values and with the results from other laboratories. This program enables TMA/E to regularly evaluate the accuracy of its analyses and take corrective action, if needed. Table 7-1 summarizes results of the comparison studies for water samples. TMA/E also participates in the DOE Environmental Measurements Laboratory interlaboratory quality assessment program. This program consists of receiving and analyzing environmental samples (air filters, water, and soil) on a quarterly basis for specific radiochemical analyses (Table 7-2).

Interlaboratory comparison of the TETLD results is provided by participation in the International Environmental Dosimeter Project sponsored jointly by DOE, EPA, and the Nuclear Regulatory Commission. During 1990, TMA/E passed the testing portion of the DOE laboratory accreditation program for dosimeters.

Chemical analyses are performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard practices manual has been reviewed and accepted by BNI. Weston

TABLE 7-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS[a,b]

(EPA and TMA/E)

Analysis and Sample Date	Value (pCi/L)[c] EPA	Value (pCi/L)[c] TMA/E	Ratio (TMA/E:EPA)[d]
Alpha			
1/90	12.0 ± 5.0	9.33 ± 1.5	0.78
4/90	90 ± 12.0	96 ± 12	1.07
5/90	22.0 ± 6.0	26.3 ± 2.3	1.20
9/90	10.0 ± 5.0	11.0 ± 1.0	1.10
Beta			
1/90	12.0 ± 5.0	11.7 ± 2.1	0.98
4/90	52.0 ± 5.0	46.0 ± 6.0	0.88
5/90	15.0 ± 5.0	15.0 ± 1.0	1.0
9/90	10.0 ± 5.0	11.0 ± 1.0	1.10
Ra-226			
3/90	4.9 ± 0.7	6.1 ± 0.4	1.24
4/90	5.0 ± 0.8	2.8 ± 0.1	0.56
7/90	12.1 ± 1.8	10.1 ± 0.1	0.84
9/90	12.1 ± 1.8	10.1 ± 0.1	0.84
Ra-228			
3/90	12.7 ± 1.9	15.9 ± 0.4	1.25
4/90	10.2 ± 1.5	10.5 ± 1.5	1.03
9/90	5.1 ± 1.2	4.9 ± 1.2	0.96
U (Natural)			
3/90	4.0 ± 6.0	4.0 ± 0.0	1.0
4/90	20.0 ± 6.0	18.7 ± 1.5	0.94
7/90	20.8 ± 3.0	19.8 ± 1.1	0.95

[a]Results are from the U.S. EPA Interlaboratory Comparison Program.

[b]Samples were for comparison only and not site-specific.

[c]1 pCi/L is equivalent to 0.037 Bq/L.

[d]This ratio can be used to determine the accuracy of TMA/E's analytical procedures.

TABLE 7-2

SUMMARY COMPARISON OF AIR, SOIL, AND WATER SAMPLE RESULTS[a,b]

(EML and TMA/E)

Sample Type	Analysis (09/07/90)	Value		Ratio (TMA/E:EML)[c]
		EML	TMA/E	
Air (Bq/fil)	U-234	0.013	0.022 ± 0.012	1.69
Air (Bq/fil)	U-238	0.013	0.021 ± 0.012	1.62
Soil (Bq/kg)	U-234	28.3	23.9 ± 1.1	0.85
Soil (Bq/kg)	U-238	27.3	23.4 ± 1.0	0.86
Water (Bq/L)	U-234	0.236	0.232 ± 0.019	0.98
Water (Bq/L)	U-238	0.244	0.250 ± 0.041	1.03

[a]Results are from the DOE Environmental Measurements Laboratory (EML) interlaboratory quality assessment program.

[b]Samples were for comparison only and not site-specific.

[c]This ratio can be used to determine the accuracy of TMA/E's analytical procedures.

maintains an internal QA program and is audited by BNI FUSRAP personnel on a semiannual basis. The internal QA program involves the following for inorganic chemical analyses:

- Initial calibration and calibration verification
- Continuing calibration verification
- Reagent blank analyses
- Matrix spike analyses
- Duplicate sample analyses
- Laboratory control sample analyses
- Interlaboratory QA/QC

For organic chemical analyses, the QA program involves:

- Gas chromatography/mass spectrometry instrumentation for both volatile and semivolatile compound analysis
- Initial multilevel calibration for each Target Compound List (TCL) compound
- Matrix spike analyses
- Reagent blank analyses
- Interlaboratory QA/QC
- Continuing calibration for each TCL compound
- Addition of surrogate compounds to each sample and blanks for determining percent recovery information

Currently, Weston participates in drinking water, wastewater, and/or hazardous waste certification programs and is certified (or pending) in 35 such state programs. Continuing certification hinges upon Weston's ability to pass regular performance evaluation testing.

Weston's QA program also includes an independent overview by its project QA coordinator.

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APPENDIX A
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 minimum, maximum, and average values are calculated for all quarters of data.

Minimums and maximums are derived by comparing sampling results and determining the lowest and highest for the year. An example is given below.

Thorium-230 Results (pCi/L)

Sampling Location	Quarter 1	2	3	4	Minimum Value	Maximum Value
1	13	7	12	5	5	13

Because 5 pCi/L is less than any other result, it is entered into the minimum value column; 13 pCi/L, the greatest result reported, is entered into the maximum value column.

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 1	2	3	4	Average Value
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. An example of these calculations is shown below.

Thorium-230 Results (pCi/L)

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

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

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

Where S = Standard deviation

x_i = Individual values

$\overline{x}$ = Average of values

n = Number of values

n	x_i	$\bar{x}$	$(x_i - \bar{x})$	$(x_i - \bar{x})^2$
1	10	8.4	1.6	2.6
2	5	8.4	-3.4	11.56
3	14	8.4	5.6	31.36
4	8	8.4	-0.4	0.16
5	5	8.4	-3.4	11.56

$$\sum (X_i - \bar{x})^2 = 57.24$$

$$S = \sqrt{\frac{57.24}{5 - 1}} = \sqrt{\frac{57.24}{4}} = \sqrt{14.31} = 3.78,$$

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 B

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 by plants used as a food source. For FUSRAP sites, the primary pathways are direct gamma radiation and transport of radioactive materials by the atmosphere, groundwater, and surface water. The others are not considered primary pathways because FUSRAP sites are not located in areas where significant sources of livestock are raised or foodstuffs are grown.

Gamma rays can travel until they expend all their energy in molecular or atomic interactions. In general, these distances are not very great and the exposure pathway would affect only the 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 controlled through 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 municipal drinking water or to water livestock and/or to irrigate crops. Contamination transported via groundwater when contaminants migrate into the groundwater system becomes a problem if there is a potential receptor.

Primary Radionuclides of Concern

The primary radionuclides of concern for these calculations are uranium-238, uranium-235, uranium-234, thorium-230, radium-226, and the daughter products (excluding radon). For several of the dose conversion factors used in these calculations, the contributions of the daughters with half-lives less than one year are included with the parent radionuclide. Table B-1 lists the pertinent radionuclides, their half-lives, and dose conversion factors for ingestion.

DOSE CALCULATION METHOD

Direct Exposure

As previously indicated, direct exposure is only important in calculating the dose to the hypothetical maximally exposed individual. The dose from direct gamma exposure is determined by using data collected through the 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) above the ground. For the purposes of this report, it is assumed that the maximally exposed individual works 40 hours per

TABLE B-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	4.47E+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]

[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.

week at Futura Coatings at an average distance of 15 m (50 ft) from the site; there are no houses and, therefore, no residents near the site.

The dose to the maximally exposed individual can be determined by assuming that the individual is exposed to a line source located along the HISS/Futura fenceline. Because the average exposure rate is known from the TETLD program for a distance of 1.6 m (5 ft) from the fenceline, the exposure at 15 m (50 ft) from the fenceline can be calculated by using the following equation (Cember 1983).

$$\textit{Exposure at 15 m} = (\textit{Exposure at 1.6 m}) \times \frac{h_1}{h_2} \times \frac{\tan^{-1}(L/h_2)}{\tan^{-1}(L/h_1)}$$

Where h_1 = TETLD distance from the fenceline [1.6 m (5 ft)]
h_2 = Maximally exposed individual's distance from the fenceline [15 m (50 ft)]
L = half of the length of the site toward McDonnell Boulevard [170 m (500 ft)]

The exposure rate at 1.6 m (5 ft) can be calculated by taking the average of the results from the six detectors along this portion of the fenceline (1, 2, 5, 6, 7, and 9). The average exposure rate for these detectors was 22.5 mR/yr. Using the formula above, the exposure rate at 15 m (50 ft) is approximately 2.1 mR/yr. Because 1 mR/yr is approximately equal to 1 mrem/yr, the resulting dose would be 2.1 mrem/yr, assuming 24-h continuous residence. However, this is the dose for the entire year; to calculate the dose to a worker (8 h/day), the following equation must be used.

$$\textit{Dose} = (\textit{Dose at 15 m}) \times \frac{(40\ h/wk)}{(7\ days/wk \times 24\ h/day)} = 0.5\ mrem/yr$$

Therefore, the dose from direct gamma radiation to the hypothetical maximally exposed individual is 0.5 mrem/yr (0.005 mSv/yr).

This exposure scenario should provide a very conservative estimate of the dose from direct gamma exposure to the hypothetical maximally exposed individual.

Surface Water

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 maximally exposed individual can be calculated by the following:

$$D_s = \sum_{i=1}^{N} Ci \times (Fs \div Fi) \times Ua \times DCFi$$

Where D_s = Committed effective dose from surface water

Ci = Concentration of the i^{th} radionuclide in surface water at the site

Fs = Average annual flow of surface water at the site

Fi = Average flow of surface water at the intake

Ua = Annual consumption of liquid (approx. 730 L/yr)

DCFi = Dose conversion factor for the i^{th} radionuclide

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 maximally exposed individual.

The approach outlined above should provide a very conservative dose calculation for the surface water pathway because it does not account for radionuclides settling out or for any municipal water treatment.

Groundwater

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 concentrations 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 maximally exposed individual can be calculated by using the following equation:

$$Dgw = \sum_{i=1}^{N} (Ci) \times (D) \times (Ua) \times (DCFi)$$

Where Dgw = Committed effective dose from groundwater
Ci = Concentration of the i^{th} radionuclide in groundwater at the site
D = Estimated dilution factor
Ua = Annual consumption of liquid (approx. 730 L/yr)
DCFi = Dose conversion factor for the i^{th} radionuclide

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 maximally exposed individual.

The approach given above should provide a conservative dose calculation for the groundwater pathway because it does not account for any water treatment.

Atmospheric

The dose to the hypothetical maximally exposed individual from particulate radionuclides transported via the atmospheric pathway is calculated using EPA's computer model AIRDOS. Doses to the general public via this pathway are also calculated using AIRDOS results; these 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 two areas: the interim storage piles and the remainder of the site. Assumptions used in the calculation model were (1) the particle size is assumed to be 0.05 mm, (2) the pile cover is modeled as the contamination being 99 percent covered by vegetation, and (3) the site had very few mechanical disturbances each month.

APPENDIX C

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 GUIDELINES

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 guidelines (DCGs). A DCG is defined as the concentration of a single 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[d]	3E-9	3E-9	--	--	3E-9
" 220[d]	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.

[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).

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

POTENTIAL STATE ARARS

The following Missouri laws and regulations have been identified as potential ARARs for the management of HISS. Where differences between state and federal requirements exist, the more restrictive requirement applies.

Potential ARAR	Requirement
Missouri Rules for Radiation Protection, Missouri CSR, Title 19, Department of Health, Division 20, Chapter 10	Contains regulations to protect public health and welfare from the effects of ionizing radiation. Contains requirements for registering nonexempt sources, maximum permissible exposure limits, personnel monitoring and radiation surveys, radiation exposure records and reports, storage of radioactive materials, control of radioactive contamination, and disposal of radioactive wastes.

Missouri Solid Waste Law, AMS, Title 16, Chapter 260	To protect the public health, safety, and welfare, it is unlawful to deposit any solid waste onto the surface of the ground or into the waters of the state, burn solid wastes, or construct, alter, or operate a solid waste processing or disposal facility or site without a permit.
Missouri Solid Waste Rules, 10 CSR 80, MoDNR	Contains requirements for obtaining a solid waste permit (10 CSR 80-2.020 through 2.070) and design and operation of solid waste processing facilities (10 CSR 80-5.010).
Missouri Hazardous Waste Management Law, 16 AMS 260	To provide safe storage, transportation, treatment, and disposal of hazardous wastes; to promote hazardous waste recycling, reuse, or reduction; and to require a permit for construction, alteration, or operation of the hazardous waste treatment, storage, or disposal facility.
Missouri Hazardous Waste Management Rules, 10 CSR 25, MoDNR Hazardous Waste Management Commission	Contains requirements for methods used for identifying hazardous waste (10 CSR 25-4.261); rules applicable to generators of hazardous waste (10 CSR 25-6.262); rules applicable to owners/operators of hazardous waste treatment, storage, and disposal facilities (10 CSR 25-7.264) including interim status standards (10 CSR 25-7.265) and state permit programs (10 CSR 25-7.270); requirements for public participation (10 CSR 25-8.010); requirements for abandoned or uncontrolled hazardous waste disposal sites (10 CSR 25-10.010); hazardous waste fees and taxes (10 CSR 25-12.010); and rules applicable to the management of polychlorinated biphenyl wastes (10 CSR 25-13.010). Text of rules is largely made up of references to federal hazardous waste regulations and are not substantively more restrictive.

Missouri Clean Water Law, 40 AMS 644	State law has intent to protect public health and welfare; protect wildlife, fish, and aquatic life; protect, maintain, and improve water quality for beneficial uses; prevent unpermitted discharges; and control and abate new or existing water pollution.
Missouri Water Pollution Control Regulations, 10 CSR 20, Chapters 1-6, MoDNR Clean Water Commission	Contains requirements for construction and operating permits and includes public participation.
Missouri Water Quality and Effluent Limitations Standards, 10 CSR 20, Chapter 7, MoDNR Clean Water Commission	Contains standards to prevent degradation of surface and groundwater quality including general criteria and specific criteria for classified waters. Prohibits unpermitted discharges to streams.
Missouri Drinking Water Act, AMS 640	State law has intent to maintain a safe quality of water dispensed to the public.
Missouri Drinking Water Regulations, 10 CSR 60, MoDNR Public Drinking Water Program	Contains maximum contaminant levels (MCLs) and monitoring requirements for inorganic chemicals, organic chemicals (including trihalomethane and volatile organic chemicals), turbidity, radionuclides, and secondary contaminants.
Missouri Air Conservation Law, 40 AMS 643	State law has intent to protect air resources and ambient air quality through prevention, abatement, and control of air pollution.
Missouri Air Pollution Control Regulations, 10 CSR 10, MoDNR Air Conservation Commission, Chapters 1-5	Contains requirements for the prevention and restriction of airborne contaminants and includes air quality standards and air pollution control regulations for the St. Louis metropolitan area (Section 5).

Missouri Air Quality Standards, 10 CSR 10, MoDNR Conservation Commission, Chapter 6	Contains ambient air quality pollutant concentration limits and requirements for permitting air pollution sources.

POTENTIAL FEDERAL ARARs

In addition to the federal regulations identified in Section 2.0, the following have been identified as potential ARARs.

Potential ARAR	Requirement
Occupational Safety and Health Administration General Industry Standards, 29 CFR 1910	Health and safety standards are established for hazardous waste operations, including limits for exposure to noise and certain hazardous materials.
Occupational Safety and Health Administration Standards Hazardous Waste Operations and Emergency Response, 29 CFR 1910	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. Procedures are established for hazardous waste operations, including decontamination of radioactive waste, shipping and transport, and container handling.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192	Contains limited permissible concentrations of radium, thorium, radon, and gamma radiation.
Radiation Protection for Occupational Workers, DOE Order 5480.11	Standards and program requirements are established for worker protection from ionizing radiation, including derived air concentration guides for inhalation and immersion. The basic dose limit of 100 mrem/yr also applies to any member of the public entering a controlled area.

Standards for Protection Against Radiation, 48 FR 20721	The standard for uranium-238 in inhaled air is 3E-12 μCi/ml daily, 1E-12 μCi/ml weekly; the standard for thorium-232 in inhaled air is 4E-15 μCi/ml weekly and 8E-15 μCi/ml yearly; the standard for thorium-230 in inhaled air is 2E-14 μCi/ml yearly; and the standard for radium-226 in inhaled air is 9E-13 μCi/ml weekly.

APPENDIX D

PARAMETERS FOR ANALYSIS

PARAMETERS FOR ANALYSIS AT HISS, 1990

Medium	Parameter	Technique
Groundwater	Total uranium	Fluorometric
	Radium-226	Emanation
	Thorium-230	Alpha spectrometry
	Total organic halides (TOX)	Carbonaceous analyzer
	Total organic carbon (TOC)	Coulometric determination
	Specific conductance	Electrometric
	pH	Electrometric
Surface Water	Total uranium	Fluorometric
	Radium-226	Emanation
	Thorium-230	Alpha spectrometry
Sediment	Total uranium	Alpha spectrometry
	Radium-226	Gamma spectrometry
	Thorium-230	Alpha spectrometry
Air	Radon-222	Track-etch
	External gamma radiation	Thermoluminescence

APPENDIX E

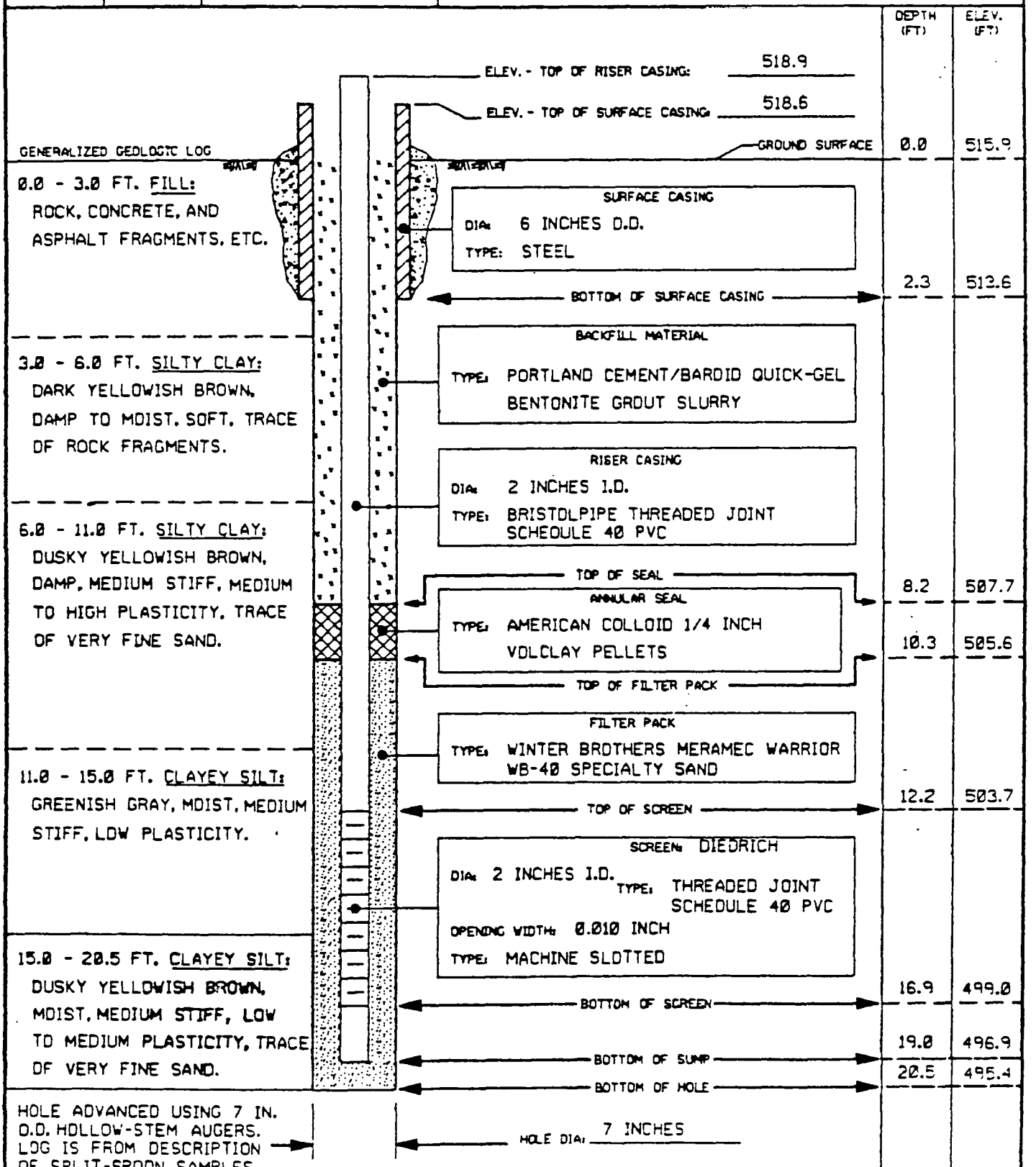
SAMPLE OBSERVATION WELL CONSTRUCTION LOGS AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS

OBSERVATION WELL

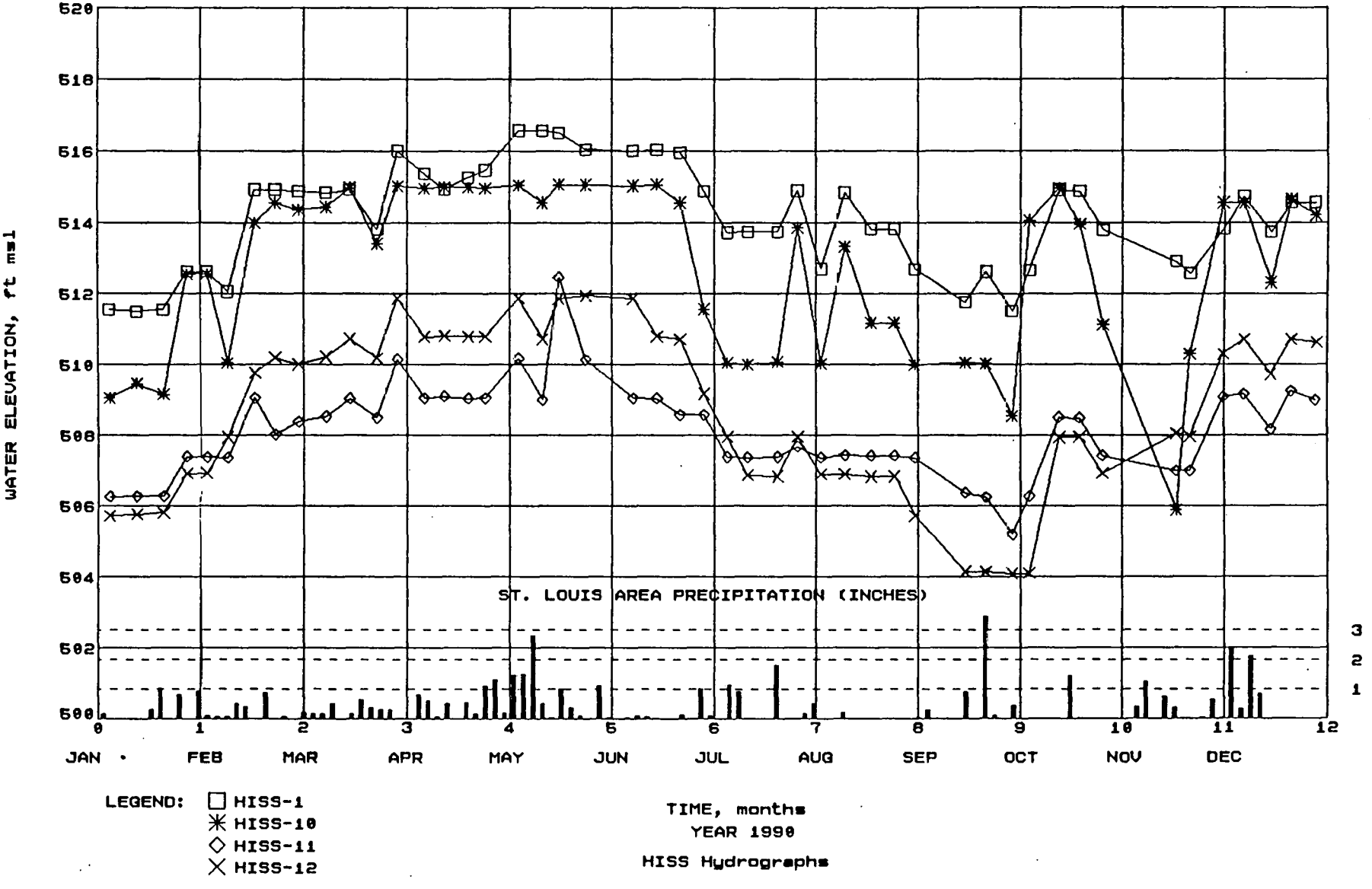
PROJECT	WELL NO.
FUSRAP	HISS-15

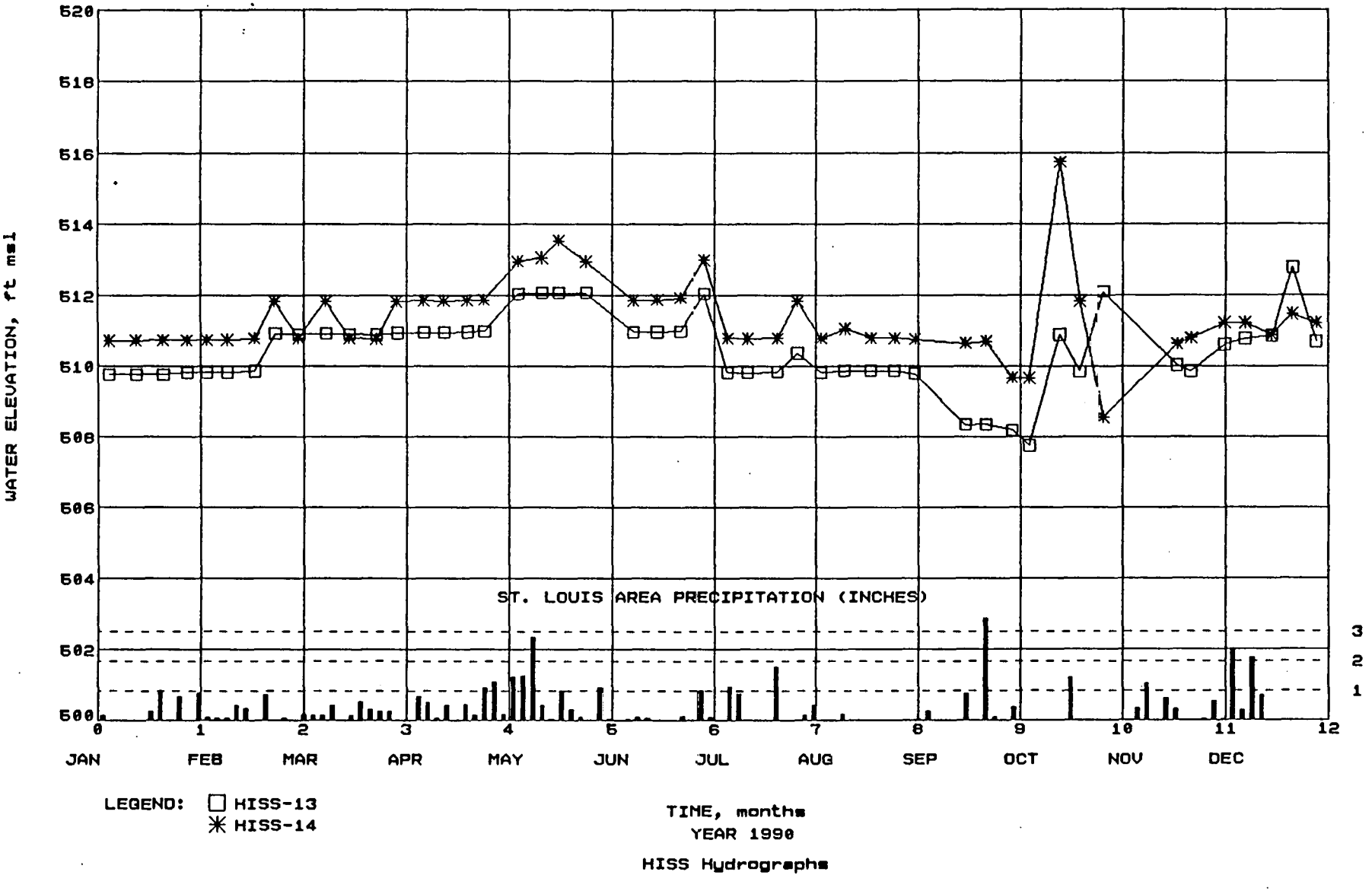
JOB NO.	SITE	LOCATION
14501	HAZELWOOD I.S.S.	STA. 8+64.5 OFFSET 101.9 FT. RIGHT

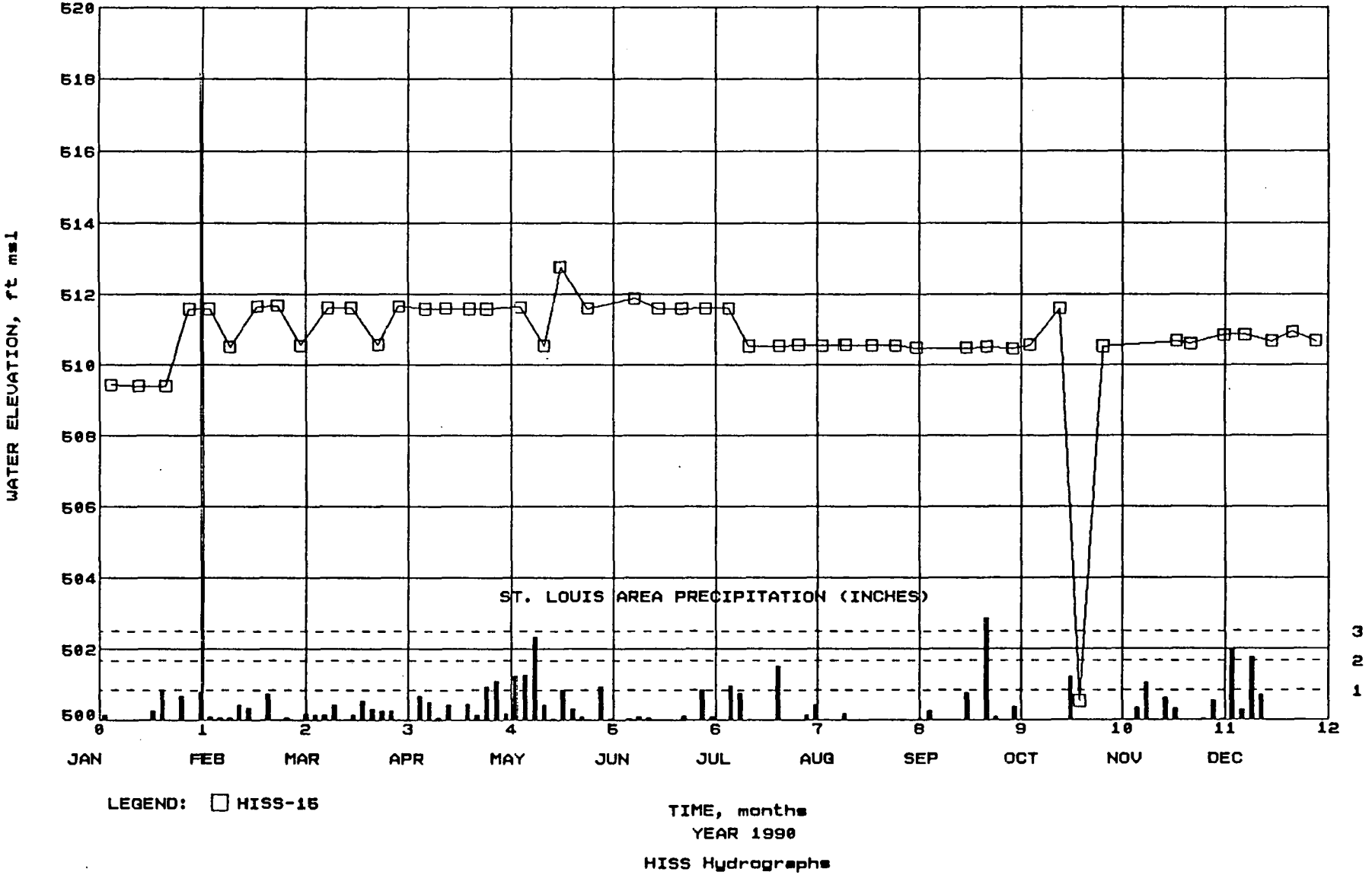
BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
12/14/84	12/14/84	L. MATTHEWS	TOP OF RISER CASING

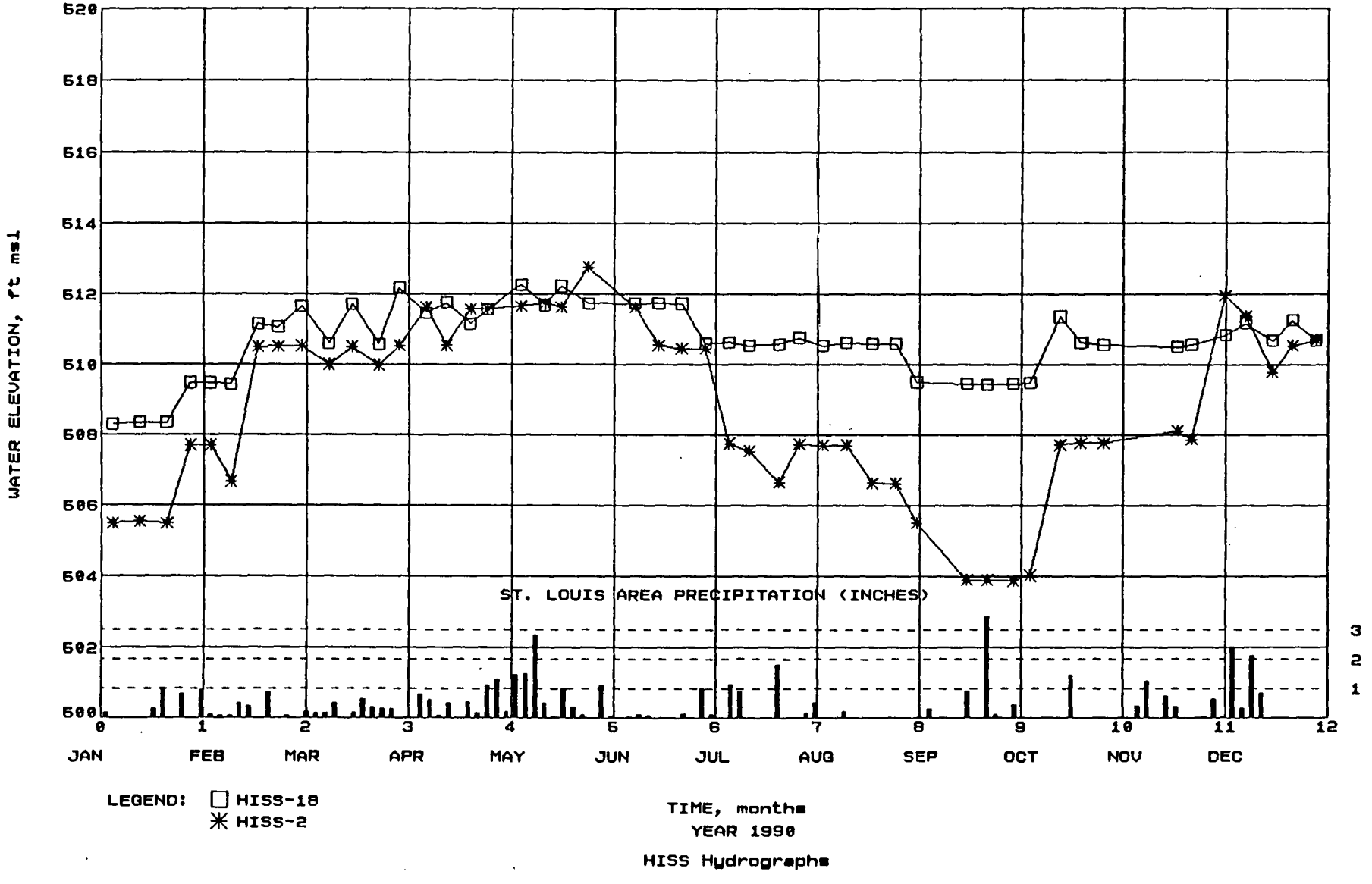


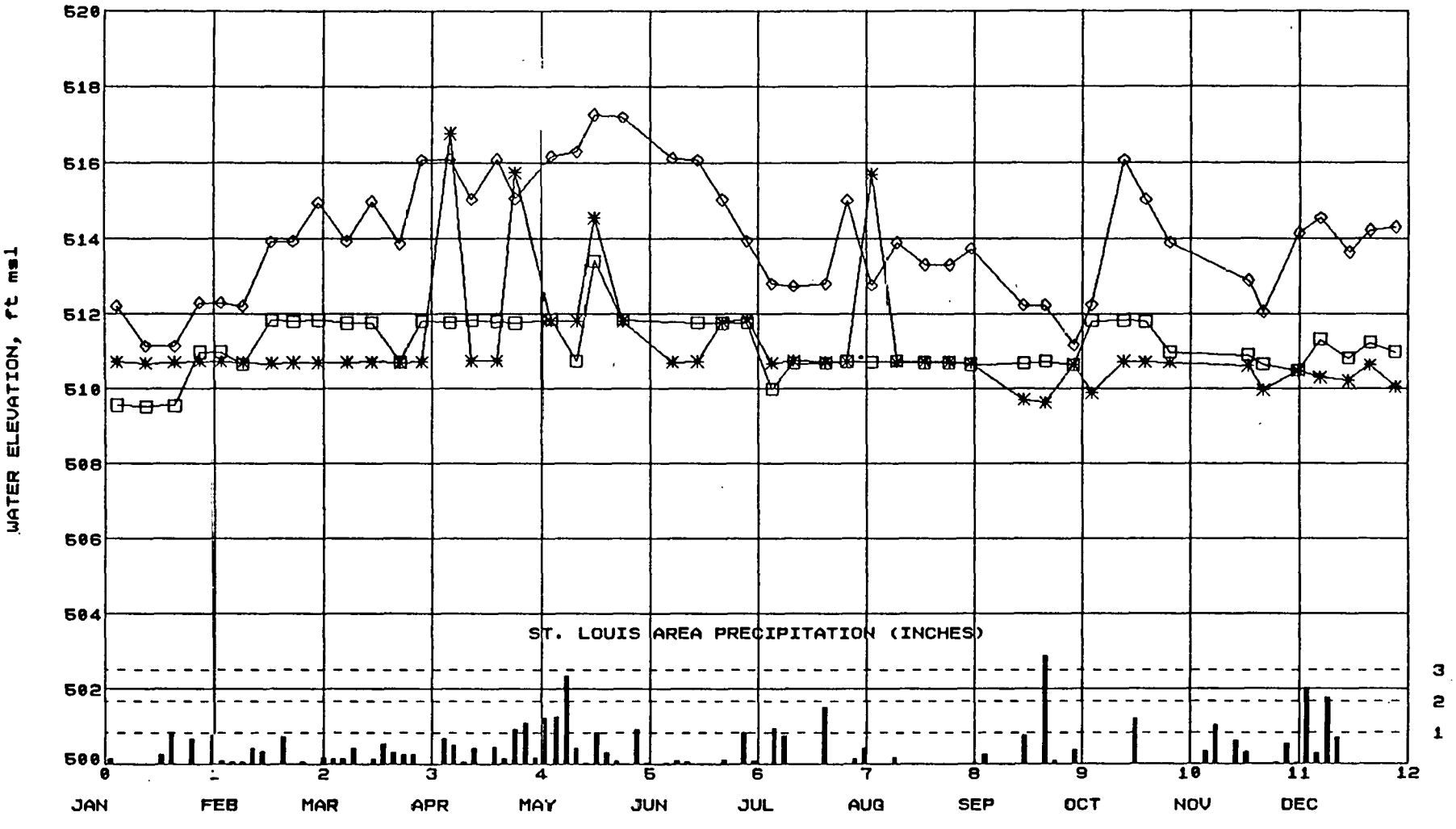
	DEPTH (FT)	ELEV. (FT)
GROUND SURFACE	0.0	515.9
BOTTOM OF SURFACE CASING	2.3	513.6
TOP OF SEAL	8.2	507.7
TOP OF FILTER PACK	10.3	505.6
TOP OF SCREEN	12.2	503.7
BOTTOM OF SCREEN	16.9	499.0
BOTTOM OF SUMP	19.0	496.9
BOTTOM OF HOLE	20.5	495.4


WATER ELEVATION, ft msl
520
518
516
514
512
510
508
506
504
502
500
ST. LOUIS AREA PRECIPITATION (INCHES)
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LEGEND:
HISS-1
HISS-10
HISS-11
HISS-12
TIME, months
YEAR 1990
HISS Hydrographs

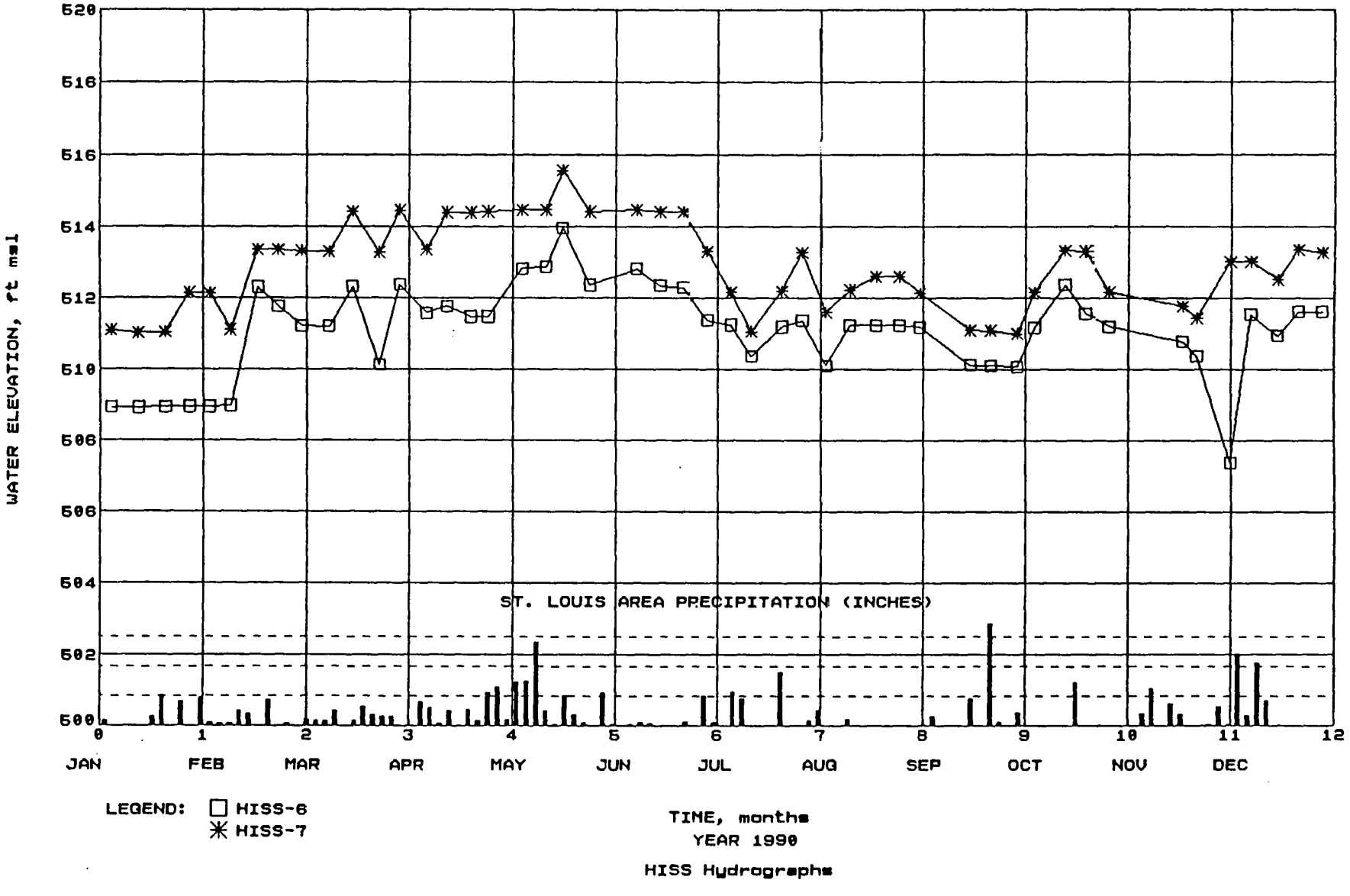

520
518
516
514
512
510
508
506
504
502
500
WATER ELEVATION, ft msl
ST. LOUIS AREA PRECIPITATION (INCHES)
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LEGEND:
HISS-13
HISS-14
TIME, months
YEAR 1990
HISS Hydrographs


520
518
516
514
512
510
508
506
504
502
500
WATER ELEVATION, ft msl
ST. LOUIS AREA PRECIPITATION (INCHES)
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LEGEND: HISS-15
TIME, months
YEAR 1990
HISS Hydrographs

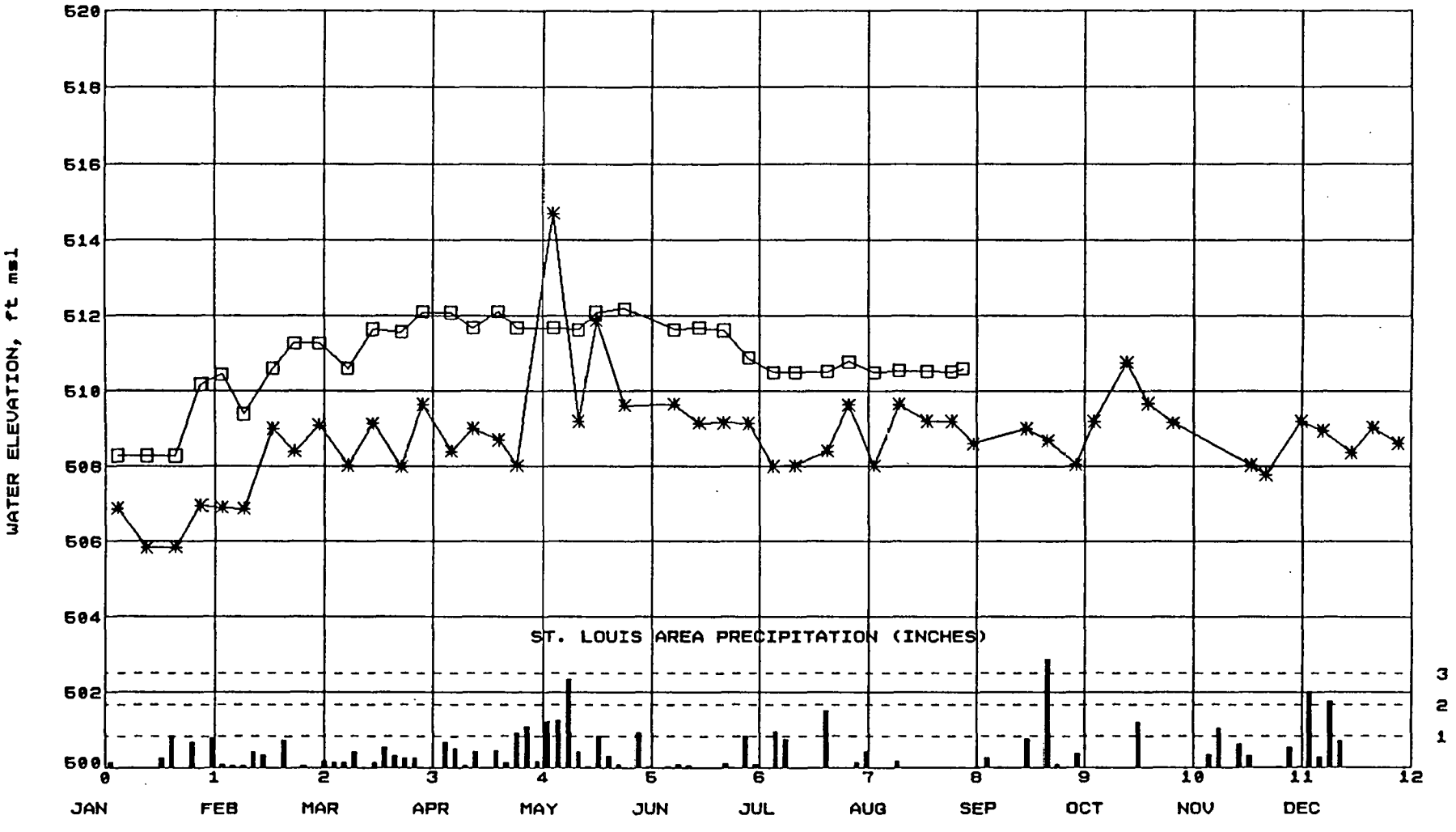

520
518
516
514
512
510
508
506
504
502
500
WATER ELEVATION, ft msl
ST. LOUIS AREA PRECIPITATION (INCHES)
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
LEGEND: HISS-18
HISS-2
TIME, months
YEAR 1990
HISS Hydrographs



HISS Hydrographs



HISS Hydrographs



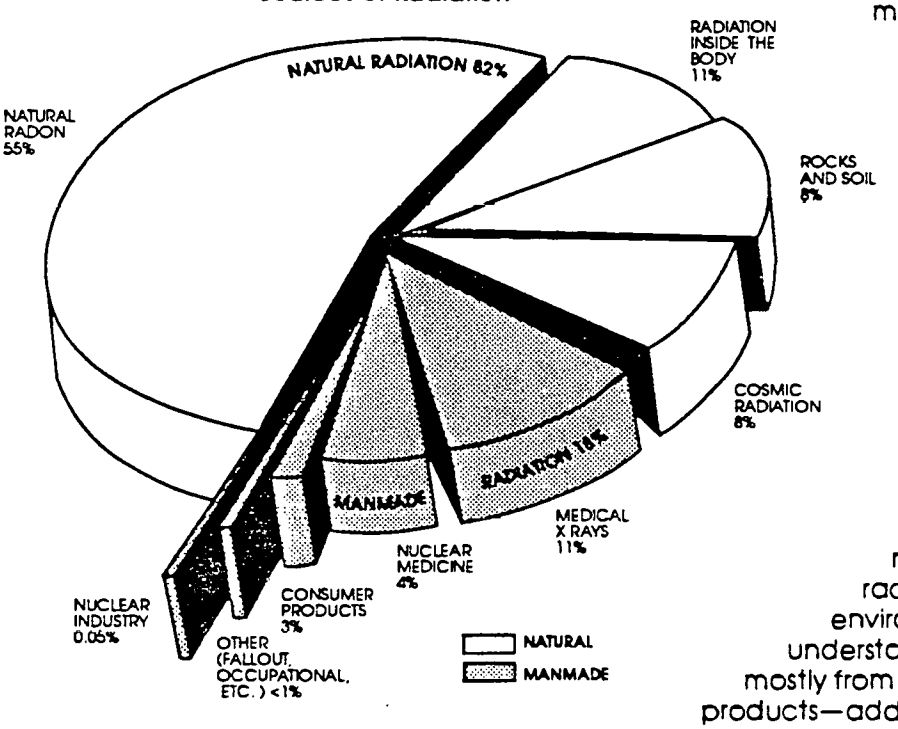
HISS Hydrographs

Radiation in the Environment

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

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

Sources of Radiation



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

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

TYPES OF IONIZING RADIATION

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

Alpha

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

Beta

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

Gamma

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

Units of Measure

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

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

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

RADIATION IN THE ENVIRONMENT

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

mrem = millirem
pCi = picocurie

Cosmic Radiation

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

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

Terrestrial Radiation

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

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

Buildings

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

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

Radon

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

Average Indoor Radon Level ..... 1.5 pCi/liter
Occupational Working Limit ..... 100.0 pCi/liter

Food

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

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

Medical Treatment

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

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

Consumer Goods

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

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

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

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

International Nuclear Weapons Test Fallout from pre–1980 atmospheric tests (average for a U.S. citizen) ..... 1 mrem/year

References

Effect of Ionizing Radiation on Human Health, The. Arthur C. Upton. New York University Medical Center. Atomic Industrial Forum, 1984.
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Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources. Report Number 95. National Council on Radiation Protection and Measurments, 1987.
Radiation in Medicine and Industry. A.P. Jacobson and G.P. Sakolosky, 1980.
Radioactivity in Consumer Products. U.S. Nuclear Regulatory Commission, 1978.

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

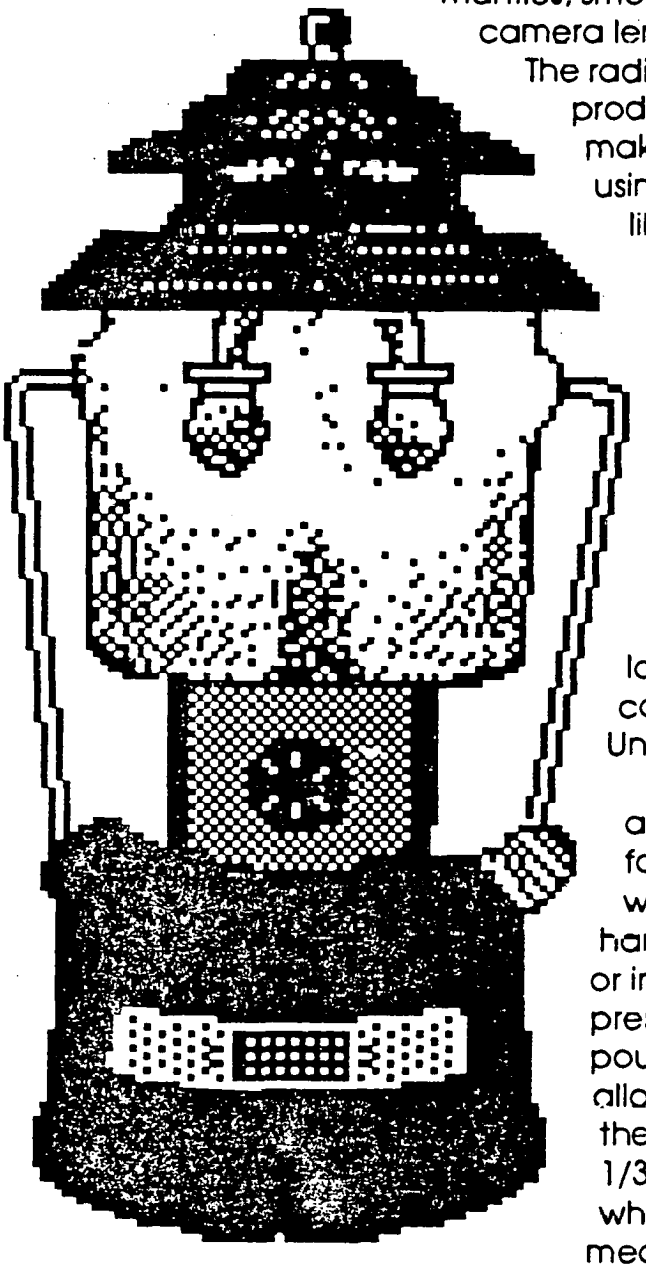
The following chart shows the relative differences between the units and gives analogies in dollars. It also gives examples of where these various amounts of radioactivity could typically be found. The number of disintegrations per minute has been rounded off for the chart.

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

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.

APPENDIX G

CONVERSION FACTORS

TABLE G-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 H

CLEAN AIR ACT COMPLIANCE REPORT

FOR HAZELWOOD 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: Hazelwood Interim Storage Site
Address: 9200 Latty Avenue
Hazelwood , MO. 63042
Annual Assessment for Year: 1990
Date Submitted: 5/24/91

Comments: Annual Assessment for Year 1990

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 3/20/91 1:39 PM

Facility: Hazelwood Interim Storage Site
Address: 9200, Latty Avenue City: Hazelwood State: MO
Comments:
Year: 1990

	Dose Equivalent Rates to Nearby Individuals (mrem/year)
Effective Dose Equivalent	0.4000
Highest Organ Dose is to ENDOSTEUM	4.6

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

Radio-nuclide	Class	Amad	Area #1 (Ci/y)	Area #2 (Ci/y)	Area #3 (Ci/y)
U-238	Y	1.0	7.5E-07	8.9E-07	4.7E-06
RA-226	Y	1.0	4.2E-07	7.1E-07	3.7E-06
TH-230	Y	1.0	1.3E-06	1.1E-04	0.0E-01
U-234	Y	1.0	7.3E-07	8.7E-07	4.6E-06
U-235	Y	1.0	3.3E-08	4.0E-08	2.1E-07
TH-232	Y	1.0	0.0E-01	0.0E-01	2.2E-07
Total Area (m**2)			5.8E+03	1.5E+03	1.4E+04

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

Wind Data	SL_MO.WND	Temperature (C)	14
Food Source	LOCAL	Rainfall (cm/y)	82
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	1.5E-03
BREAST	1.6E-03
RED MARROW	3.7E-01
LUNGS	1.8E+00
THYROID	1.5E-03
ENDOSTEUM	4.6E+00
REMAINDER	5.6E-03
EFFECTIVE	4.0E-01

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	7.9E-03	1.8E-01
INHALATION	4.0E-01	4.5E+00
AIR IMMERSION	9.7E-10	1.2E-09
GROUND SURFACE	3.9E-05	3.7E-05
TOTAL:	4.0E-01	4.6E+00

Hazelwood 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-02	1.1E-02
RA-226	9.4E-03	1.5E-02
TH-230	3.7E-01	4.6E+00
U-234	1.1E-02	1.2E-02
U-235	4.9E-04	5.4E-04
TH-232	1.1E-03	9.2E-03
TOTAL :	4.0E-01	4.6E+00

Hazelwood 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 : NORTHWEST

DISTANCE (meters)	EFFECTIVE DOSE EQUIVALENT (mrem/y)
300	4.0E-01
1000	3.4E-02
3000	4.2E-03
10000	4.7E-04
80000	1.2E-05

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	2.5E-01	1.2E-01	1.4E-01	2.1E-01	3.8E-01	3.0E-01	1.6E-01	1.0E-01
1000	2.3E-02	1.1E-02	1.3E-02	1.8E-02	3.2E-02	2.5E-02	1.4E-02	9.3E-03
3000	3.2E-03	1.5E-03	1.7E-03	2.4E-03	4.0E-03	3.3E-03	1.9E-03	1.3E-03
10000	4.2E-04	2.1E-04	2.3E-04	2.8E-04	4.5E-04	3.9E-04	2.5E-04	1.7E-04
80000	1.6E-05	8.0E-06	8.6E-06	9.2E-06	1.3E-05	1.3E-05	8.6E-06	6.1E-06

	S	SSW	SW	WSW	W	WNW	NW	NNW
DISTANCE (METERS):								
300	1.1E-01	1.5E-01	2.1E-01	1.7E-01	1.9E-01	2.6E-01	4.0E-01	2.8E-01
1000	9.6E-03	1.3E-02	1.8E-02	1.4E-02	1.6E-02	2.2E-02	3.4E-02	2.4E-02
3000	1.3E-03	1.7E-03	2.2E-03	1.8E-03	2.0E-03	2.8E-03	4.2E-03	3.1E-03
10000	1.6E-04	1.9E-04	2.4E-04	1.9E-04	2.3E-04	3.2E-04	4.7E-04	3.7E-04
80000	5.4E-06	5.5E-06	6.1E-06	5.1E-06	5.8E-06	9.4E-06	1.2E-05	1.2E-05

APPENDIX I

DISTRIBUTION LIST FOR HAZELWOOD INTERIM STORAGE SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

DISTRIBUTION LIST FOR HAZELWOOD INTERIM STORAGE SITE

ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

Media:

Editor, North County Publications
9320 Lewis and Clark Boulevard
St. Louis, MO 63136

Editor
RiverFront Times
1221 Locust Street, #900
St. Louis, MO 63103

Environmental Editor
St. Louis Post-Dispatch
1710 North Tucker Boulevard
St. Louis, MO 63101

Ms. Chris Bertelson, Reporter
St. Louis Post-Dispatch
1710 North Tucker Boulevard
St. Louis, MO 63101

Mr. Richard Byrne, Reporter
RiverFront Times
1221 Locust Street, #900
St. Louis, MO 63103

Ms. Laura Hopper, Reporter
North County Journal
4305 Woodson Road
St. Louis, MO 63134

Ms. Donna Tepper, Reporter
Associated Press Wire Service
470 Fourwynd Drive
St. Louis, MO 63141

News Editor
Suburban Newspapers of Greater St. Louis
1714 Deer Track Trail
St. Louis, MO 63119

News Director
KDNL-TV
1215 Cole Street
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