063070

DOE/OR/20722-143

HAZELWOOD INTERIM STORAGE SITE

ANNUAL SITE ENVIRONMENTAL REPORT

CALENDAR YEAR 1986

JUNE 1987

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

P.O. Box 350

Oak Ridge, Tennessee

Bechtel Job No. 14501

ABSTRACT

During 1986, the environmental monitoring program was continued at the Hazelwood Interim Storage Site (HISS), a U.S. Department of Energy (DOE) facility located in the City of Hazelwood, Missouri. Originally known as the Cotter Corporation site on Latty Avenue in Hazelwood, the HISS is presently used for the storage of soils contaminated with residual radioactive material. The HISS is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive material remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has mandated DOE to remedy. As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, remedial action is being conducted at the site and at vicinity properties by Bechtel National, Inc. (BNI), Project Management Contractor for FUSRAP. The environmental monitoring program is also carried out by BNI.

The monitoring program at the HISS measures radon gas concentrations in air; external gamma radiation levels; and uranium, radium, and thorium concentrations in surface water, groundwater, and sediment. To verify that the site is in compliance with the DOE radiation protection standard (100 mrem/yr) and assess its potential effect on public health, the radiation dose was calculated for the maximally exposed individual. Based on the scenario described in this report, the maximally exposed individual at the HISS would receive an annual external exposure approximately equivalent to 2 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than the exposure a person would receive during a round-trip flight from New York to Los Angeles (due to greater amounts of cosmic radiation at higher altitudes). The cumulative dose to the population within an 80-km (50-mi) radius of the HISS that would

result from radioactive materials present at the site would be indistinguishable from the dose that the same population would receive from naturally occurring radioactive sources.

Results of the 1986 monitoring show that the HISS is in compliance with the DOE radiation protection standard.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This report presents the findings of the environmental monitoring conducted at the Hazelwood Interim Storage Site (HISS) during calendar year 1986. Environmental monitoring has been conducted at the HISS since 1984. As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, Bechtel National, Inc. is conducting remedial action on-site and at vicinity properties. The work is being performed as part of the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

1.1 LOCATION AND DESCRIPTION

The HISS is located in northern St. Louis County within the city limits of Hazelwood, Missouri, at 9200 Latty Avenue (Figure 1-1). (The site was originally known as the Cotter Corporation site on Latty Avenue.) The vicinity properties lie along Latty Avenue from Coldwater Creek to Interstate Highway 170 in Hazelwood. Some of the vicinity properties are located within the corporate limits of the adjacent City of Berkeley. The HISS lies 3.2 km (2 mi) northeast of the control tower of Lambert-St. Louis International Airport. An aerial photograph of the HISS and its vicinity is shown in Figure 1-2.

The HISS is located on a broad, shallow bedrock depression known as the Florissant Basin. During glacial times drainage from the area was blocked, and the Florissant Basin was filled with silts, clays, and sands. The surface and near-surface soils are fine-grained sandy silts and clayey silts. These materials are unconsolidated to poorly consolidated, erode easily, and have poor load-bearing capacity (Ref. 1).

Surface water runoff follows surface elevation contours and flows to the north and the south across the site. Water flowing to the north enters storm drainage ditches on both sides of Latty Avenue before discharging into Coldwater Creek, the main receiving body for site

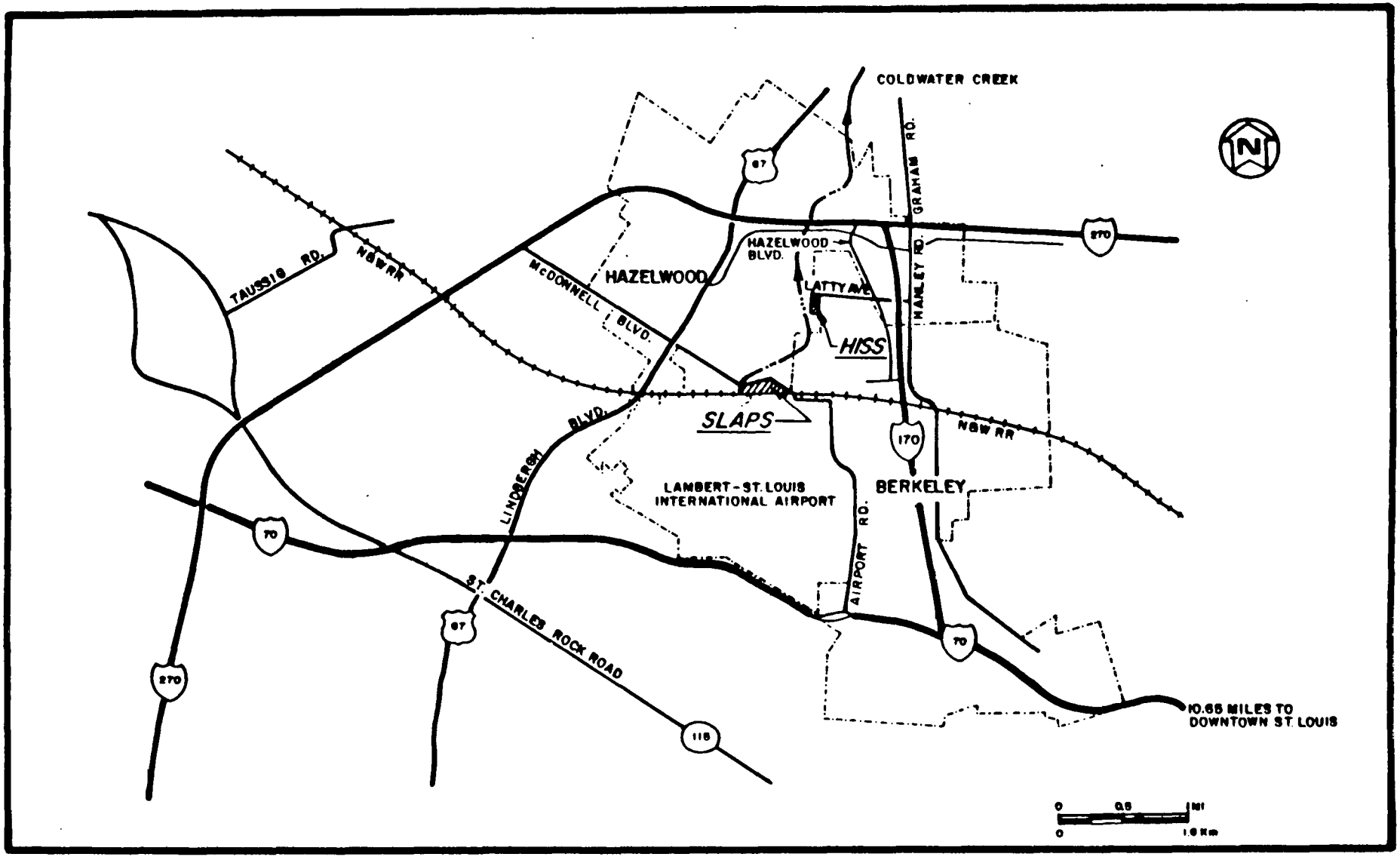


FIGURE 1-1 LOCATION OF THE HISS

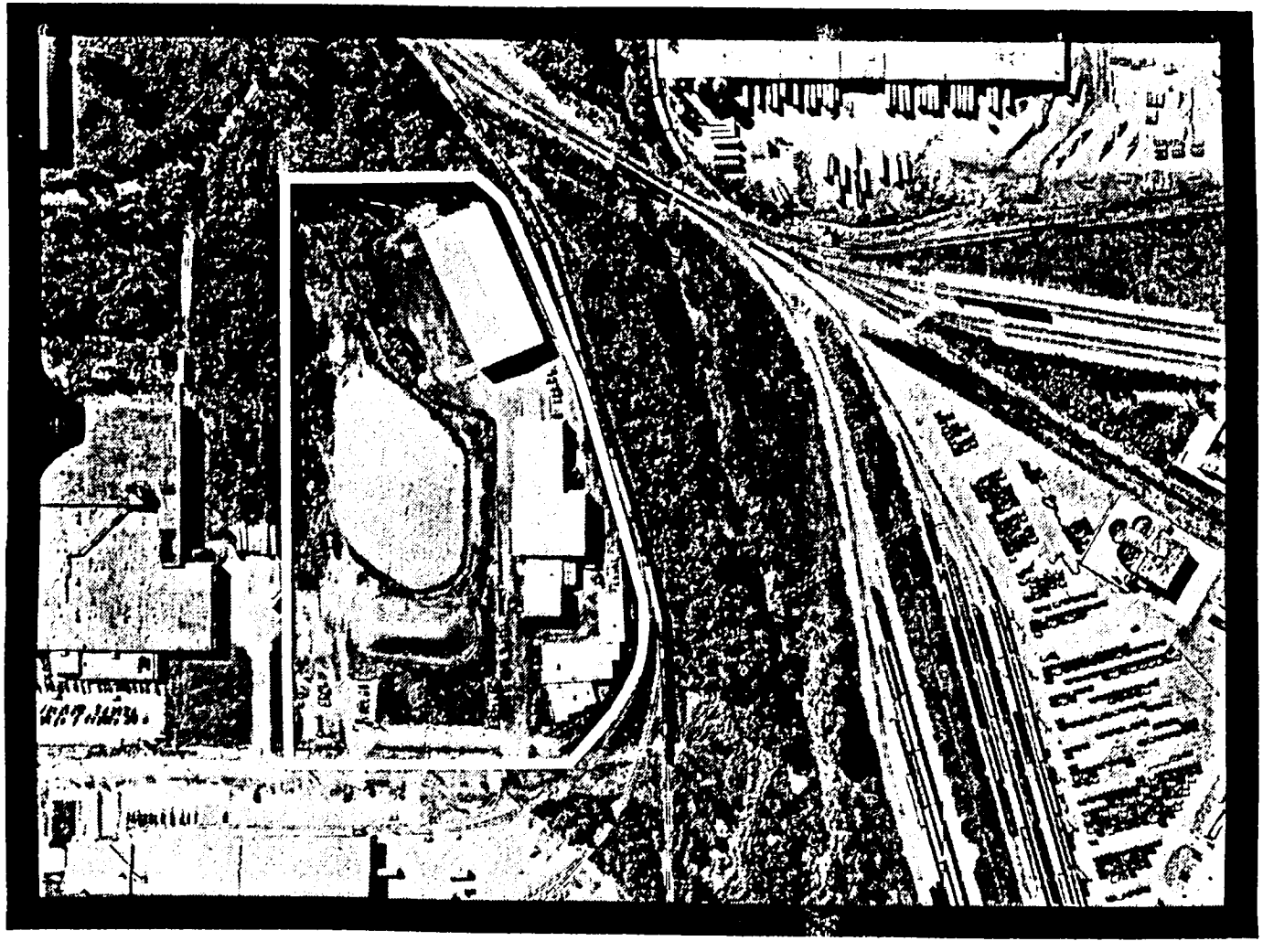


FIGURE 1-2 AERIAL VIEW OF HISS AND ITS VICINITY

runoff. Water flowing to the south leaves the site via two ditches, one located near the western boundary of the site, the other near the southeastern boundary. These ditches flow into an unnamed tributary before discharging into Coldwater Creek. The 100-yr flood elevation for the HISS is approximately 158.5 m (520 ft) above sea level (Ref. 2). Portions of the site are located in the 100-yr floodplain.

Groundwater in St. Louis County occurs in unconsolidated deposits and in bedrock aquifers. Groundwater flow in the vicinity of the site generally follows surface topography; thus, the direction of flow is toward Coldwater Creek (Ref. 1). In the area surrounding the HISS, water content of the subsoils is very high, but percolation rates are low. Treated water from the Mississippi River is used for municipal drinking water in this area (Ref. 3).

The average annual daily maximum temperature for the HISS area is 18.6°C (65.5°F), and the average daily minimum is 7.4°C (45.4°F). The highest average monthly temperature is 31.7° (89°F) (July) and the lowest is -6.7°C (19.9°F) (January). Average annual precipitation is 85 cm (34 in.), with an average annual snowfall of 65.8 cm (26.3 in.) (Ref. 4). As shown in Figure 1-3, prevailing winds in the vicinity of the HISS are primarily from the south during the summer and fall. Wind speeds during these months average 13.9 km/h (8.7 mph). Winds during the winter months were from the west and west-northwest, averaging 17.6 km/h (11 mph) (Refs. 4 and 5).

The residential areas nearest the site are approximately 0.5 km (0.3 mi) east in the City of Hazelwood. Residences in the City of Berkeley lie southeast of the site. In 1980, the populations of Berkeley and Hazelwood were 16,146 and 8,819, respectively (Ref. 6). There are no churches, schools, hospitals, municipal buildings, or other community facilities adjacent to the Hazelwood site or Latty Avenue.

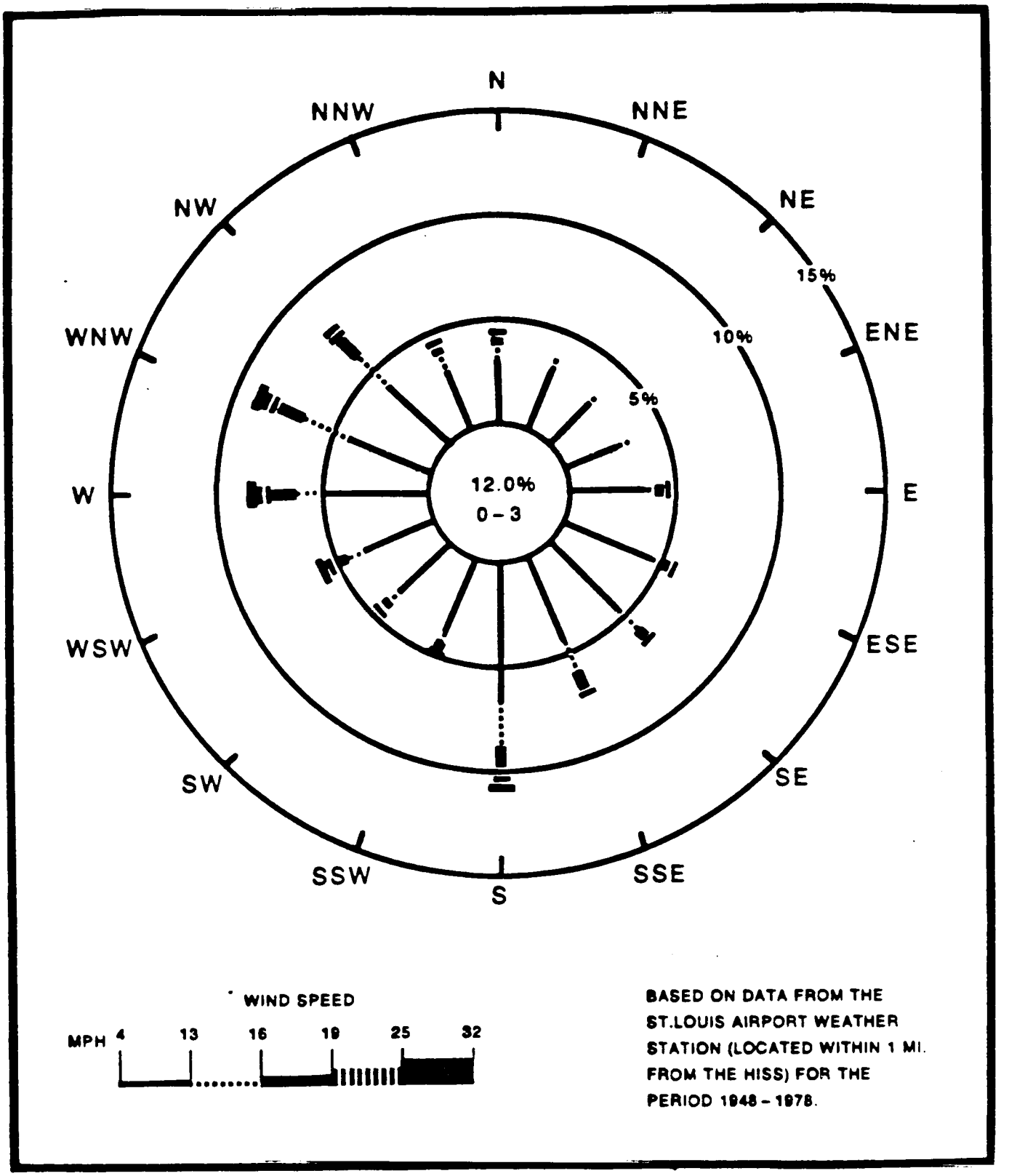


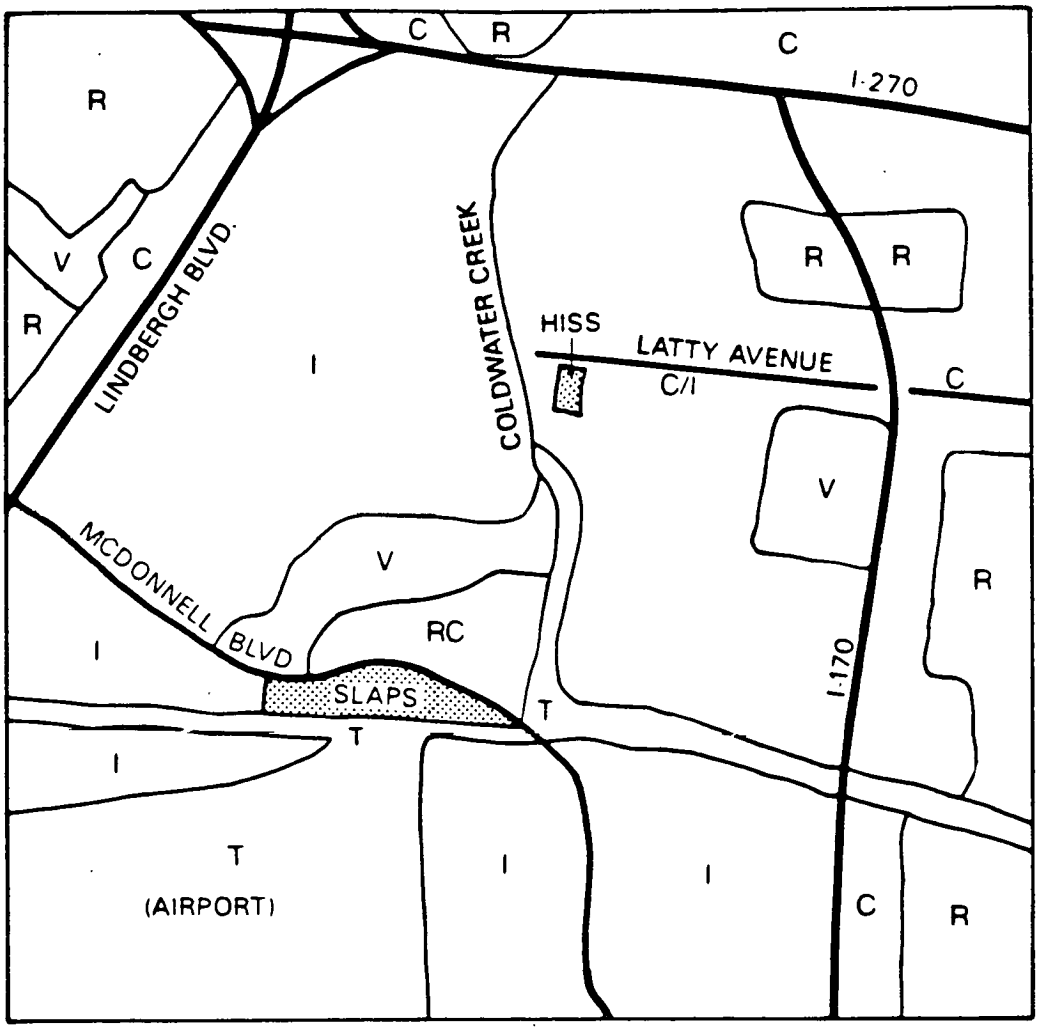
FIGURE 1-3 ANNUAL WIND ROSE FOR THE HISS

As shown in Figure 1-4, land use in the vicinity is predominantly industrial. Other land uses (in descending order of prevalence) are commercial, transportation-related, unused (vacant), and residential (Ref. 1).

1.2 SITE HISTORY

In early 1966, 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 residues and wastes were moved to a storage site on Latty Avenue. These wastes had been generated by a St. Louis plant from 1942 through the late 1950s under contracts with the Atomic Energy Commission (AEC) and its predecessor, the Manhattan Engineer District (MED). Residues on the site at that time included 74,000 tons of Belgian Congo pitchblende raffinate containing approximately 113 tons of uranium; 32,500 tons of Colorado raffinate containing roughly 48 tons of uranium; and 8,700 tons of leached barium sulfate containing about 7 tons of uranium. In January 1967, the Commercial Discount Corporation of Chicago, Illinois, purchased the residues. Much of the material was then dried and shipped to the Cotter Corporation facilities in Canon City, Colorado. The material remaining at the Latty Avenue site was sold to the Cotter Corporation in December 1969. From August through November 1970, Cotter Corporation dried some of the remaining residues at the site and shipped them to its mill in Canon City. In December 1970, an estimated 10,000 tons of Colorado raffinate and 8,700 tons of leached barium sulfate remained at the Latty Avenue Site.

In April 1974, the newly established Nuclear Regulatory Commission was informed by Cotter Corporation that the remaining Colorado raffinate had been shipped in mid-1973 to Canon City without drying and that the leached barium sulfate and 30 to 45 cm (12 to 18 in.) of topsoil had been removed and transported to a landfill area in St. Louis County.



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

R RESIDENTIAL	C/I MIXED COMMERCIAL AND INDUSTRIAL
C COMMERCIAL	V VACANT
T TRANSPORTATION	RC RECREATIONAL
I INDUSTRIAL	

0 0.5 MI
0 0.8 KM

N

FIGURE 1-4 GENERALIZED LAND USE IN THE VICINITY OF THE HISS

Before the present owner occupied the site, a radiological characterization was performed by the Oak Ridge National Laboratory (ORNL). Thorium and radium contamination in excess of DOE guidelines was found in and around the buildings, and in the soil to depths of up to 45 cm (18 in). Consequently, in preparing the property for use, the owner demolished one building, excavated portions of the western half of the property, and paved certain areas in addition to erecting several new buildings. The material excavated during these activities was piled on the eastern portion of the property.

In 1981, Oak Ridge Associated Universities (ORAU) characterized the pile and surveyed the northern and eastern boundaries of the property for radioactivity. Levels of contamination (principally thorium-230) similar to those on-site were found in both boundary areas. As a followup to this survey, ORNL conducted a detailed radiological survey of the north and south shoulders of Latty Avenue for DOE in January and February 1984. Results indicated that contamination in excess of DOE guidelines was present along the road almost all the way to Hazelwood Boulevard. Properties adjacent to the HISS were also found to be contaminated.

As part of the decontamination research and development project authorized by Congress under the 1984 Energy and Water Appropriations Act, BNI is conducting remedial action at the site and at vicinity properties. The remedial action project at the HISS is divided into two phases. Phase I began in FY 1984 with the radiological characterization and initial cleanup of Latty Avenue, and storage of the contaminated materials in the interim storage pile at the HISS. In addition, the area around the pile was cleared, a decontamination facility was constructed, environmental monitoring stations were installed, and a fence was installed around the HISS. During 1985 and 1986 cleanup along Latty Avenue continued, and additional contaminated material was stored in a supplementary pile at the HISS (Figure 1-2).

Phase I also includes characterization of the Futura Coatings site, the HISS itself, and vicinity properties along Latty Avenue. These activities began in 1986 and will be completed in 1987.

During Phase II, the contaminated soil at the Futura Coatings site, the HISS, and the vicinity properties will be removed to a permanent disposal site.

2.0 SUMMARY OF MONITORING RESULTS

During 1986, the environmental monitoring program at the HISS continued; air, water, and sediment samples were taken, and radon levels and external gamma radiation levels were monitored to verify compliance with the DOE radiation protection standard of 100 mrem/yr (Ref. 7). The potential radiation dose that might be received by the maximally exposed individual was calculated to determine the degree of compliance with the radiation protection standard.

Annual average radon concentrations ranged from 2×10^{-10} uCi/ml (0.2 pCi/l) to 1.8×10^{-9} uCi/ml (1.8 pCi/l), including background (Table 3-1). The background radon concentration in the vicinity of the HISS was 3×10^{-10} uCi/ml (0.3 pCi/l). Subsection 3.1 contains a discussion of radon concentrations at the HISS in 1986. There have been no significant trends in radon concentrations measured at the HISS since 1984 (see Subsection 3.6.1) (Refs. 8 and 9).

Annual average external radiation levels measured at the HISS in 1986 ranged from 15 to 179 mR/yr above background, which was 97 mR/yr (Table 3-2). External radiation levels are discussed in Subsection 3.2. Since 1984, external gamma radiation levels have decreased sharply at almost all monitoring locations (see Subsection 3.6.2) (Refs. 8 and 9).

In surface water (Subsection 3.3.1), concentrations of uranium, radium-226, and thorium-230 were at approximately background levels. Since 1984, concentrations of uranium in surface water have declined significantly. Concentrations of radium-226 and thorium-230 have remained basically stable (see Subsection 3.6.3) (Refs. 8 and 9).

In groundwater (Subsection 3.3.2), the highest annual average concentration of uranium was 3.3×10^{8} uCi/ml (33 pCi/l)

(Table 3-4). For radium-226, the highest annual average concentration was 7×10^{-10} uCi/ml (0.7 pCi/l). The highest annual average thorium-230 concentration was 2.6×10^{-9} uCi/ml (2.6 pCi/l). There have not been enough data collected to draw any conclusions regarding trends for radionuclide concentrations in groundwater at the HISS. However, there has been little change in such concentrations since 1985 (see Subsection 3.6.4) (Refs. 8 and 9).

Concentrations of radionuclides in surface water and groundwater may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D, Radiation in the Environment.

In stream sediments (Subsection 3.4) the highest concentration of total uranium was 8 pCi/g; the highest radium-226 concentration was 5.6 pCi/g; and the highest concentration of thorium-230 was 200 pCi/g (Table 3-5). The latter value is from a sample taken in an area of extensive excavation and is assumed to have been contaminated with excavated materials. These concentrations may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

Calculations were made of radiological doses received by the maximally exposed individual. Exposure to external gamma radiation was the exposure pathway quantified. This individual is one who, when all potential routes of exposure are considered, would receive the greatest dose. Exposure to external gamma radiation was the exposure pathway quantified. The highest annual average external gamma radiation level at the HISS boundary was 179 mR/yr above background. When occupancy is considered, this radiation level would result in an annual exposure to the maximally exposed individual of 2 mR/yr above background (Subsection 3.5.1). Since 1 mR is approximately equivalent to 1 mrem, this exposure is equivalent to 2 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than the exposure a person would receive during a round-trip flight from New York to Los Angeles (due

to greater amounts of cosmic radiation at higher altitudes). The cumulative dose to the population within an 80-km (50-mi) radius of the HISS that would result from radioactive materials present at the site would be indistinguishable from the dose that the same population would receive from naturally occurring sources.

Results of the 1986 monitoring show that the HISS is in compliance with the DOE radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of the 1986 environmental monitoring at the HISS (Ref. 10) and includes descriptions of the sampling, monitoring, and analytical procedures used. Calculations were made to determine the estimated possible maximum radiation dose based on environmental conditions, measurements recorded, and evaluation of potential exposure pathways.

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

During 1986, the routine environmental monitoring program for the HISS included radon gas monitoring, external gamma radiation measurements, surface water and sediment sampling, and groundwater sampling of monitoring wells within the site boundary (which is a fenced and posted area).

Trend tables are provided for radon, external gamma radiation levels, surface water, and groundwater. These tables list annual averages for each monitoring location for 1984, 1985, and 1986 to allow for comparisons of data and identification of trends in monitoring results (see Subsection 3.6).

3.1 RADON GAS SAMPLING

Radon gas detectors were maintained at 11 locations on the site and along the site boundary at the HISS, as shown in Figure 3-1. Two of these locations were added in August 1986. One location is maintained some distance off-site to measure the background level. Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions.

The radon gas monitors are Terradex Type-F Track-Etch detectors. Detectors are obtained from the Terradex Corporation, placed at the sampling locations, collected by site personnel on a quarterly exchange, and then returned to Terradex for analysis.

Table 3-1 reports the measured concentrations of radon gas in the air at the HISS. Annual average concentrations ranged from 2×10^{-10} to 1.8×10^{-9} uCi/ml (0.2 to 1.8 pCi/l), including background, which was 3×10^{-10} uCi/ml (0.3 pCi/l).

For a comparison of radon concentrations measured at the site from 1984 through 1986, see Subsection 3.6.1.

3.2 EXTERNAL GAMMA RADIATION LEVELS

External gamma radiation levels were measured at 11 locations, all of which correspond to radon (Terradex) detector Locations 1 through 11 shown in Figure 3-1. Detectors are located around the site boundary to ensure adequate measurement of external gamma radiation levels where the potential for exposure to members of the public is expected to be highest.

The external gamma radiation levels are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs), which are exchanged quarterly. Each dosimeter contains five TLD chips, the responses of which are averaged. Analysis is performed by Thermo Analytical/Eberline (TMA/E).

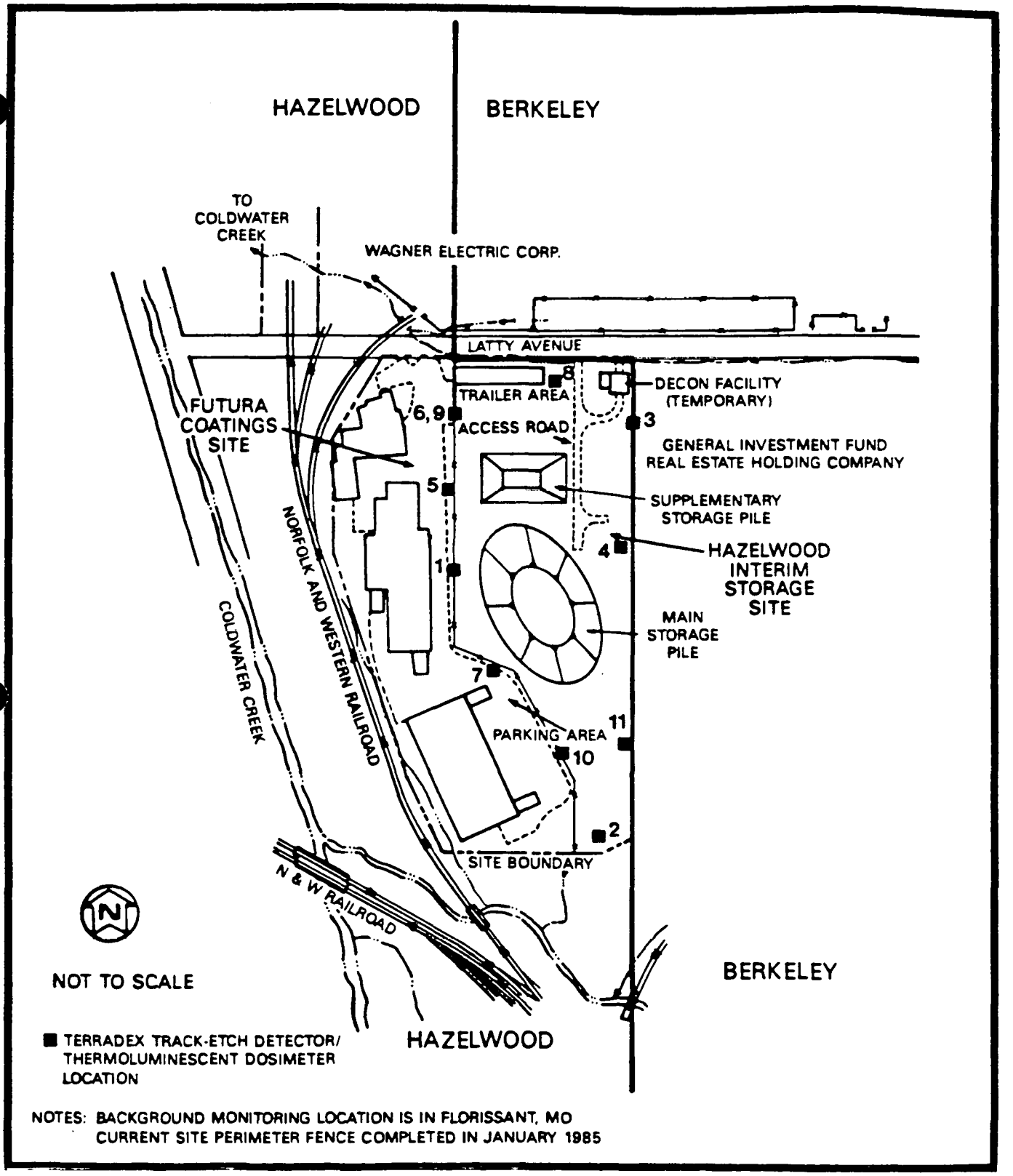


FIGURE 3-1 RADON AND EXTERNAL GAMMA RADIATION MONITORING LOCATIONS AT THE HISS

TABLE 3-1

CONCENTRATIONS OF RADON-222 AT THE HISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b,c] Minimum	Maximum	Average
1	4	0.3	2.5	0.9
2	4	0.2	1.3	0.8
3	4	0.2	0.3	0.3
4	4	0.3	3.4	1.3
5	4	0.1	1.8	0.6
6	4	0.3	1.1	0.6
7	4	0.3	3.2	1.1
8	4	0.2	0.3	0.2
9[d]	4	0.3	0.6	0.5
10	2[e]	0.1	0.2	0.2
11	2[e]	0.3	3.3	1.8
Background[f]	1[g]	0.3	0.3	-

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

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

[c]Background has not been subtracted.

[d]Location 9 is a quality control for Location 6.

[e]New station established in August 1986.

[f]Located in Florissant, MO.

[g]Detector was vandalized.

The results of external gamma monitoring are presented in Table 3-2. External radiation data for the first quarter of 1986 were invalidated because the dosimeters were exposed to radiation during shipment to the laboratory. The magnitude and nonuniformity of the exposure prevented a correction of the data. In the fourth quarter of 1986, procedures were implemented to reduce the probability of such in-transit exposures in the future.

The background external gamma radiation level for the HISS area (97 mR/yr) has been subtracted from the measured levels in Table 3-2 to provide an estimate of the effect of the site on levels measured at the site boundary. The highest annual average external gamma radiation level was 179 mR/yr at Location 6. Because the area adjacent to Location 6 is used as a parking lot, a 2-h/week occupancy factor is appropriate. On this basis, the external exposure to an individual working on this property would be 2 mR/yr. Because 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 2 percent of the DOE radiation protection standard of 100 mrem/yr.

To compare the 1986 external radiation levels reported in Table 3-2 with those measured in 1985 (Ref. 9), the 1986 values for minimum, maximum, and average should be divided by 4 since they are expressed as annual values, whereas the 1985 values were expressed as quarterly values.

For comparisons of external gamma radiation levels measured from 1984 to 1986, see Subsection 3.6.2.

3.3 WATER SAMPLING

During 1986, sampling was performed to determine the concentrations of uranium, radium-226, and thorium-230 in surface water in the vicinity of the HISS and in groundwater at the site. The six

TABLE 3-2

EXTERNAL GAMMA RADIATION LEVELS AT THE HISS, 1986

Sampling Location[a]	Number of Measurements[b]	Radiation Levels (mR/yr)[c,d]		
		Minimum	Maximum	Average
1	3	25	45	34
2	3	41	112	68
3	3	23	24	23
4	3	46	109	71
5	3	46	96	77
6	3	119	218	179
7	3	37	52	46
8	3	11	25	17
9[e]	3	115	172	151
10	2[f]	19	23	21
11	2[f]	10	19	15
Background[g]	1[h]	97	97	-

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

[b]First quarter data invalidated by in-transit exposure.

[c]Background has been subtracted.

[d]Divide by 4 to compare with 1985 mrem/quarter values.

[e]Location 9 is a quality control for Location 6.

[f]New station established in August 1986.

[g]Located in Florissant, MO.

[h]Detectors were vandalized.

surface water sampling locations and seven groundwater sampling locations are shown in Figure 3-2.

3.3.1 Surface Water

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 both upstream to establish background conditions and downstream to determine the effect of runoff from the site on surface waters in the vicinity. Sampling Locations 1 and 2 were on a surface stream but were removed during July 1986 during installation of a subsurface sewer system.

Nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container. Samples were analyzed by TMA/E. The concentration of total uranium was determined by a fluorometric method. Radium-226 concentrations in water were determined by radon emanation. This method consists of precipitating radium as the sulfate and transferring the treated sulfate to a radon bubbler, wherein radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 gas is then withdrawn into a scintillation cell and counted using 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. Thorium-230 was eluted in solution, electrodeposited on stainless steel discs, and counted by alpha spectrometry.

The results of analyses of surface water samples are presented in Table 3-3. Average total uranium, radium-226, and thorium-230 concentrations did not vary significantly from background. These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D.

For comparisons of radionuclide concentrations measured in surface water from 1984 through 1986, see Subsection 3.6.3.

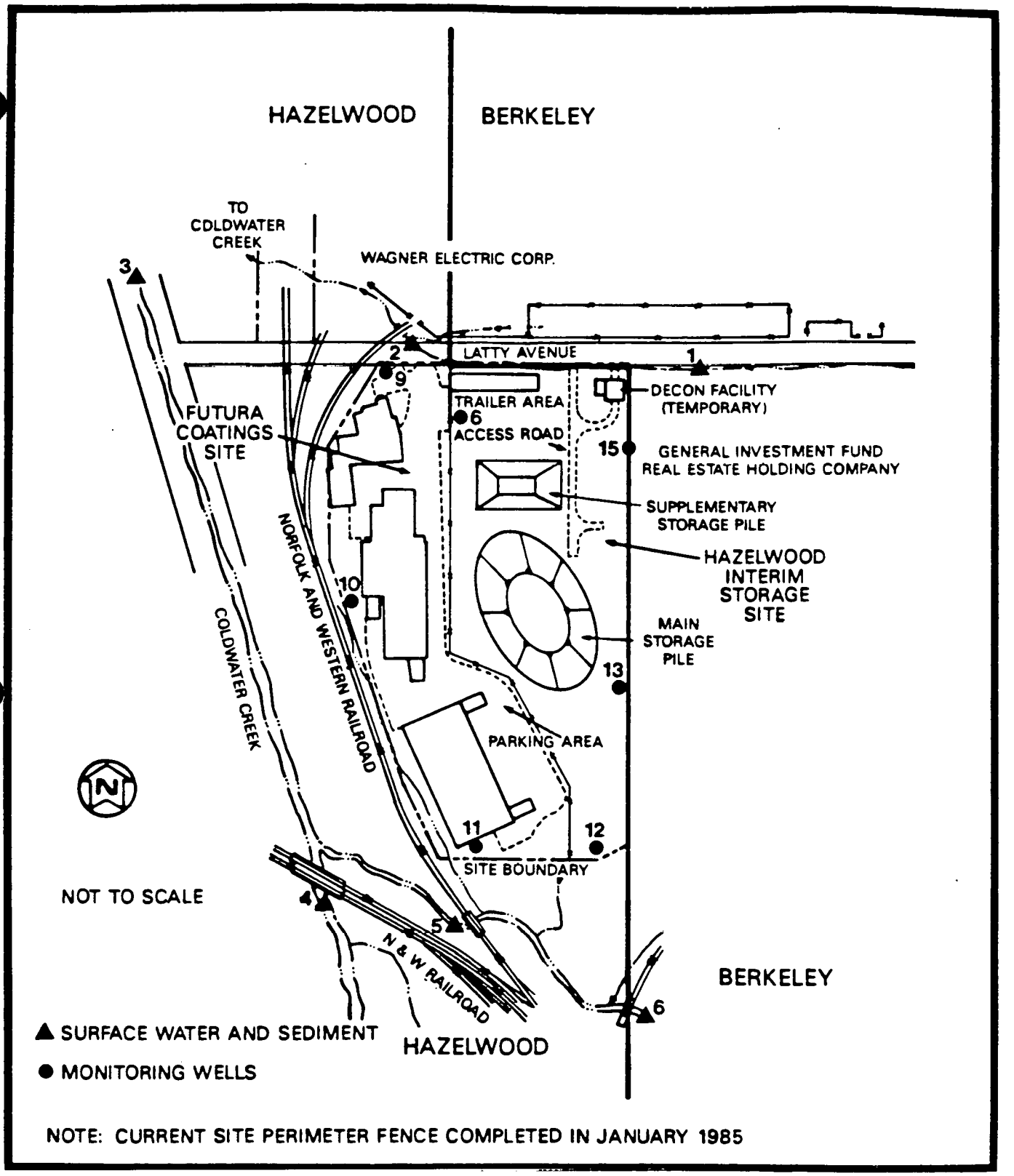


FIGURE 3-2 SURFACE WATER, GROUNDWATER, AND SEDIMENT SAMPLING LOCATIONS AT THE HISS

TABLE 3-3

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF THE HISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b] Minimum	Maximum	Average[c]
Total Uranium				
1[d]	1	<3.0	<3.0	<3.0
2[d]	1	<3.0	<3.0	<3.0
3	4	<3.0	5.0	4.0
4	4	<3.0	6.0	4.0
5	4	<3.0	<3.0	<3.0
6	4	<3.0	<3.0	<3.0
Radium-226				
1[d]	1	0.3	0.3	-
2[d]	1	0.1	0.1	-
3	4	0.2	0.4	0.3
4	4	0.1	0.5	0.3
5	4	0.1	0.3	0.2
6	4	0.1	0.2	0.2
Thorium-230				
1[d]	1	0.2	0.2	-
2[d]	1	<0.1	<0.1	<0.1
3	4	<0.2	0.7	0.4
4	4	0.1	<0.4	0.2
5	4	0.1	1.0	0.4
6	4	0.1	0.4	0.2

[a]Locations shown in Figure 3-2; Locations 1, 4, and 6 are background.

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

[c]Where values are less than the limit of sensitivity of the analytical method, values are considered as being equal to the limit of sensitivity, and the average value is reported without the notation "less than."

[d]Location no longer exists because surface drainage was routed through a new sewer system installed in July 1986.

3.3.2 Groundwater

During 1986, groundwater samples were collected quarterly from seven monitoring wells established along the perimeter of the property on the basis of available geohydrological data. After the wells had been bailed dry or two casing volumes had been removed, nominal 1-liter (0.26-gal) grab samples were collected to fill a 4-liter (1-gal) container. Samples were analyzed by TMA/E for total uranium, dissolved radium-226, and dissolved thorium-230 using the methods applied to surface water analyses.

Results of the analyses of groundwater samples are presented in Table 3-4. The highest annual average total uranium concentration was 3.3×10^{-8} uCi/ml (33 pCi/l). The highest annual average radium concentration was 7×10^{-10} uCi/ml (0.7 pCi/l), and the highest annual average thorium concentration was 2.6×10^{-9} uCi/ml (2.6 pCi/l). These values may be compared with the levels of radioactivity in the commonly consumed liquids listed in Appendix D. For a discussion of the comparison of groundwater radionuclide concentrations measured in 1985 and 1986, see Subsection 3.6.4.

3.4 SEDIMENT SAMPLING

Sediment samples that consisted of composites weighing approximately 500 g (1.1 lb) were collected quarterly at surface water sampling locations where sediment is present. The bases for selection of the individual sampling locations are given in Subsection 3.3.1.

TMA/E analyzed the samples for uranium, radium-226, and thorium-230. The uranium concentration was calculated by summing the analysis results for isotopic uranium. Isotopic uranium and thorium-230 were determined by alpha spectrometry, where the uranium and thorium-230 are leached, extracted, and electroplated on metal substrates. Radium-226 concentrations were determined by radon emanation (described earlier).

TABLE 3-4

CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT THE HISS, 1986

Sampling Location[a]	Number of Samples	Concentration (10^{-9} uCi/ml)[b] Minimum	Maximum	Average[c]
Total Uranium				
6	4	17	45	33
9	3[d]	<3	<3	<3
10	4	4	7	6
11	4	4	5	5
12	4	<3	5	4
13	4	5	10	8
15	4	<3	8	5
Radium-226				
6	4	0.2	1.3	0.7
9	3[d]	0.1	0.3	0.2
10	4	<0.07	0.2	0.1
11	4	0.1	1.0	0.4
12	4	0.3	0.7	0.4
13	4	0.1	0.7	0.3
15	4	<0.1	0.7	0.4
Thorium-230				
6	4	0.2	8.0	2.6
9	3[d]	<0.1	1.4	0.6
10	4	0.1	1.9	0.7
11	4	0.3	4.2	1.3
12	4	<0.1	5.6	2.0
13	4	<0.1	2.9	1.0
15	4	0.1	2.9	1.3

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

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

[c]Where values are less than the limit of sensitivity of the analytical method, values are considered as being equal to the limit of sensitivity, and the average value is reported without the notation "less than."

[d]Well covered by fill rock in December 1986.

Results of the analyses, based on dry weight, are presented in Table 3-5. Average annual uranium concentrations ranged from 1.6 to 8 pCi/g, while radium-226 concentrations ranged from 0.8 to 5.6 pCi/g. Average annual thorium-230 concentrations ranged from 6.0 to 200 pCi/g. The latter value is from a sample taken in an area of extensive excavation and is assumed to have been contaminated with excavated materials. These values may be compared with the levels of radioactivity in phosphate fertilizers listed in Appendix D.

Sediment sampling at the HISS was limited because of the road and sewer pipe construction activities adjacent to the site and the dry weather experienced in the St. Louis area in 1986. By October 1986, construction activities had eliminated the ditches in which two sampling locations had been located. At the remaining locations, lack of runoff water prevented sampling of sediments in all but three cases.

3.5 RADIATION DOSE

To assess the health effects of the radioactive materials stored at the HISS, radiological exposure pathways were evaluated to calculate the dose to the maximally exposed individual. This individual is one who is assumed to be adjacent to the site and who, when all potential routes of exposure are considered, would receive the greatest dose. An appraisal of potential pathways (ingestion of water, exposure to external gamma radiation, and inhalation of radon) suggested that exposure to external gamma radiation was the principal exposure mode.

The dose from ingesting groundwater or surface water from sources on the HISS property was not calculated because it was considered unrealistic to assume that ingestion of this water could occur. The HISS is fenced and locked, and security is well maintained, and a member of the public could only consume water on the site by trespassing on the property every day to gain access to the water.

TABLE 3-5

CONCENTRATIONS OF RADIUM-226, THORIUM-230, AND URANIUM IN SEDIMENT IN THE VICINITY OF THE HISS, 1986

Sampling Location[a]	Number of Samples	Concentration [pCi/g (dry)] Minimum	Maximum	Average
Radium-226				
1	2[b]	0.1	1.5	0.8
2	1[c]	5.6	5.6	5.6
Thorium-230				
1	2[b]	5.2	6.7	6.0
2	1[c]	200.0	200.0	200.0
Uranium-234				
1	2[b]	0.7	0.8	0.8
2	1[c]	2.4	2.4	2.4
Uranium-235				
1	2[b]	0.03	0.04	0.04
2	1[c]	0.08	0.08	0.08
Uranium-238				
1	2[b]	0.8	0.8	0.8
2	1[c]	5.6	5.6	5.6
Total Uranium				
1	2[b]	1.5	1.6	1.6
2	1[c]	8.0	8.0	8.0

[a]Sampling locations shown in Figure 3-2. Location 1 is upstream of the site and is a background location.

[b]No sediment at sampling location in the third and fourth quarters; construction activity destroyed sampling location.

[c]No sediment at sampling location in the first, third, and fourth quarters due to lack of runoff (first quarter) and loss of sampling locations to construction activity. Single sample taken after extensive excavation near the sampling location.

To consume groundwater from a well at the site, the trespasser would also have to be equipped with a means of removing the well cap, a power source, a pump, and a hose.

Most of the annual average radon concentrations measured at the boundary of the HISS were within the normal variation associated with background measurements for this area. Given the amount of time that the maximally exposed individual would spend near the higher-than-background locations, the dose from radon would be indistinguishable from the dose received from background. Consequently, this pathway would not contribute additional dose to the maximally exposed individual.

3.5.1 Dose to Maximally Exposed Individual

To identify the individual in the vicinity of the HISS who would receive the highest dose from on-site radioactive materials, the dose from exposure to external gamma radiation was calculated at various monitoring locations that could be accessible by the public. This dose was then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points. For the properties surrounding the HISS, the highest overall dose would be received by an individual west of the site. Since this is a commercial area parking lot, the calculation dose was based on an estimated 2-h/week exposure period. (Exposure to workers in nearby commercial buildings would be negligible due to the distance of the buildings from the site perimeter and the attenuation provided by the building walls.)

The average exposure rate above background was 179 mR/yr, as measured at monitoring Location 6 (Figure 3-1). Exposure at this rate for 2 h/week would result in an annual exposure to the total body of approximately 2 mR. Since 1 mR is approximately equivalent to 1 mrem, this exposure is approximately equivalent to 2 percent of the DOE radiation protection standard of 100 mrem/yr. This exposure is less than the exposure a person would receive during a round-trip

flight from New York to Los Angeles (due to greater amounts of cosmic radiation at higher altitudes).

3.5.2 Dose to the Population in the Vicinity of the HISS

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

The contribution to the population dose made by gamma radiation from the radioactive materials present on-site is too small to be measured, since gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma exposure rate at a distance of 0.9 m (3 ft) from a small-area radioactive source were 100 mR/yr, the exposure rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon gas is known to dissipate rapidly as distance from the radon source increases (Ref. 11). Therefore, exposure from the low radon concentrations at the HISS does not contribute significantly to population dose.

On the basis of radionuclide concentrations measured in water leaving the HISS, it also appears that there is no predictable pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels. Since the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within an 80-km (50-mi) radius of the HISS that would result from radioactive

materials present at the site would be indistinguishable from the dose that the same population would receive from naturally occurring radioactive sources.

3.6 TRENDS

The environmental monitoring program at the HISS has been established to allow an annual assessment of the environmental conditions at the site, provide a historical record for comparisons from year to year, and permit detection of trends over time. In the following subsections, 1986 annual averages for each monitoring location for radon, external gamma radiation, surface water, and groundwater are compared with results for 1984 and 1985. As the environmental monitoring program continues at the HISS and more data are collected, comparisons and analyses of trends will become more valid.

3.6.1 Radon

As shown in Table 3-6, there have been no significant trends in radon concentrations at the HISS since 1984. Though concentrations at several sampling locations showed increases over 1985 concentrations, these can be attributed to construction and remedial action activities. Such increases are temporary and will decrease once remedial action is complete. Overall, radon concentrations have remained basically stable, with some monitoring locations showing slight increases and other locations exhibiting slight decreases.

3.6.2 External Gamma Radiation Levels

As shown in Table 3-7, external gamma radiation levels measured at the HISS have declined sharply since 1984 at all monitoring locations except Location 9, at which levels increased from 1984 to 1985 and decreased in 1986. This overall decline reflects the progress of remedial action at the site. The monitoring locations

TABLE 3-6

ANNUAL AVERAGE CONCENTRATIONS OF RADON-222 AT THE HISS, 1984-1986*

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b,c] 1984[d]	1985	1986
1	2.2	0.3	0.9
2	0.6	0.5	0.8
3	0.3	0.4	0.3
4	0.8	0.5	1.3
5	0.4	0.4	0.6
6	0.4	0.7	0.6
7	0.5	0.4	1.1
8	2.0	0.3	0.2
9	0.4	0.5	0.5
10[e]	-[e]	-[e]	0.2
11[e]	-[e]	-[e]	1.8
Background	-[f]	0.5	0.3

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

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

[c]Background has not been subtracted.

[d]Monitoring program began in September 1984, and 1984 data are for approximately one quarter only.

[e]Sampling locations established in August 1986.

[f]Background monitoring location established in 1985.

*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 8 and 9). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

TABLE 3-7

ANNUAL AVERAGE EXTERNAL GAMMA RADIATION LEVELS AT THE HISS, 1984-1986*

Sampling Location[a]	Radiation Levels (mR/yr)[b] 1984[c]	1985	1986
1	501	58	34
2	328	87	68
3	219	25	23
4	1062	83	71
5	466	141	77
6	1106	287	179
7	613	89	46
8	307	7	17
9	202	261	151
10[d]	-[d]	-[d]	21
11[d]	-[d]	-[d]	15
Background	-[e]	99	97

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

[b]Background has been subtracted.

[c]Monitoring program began in September 1984, and 1984 data are for approximately one quarter only.

[d]Sampling locations established in August 1986.

[e]Background monitoring location established in 1985.

*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 8 and 9). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

at which external gamma radiation levels are still relatively high, Locations 6 and 9 (Location 9 is a quality control for Location 6 -- both are located at the same position on the site), are adjacent to an area that is known to be contaminated and for which remedial action is scheduled.

3.6.3 Surface Water

As shown in Table 3-8, concentrations of uranium in surface water in the vicinity of the HISS have declined dramatically since 1984. This decline reflects the effects of remedial action at the HISS since 1984. Concentrations of radium-226 have remained almost unchanged over the 3-year period. Thorium-230 concentrations at Location 2 have declined sharply since 1984. Other sampling locations show declines in thorium-230 concentrations from 1985 to 1986, but overall, thorium-230 concentrations have been relatively stable over the 3-year monitoring period.

3.6.4 Groundwater

Due to remedial action at the HISS, almost all wells monitored at the site during 1984 were removed, and new monitoring wells were established in 1985. Therefore, Table 3-9 reports data for 1985 and 1986 only, and any meaningful trend analysis is not possible. The table does show a significant decline in the concentrations of uranium in Wells 6 and 9, but comparisons of the other radionuclides at these and other wells show no significant changes. As more data are collected, trends may become more apparent.

TABLE 3-8

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN SURFACE WATER IN THE VICINITY OF THE HISS, 1984-1986*

Sampling Location[a]	Concentration (10^{-9} uCi/ml)[b] 1984	1985	1986
Total Uranium			
1[c]	67.0	<3.0	<3.0
2[c]	69.0	<3.0	<3.0
3	97.0	4.3	4.0
4	116.0	4.3	4.0
5	67.0	<3.0	<3.0
6	69.0	<3.0	<3.0
Radium-226			
1[c]	0.3	0.1	0.3
2[c]	0.3	0.1	0.1
3	0.1	0.1	0.3
4	0.1	0.2	0.3
5	0.2	0.1	0.2
6	0.2	0.2	0.2
Thorium-230			
1[c]	0.2	0.1	0.2
2[c]	15.4	0.4	<0.1
3	0.4	3.3	0.4
4	0.5	0.2	0.2
5	0.5	0.2	0.4
6	0.5	2.9	0.2

[a]Locations shown in Figure 3-2.

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

[c]Location no longer exists because surface drainage was routed through a new sewer system installed in July 1986.

*Sources for 1984 and 1985 data are the Annual Site Environmental Reports for the two years (Refs. 8 and 9). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

TABLE 3-9

ANNUAL AVERAGE CONCENTRATIONS OF TOTAL URANIUM, RADIUM-226, AND THORIUM-230 IN GROUNDWATER AT THE HISS, 1985-1986*

Sampling Location[a]	Concentration (10-9 uCi/ml)[b] 1985	1986
Total Uranium		
6	71.6	33
9	25.6	<3
10	3.1	6
11	<3.0	5
12	<3.0	4
13	<3.0	8
15	<3.0	5
Radium-226		
6	0.8	0.7
9	0.4	0.2
10	0.2	0.1
11	0.3	0.4
12	0.4	0.4
13	0.1	0.3
15	0.3	0.4
Thorium-230		
6	5.5	2.6
9	0.2	0.6
10	0.2	0.7
11	0.9	1.3
12	0.4	2.0
13	0.3	1.0
15	0.5	1.3

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

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

*Source for 1985 data is the Annual Site Environmental Report for that year (Ref. 9). In some cases, previous years' data have been reported in different units of measurement. For ease of comparison, all data in trend tables are reported in the units used in the 1986 report. Applicable conversion factors are listed in Appendix B of this report.

4.0 RELATED ACTIVITIES AND SPECIAL STUDIES

4.1 RELATED ACTIVITIES

Several areas of residual contamination along Latty Avenue were cleaned up during 1986, after which the Cities of Berkeley and Hazelwood began work on improvements to the sewer line, the water line, and the road at the western end of Latty Avenue. Additional cleanup was performed to remove contaminated soil found before and during installation of the new sewer and water pipes. The excavated areas were subsequently backfilled, and the contaminated material was placed in the supplementary storage pile at the HISS (Figure 1-2). Characterization of the Futura Coatings buildings and of the HISS began late in 1986.

4.2 SPECIAL STUDIES

No special studies were undertaken at the HISS during 1986.

REFERENCES

1. Ford, Bacon and Davis Utah, Inc. Engineering Evaluation of the Latty Avenue Site, Hazelwood, Missouri (Draft), FB&DU UC-225, Salt Lake City, UT, January 1978.

2. Zerega, J.J., United States Army Corps of Engineers, St. Louis District, personal communication with J. Englick, Bechtel National, Inc., Oak Ridge Office, March 12, 1984.

3. Emmett, L.F., United States Geological Survey, personal communication with S. Liedle, Bechtel National, Inc., Oak Ridge Office, April 29, 1984.

4. Gale Research Company. Climates of the States, 3rd Edition, Vol. 1, Detroit, MI, 1985.

5. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Wind - Ceiling - Visibility Data at Selected Airports, Interagency Agreement DOT-FA79WAI-057, National Climatic Data Center, Asheville, NC, January 1981.

6. U.S. Department of Commerce, Bureau of the Census. 1980 Census of Population and Housing, PH C80-V-27, Final Population and Housing Counts, Missouri, Washington, DC, 1982.

7. Memorandum, R.J. Stern, Department of Energy, to Distribution. "Preparation of Annual Site Environmental Reports for Calendar Year 1985" (Attachment: DOE-Derived Concentration Guides for Drinking Water and Breathing Air Contaminated With Radionuclides by Members of the Public), February 28, 1986.

8. Bechtel National, Inc. Hazelwood Interim Storage Site Environmental Monitoring Summary Calendar Year 1984, DOE/OR/20722-57, Oak Ridge, TN, July 1985.

9. Bechtel National, Inc. Hazelwood Interim Storage Site Annual Site Environmental Report Calendar Year 1985, DOE/OR/20722-99, Rev. 1, Oak Ridge, TN, November 1986.

10. Memorandum, R. W. Evers, Bechtel National, Inc., to File. "Environmental Monitoring Program - 1986 Environmental Data," CCN 043490, March 4, 1987.

11. Bechtel National, Inc. Niagara Falls Storage Site Environmental Monitoring Report Calendar Year 1984, DOE/OR/20722-55, Oak Ridge, TN, July 1985.

APPENDIX A
QUALITY ASSURANCE

APPENDIX A
QUALITY ASSURANCE

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

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

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

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the Department of Energy, the Nuclear Regulatory Commission, and the EPA.

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

APPENDIX B
ENVIRONMENTAL STANDARDS

APPENDIX B
ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard is 100 mrem/yr (Ref. 7). 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 represents actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions will result in calculated doses that more accurately reflect the exposure potential from site activities.

TABLE B-1

CONVERSION FACTORS

1 yr	=	8760 h
1 liter	=	1000 ml
1 mR	$\cong$	1 mrem
1 mrem	$\cong$	1000 uR
1 mrem/yr	$\cong$	8.7 uR/h (assuming 8760 hours of exposure per year)
1 uCi	=	1,000,000 pCi
1 pCi	=	0.000001 uCi
1 pCi/l	=	10^{-9} uCi/ml
1 pCi/l	=	0.000000001 uCi/ml
1 uCi/ml	=	1,000,000,000 pCi/l
10^{-6}	=	0.000001
10^{-7}	=	0.0000001
10^{-8}	=	0.00000001
10^{-9}	=	0.000000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

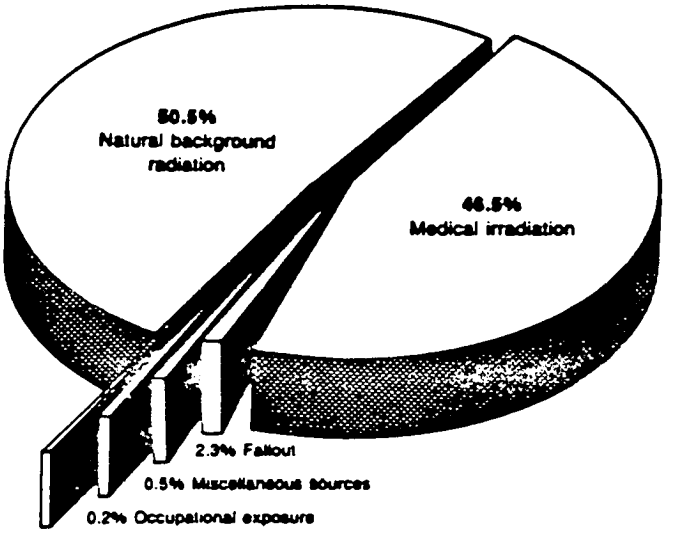
APPENDIX C
ABBREVIATIONS

APPENDIX C
ABBREVIATIONS

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

APPENDIX D
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.



Source: National Academy of Sciences, 1980; National Council of Radiation Protection and Measurement

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.

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

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 only move through the air 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 may 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 wall 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.

References

Effect of Ionizing Radiation on Human Health, The. Arthur C. Upton. New York University Medical Center. Atomic Industrial Forum, 1984.

Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Committee on the Biological Effects of Ionizing Radiations. National Academy Press, 1984.

Radiation Exposure from Consumer Products and Miscellaneous Sources: Report Number 56. National Council on Radiation Protection and Measurements, 1977.

Radiation in Medicine and Industry. A.P. Jacobson and G.P. Sakolosky, 1980.

Radioactivity in Consumer Products. U.S. Nuclear Regulatory Commission, 1978.

Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either the total amount of radioactivity present in a substance, or 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 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. Quantities 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, or mrem (one-thousandth of a rem) range. On the average, people receive about 180 mrem of radiation a year. Most of this radiation is from natural radiation and medical exposure.

RADIATION IN THE ENVIRONMENT

Cosmic Radiation

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

Sea Level (add one for each additional 100 feet in elevation)	26 mrem/year
Atlanta, GA (1,050 feet)	37 mrem/year
Denver, CO (5,300 feet)	79 mrem/year
Minneapolis, MN (815 feet)	34 mrem/year
Salt Lake City, UT (4,400 feet)	70 mrem/year
Spokane, WA (1,890 feet)	45 mrem/year

Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as thorium, radium, uranium, and carbon.

United States (average)	26 mrem/year
Denver, Colorado	90 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

Based on occupancy 75 percent of the time.

Wood House	35 mrem/year
Brick House	45 mrem/year
Concrete House	45 mrem/year
Stone House	50 mrem/year

Specific Buildings

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.

Typical Radon Level	1.5 pCi/liter
Occupational Working Limit	100.0 pCi/liter

The numbers given here are approximate or represent an average since samples vary.

mrem = millirem

pCi = picocurie

Foods

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

Beer	390 pCi/liter
Domestic 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
Flour	0.14 pCi/g
Peanuts and 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	20 mrem
Dental X Ray, Whole Mouth	900 mrem

International Nuclear Weapons Test Fallout

Average for a U.S. citizen	1 mrem/year

Consumer Goods

Cigarettes (2 packs/day) (Polonium-210)	8,000 mrem/year
Color Television	1 mrem/year
Gas Lantern Mantle (thorium-232)	3 mrem/hour
Highways	4 mrem/year
Jet Airplane Travel/1,500 miles (cosmic)	1 mrem
Natural Gas Stove (radon-222)	6-9 mrem/year
Phosphate Fertilizers*	4 mrem/year
Porcelain Dentures (uranium salts)	1,500 mrem/year
Radioluminescent Clock (radium-226)	9 mrem/year
Smoke Detector (americium-241)	0.2 mrem/year

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

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

APPENDIX E
DISTRIBUTION LIST FOR HAZELWOOD INTERIM STORAGE SITE ANNUAL SITE ENVIRONMENTAL REPORT

APPENDIX E

DISTRIBUTION LIST FOR HAZELWOOD INTERIM STORAGE SITE ANNUAL SITE ENVIRONMENTAL REPORT

Media:

City Editor
GLOBE-DEMOCRAT
1710 North Tucker Boulevard
St. Louis, Missouri 63101

Editor
RIVER FRONT TIMES
1915 Park
St. Louis, Missouri 63104

Environmental Editor
ST. LOUIS POST-DISPATCH
1710 North Tucker Boulevard
St. Louis, Missouri 63101

News Editor
Suburban St. Louis Newspaper Group
7020 Chippewa Street
St. Louis, Missouri 63119

ASSOCIATED PRESS
1710 North Tucker Boulevard
St. Louis, Missouri 63101

UNITED PRESS INTERNATIONAL
900 North Tucker Boulevard, 2nd Floor
St. Louis, Missouri 63101

News Director
KDNL-TV
1215 Cole Street
St. Louis, Missouri 63106

News Director
KETC-TV
6996 Milbrook Boulevard
St. Louis, Missouri 63130

News Director
KMOX-TV
One Memorial Drive
St. Louis, Missouri 63102

News Director
KPLR-TV
4935 Lindell
St. Louis, Missouri 63108

News Director
KSDK-TV
1111 Olive Street
St. Louis, Missouri 63105

News Director
KTVI-TV
5915 Berthold Avenue
St. Louis, Missouri 63110

News Director
Radio Station KMOX
One Memorial Drive
St. Louis, Missouri 63102

News Director
Radio Station KEZK
7711 Carondelet Avenue
St. Louis, Missouri 63105

News Director
Radio Station WIL
300 North Tucker Boulevard
St. Louis, Missouri 63101

Federal:

Mr. Morris Kay, Administrator (5 Copies)
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Mr. Robert Morby, Superfund Section
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Missouri 66101

Mr. George DeBuchannanne, Chief
Office of Radiohydrology
U.S. Department of Interior
Geological Survey, MS 140
Reston, Virginia 22000

Mr. William Crow
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Springs, Maryland 20910

Mr. James Zeregia
U.S. Army Corps of Engineers
210 North Tucker Boulevard
St. Louis, Missouri 63101-1986

State:

Dr. Fred Brunner, Director
State of Missouri
Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dr. David Bedan (5 Copies)
State of Missouri
Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Mr. John R. Crellin, Director
Bureau of Environmental Epidemiology
Division of Health
State of Missouri
Department of Social Services
Post Office Box 570
Jefferson City, Missouri 65102

Mr. D. R. Dodson
Division of Health
State of Missouri
Department of Social Services
1511 Locust Street, Third Floor
St. Louis, Missouri 63103

Local:

Honorable Douglas Palmer
Mayor, City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Mr. Ed Carlstom
City Manager
City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Mr. Jose Hernandez
Division of Public Works
City of Hazelwood
415 Elm Grove
Hazelwood, Missouri 63042

Ms. Dian Sharma
Health Commissioner
City of St. Louis
Department of Health and Hospitals
Division of Health
P.O. Box 14702
St. Louis, Missouri 63178-4702

Honorable Jack Quigle
Mayor, City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Mr. Larry Birkla
City Manager
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Mr. Vijay K. Bhasin, P.E., Director
Division of Public Works
City of Berkeley
6140 North Hanley Road
Berkeley, Missouri 63134

Honorable Vincent C. Schoemehl
Mayor, City of St. Louis
Tucker and Market Streets
St. Louis, Missouri 63103

Mr. Robert H. Dierker, Jr.
Assistant City Counselor
City of St. Louis
314 City Hall
St. Louis, Missouri 63103

Honorable Robert Feigenbaum
Redacted - Privacy Act

Mr. Leonard L. Griggs, Jr.
Director of Airports
Lambert-St. Louis International Airport
Post Office Box 10036
St. Louis, Missouri 63145

Mr. Gene McNary
County Executive
County Government Center
Clayton, Missouri 63105

Honorable E. W. Abram
Mayor, City of Bridgeton
11955 Natural Bridge Road
Bridgeton, Missouri 63044

Mr. John Spell
Administrative Chief
Industrial Hygiene Section
Department of Community Health and Medical Care
801 S. Brentwood Boulevard
Clayton, Missouri 63105

Mr. David A. Visintainer
City of St. Louis, Water Division
Chain of Rocks Plant
10450 Riverview Drive
St. Louis, Missouri 63137

Congressional:

Honorable Christopher S. Bond
U.S. Senate
321 Hart Senate Office Building
Washington, DC 20510

Honorable John C. Danforth
U.S. Senate
497 Russell Senate Office Building
Washington, DC 20510

Ms. Clair Elsberry
Senator Danforth's Office
1223 Jefferson Street
Jefferson City, Missouri 65101

Mr. Rod McDonald
Senator Danforth's Office
815 Olive Street, Room 228
St. Louis, Missouri 63101

Honorable Jack Buechner
U.S. House of Representatives
502 Cannon House Office Building
Washington, DC 20515

Honorable William L. Clay
U.S. House of Representatives
2470 Rayburn House Office Building
Washington, DC 20515

Honorable Harold L. Volkmer
U.S. House of Representatives
2411 Rayburn House Office Building
Washington, DC 20515

Mr. L. J. Peery, Science Consultant
Senate Research Staff
Senate Post Office
State Capitol
Jefferson City, Missouri 65101

Honorable Edwin L. Dirck
Missouri State Senate
State Capitol
Jefferson City, Missouri 65101

Honorable Fred Dyer
Member, Missouri State Senate
1025 Sherbrook
St. Charles, Missouri 63301

Honorable Neil Molloy
Missouri House of Representatives
State Capitol
Jefferson City, Missouri 65101

Honorable James Russell
Missouri House of Representatives
District 75
State Capitol
Jefferson City, Missouri 65101

Honorable Judith O'Connor
Missouri House of Representatives
District 76
State Capitol
Jefferson City, Missouri 65101

Honorable George Dames
Member, Missouri House of Representatives
Route #3, Box 82, 623 Highway P
O'Fallon, Missouri 63366

Honorable Craig Kilby
Missouri House of Representatives
District 21
State Capitol
Jefferson City, Missouri 65101

Honorable Thomas Barklage
Member, Missouri House of Representatives
1 Johns Drive
St. Charles, Missouri 63301

Library:

Kathryn Linneman Branch
St. Charles City/County Library
2323 Elm Street
St. Charles, Missouri 63301

Spencer Road Branch
St. Charles City/County Library
425 Spencer Road
Post Office Box 529
St. Peters, Missouri 63376

Reference Librarian
St. Louis County Library
1640 Lindbergh Boulevard
St. Louis, Missouri 63131

Miscellaneous:

Mr. Park Owen (2 Copies)
Remedial Action Program Information Center
Oak Ridge National Laboratory
Martin Marietta Energy Systems, Inc.
Post Office Box X
Oak Ridge, Tennessee 37831

Distribution (30 Copies)
Office of Scientific and Technical Information
U.S. Department of Energy
Post Office Box 62
Oak Ridge, Tennessee 37831

Mr. J. P. Corley
Battelle Pacific Northwest Laboratories
Post Office Box 999
Richland, Washington 99352

Mr. John M. Peterson (3 Copies)
Division of Environmental Impact Studies
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Mr. A. J. Bardol
S-L-T Development Company
1015 Locust Street
Post Office Box 242
St. Louis, Missouri 63166

Bechtel National, Inc.
Post Office Box 37
Hazelwood, Missouri 63042

Ms. Meredith Bollmeier
Redacted - Privacy Act

Mr. Lewis Cunningham
Norfolk & Western Railway Company
200 Carr Street
St. Louis, Missouri 63102

Mr. C. Richard Desselman
Donnelly Printing Company
8920 Latty Avenue
St. Louis, Missouri 63134

Ms. Key Drey
Redacted - Privacy Act

Ms. Pat Hicks
Public Relations Director
Mallinckrodt, Inc.
Post Office Box 5840
St. Louis, Missouri 63134

Mr. Larry Hoffman
X-L Company, Inc.
A.J.F. Distribution System
9043 Frost Avenue
St. Louis, Missouri 63134

Houston-St. Louis Properties
1001 Craig Road
Post Office Box 28580
St. Louis, Missouri 63146

Mr. E. Dean Jarboe
Futura Coatings
9200 Latty Avenue
Hazelwood, Missouri 63042

Mr. Roger Kelly, Attorney
Mallinckrodt, Inc.
McDonnel Boulevard
Post Office Box 5840
St. Louis, Missouri 63134

Ms. Lenore Loeb
First Vice President
League of Women Voters of Missouri
2138 Woodson Road
St. Louis, Missouri 63114

Mr. Jack Long
General Investment Fund
Real Estate Holding Company
1 General Street
Akron, Ohio 44308

Mr. Frederick B. Mathias
Gateway Warehousing, Inc.
4806 Potomac
St. Louis, Missouri 63116

Mr. Bob Parks
Champion International Company
9150 Latty Avenue
St. Louis, Missouri 63134

Mr. William E. Patton
Wetterau, Inc.
8920 Pershall Road
Hazelwood, Missouri 63042

Mr. George Rifakes
Cotter Corporation
Post Office Box 767
Chicago, Illinois 60690

Mr. J. L. Tuepker
Vice President for Production
St. Louis County Water Company
535 N. New Ballas Road
St. Louis, Missouri 63141

Mr. Robert M. Wester, President
R. M. Wester and Associates, Inc.
3317 Highway 94 North
St. Charles, Missouri 63301

Mr. John C. Whiteley
McGraw-Edison Company
Wagner Division
1848 Craig Road
St. Louis Missouri 63146

Mr. Steve Willis
Bi-State Development Company
707 North First Street
St. Louis, Missouri 63102

Mr. Harold Yeager, Senior Vice President
Mallinckrodt, Inc.
McDonnell Boulevard
Post Office Box 5840
St. Louis, Missouri 63134

DOE-Headquarters:

Mr. Douglas G. Elmets, Director, Press Services
Office of Communications
CP-22, Room 8G-082, HQ, FORSTL

Mr. Raymond P. Berube (10 Copies)
Acting Director
Division of Environmental Guidance
EH-23, Room 7A-075, HQ, FORSTL

Mr. William R. Voigt, Jr., Director
Office of Remedial Action and Waste Technology
NE-20, Room E-435, HQ, GTN

Mr. John E. Baublitz, Deputy Director
Office of Remedial Action and Waste Technology
NE-20, Room D-429, HQ, GTN

Mr. James J. Fiore, Director
Division of Facility and Site
Decommissioning
NE-23, Room D-430, HQ, GTN

Ms. Gale Turi
Office of Facility and Site
Decommissioning
NE-23, Room D-424, HQ, GTN

Mr. James W. Wagoner, II
Division of Facility and Site
Decommissioning
NE-23, Room D-428, HQ, GTN

Mr. Andrew Wallo, III
Division of Facility and Site
Decommissioning
NE-23, Room D-428, HQ, GTN

DOE-ORO:

J. W. Range, M-4 (3 copies)
G. W. Benedict, CE-50
S. W. Ahrends, CE-53
L. F. Campbell, CE-53
S. K. Oldham, CE-53
J. F. Wing, CE-53
S. H. McCracken, CE-53
R. L. Egli, SE-30
B. J. Davis, SE-31 (3 Copies)

Administrative Record for the Formerly Utilized Sites Remedial Action Program (FUSRAP) North St. Louis County Sites

St. Louis County, Missouri

US Army Corps of Engineers
St. Louis District®

Volume 1.11c
Site Management –
Environmental Reports

Administrative Record for the Formerly Utilized Sites Remedial Action Program (FUSRAP) North St. Louis County Sites

St. Louis County, Missouri

US Army Corps of Engineers
St. Louis District®

Volume 1.11d
Site Management –
Reference Documents