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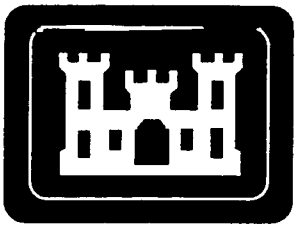
ANNUAL ENVIRONMENTAL MONITORING DATA AND ANALYSIS REPORT FOR CY00

ST. LOUIS, MISSOURI

JUNE 2001



U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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ST. LOUIS, MISSOURI

JUNE 2001

prepared by

U.S. Army Corps of Engineers, St. Louis District Office, Formerly Utilized Sites Remedial Action Program

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ACRONYMS AND ABBREVIATIONS

Ac	actinium
ADM	Archer Daniel Midland
AEC	Atomic Energy Commission
Am	americium
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
ATD	alpha track detector
AWQC	ambient water quality criteria
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Ci	curies
CLP	Contract Laboratory Program
COC	contaminant of concern
COD	chemical oxygen demand
Cs	cesium
CSR	Code of State Regulations
CV	coefficient of variation
CY	calendar year
DOE	U.S. Department of Energy
DQO	data quality objective
EE/CA	Engineering Evaluation/Cost Analysis Report
EMDAR	Environmental Monitoring Data and Analysis Report
EMG	Environmental Monitoring Guide
EMIFY	Environmental Monitoring Implementation for Fiscal Year
EMP	Environmental Monitoring Program
FFA	Federal Facilities Agreement
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
ft	feet
ft/ft	feet per foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GRAAA	Ground-water Remedial Action Alternative Assessment

ACRONYMS AND ABBREVIATIONS (CONT'D)

HISS	Hazelwood Interim Storage Site
HU	hydrostratigraphic unit
HZ	hydrostratigraphic zone
IA	Investigation Area
IAL	investigative action level
ICRP	International Commission on Radiation Protection
IDW	investigation derived wastes
K	potassium
LCS	laboratory control sample
m	meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MDA	minimum detectable activity
MDNR	Missouri Department of Natural Resources
MED	Manhattan Engineering District
mg/kg	milligram per kilogram
mg/L	milligrams per liter
ml/L/hr	milliliter per liter per hour
mrem	millirem
mrem/pCi	millirem per picocurie
mrem/yr	millirem per year
MSD	Metropolitan Sewer District
NCR	non-conformance report
ND	non-detect
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
OVA	organic vapor analyzer
Pa	protactinium
PAH	Polynuclear (or polycyclic) aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram

ACRONYMS AND ABBREVIATIONS (CONT'D)

pCi/L	picocurie per liter
$pCi/m^2/s$	picocurie per square meter per second
PCOC	potential contaminant of concern
PID	photoionization detector
PVC	polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
Ra	radium
RI	Remedial Investigation
Rn	radon
ROD	Record of Decision
RPD	relative percent difference
SAG	Sampling and Analysis Guide
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
SLS	St. Louis Sites
SMCL	secondary maximum contaminant level
SOP	standard operating procedure
SOR	sum of ratio
SSHP	Site Safety and Health Plan
SVOC	semivolatile organic compound
TAL	target analyte list
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent dosimeter
TOC	total organic compound
TOX	total organic halogen
U	uranium
UCL	Upper Confidence Limit

ACRONYMS AND ABBREVIATIONS (CONT'D)

UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USACE	United States Army Corps of Engineers
UST	underground storage tanks
VC	vinyl chloride
VOC	volatile organic compound
VP	vicinity property
WD	work description
WDNR	Wisconsin Department of Natural Resources
yd^3	cubic yard
µCi/mL	microcurie per milliliter
µg/kg	microgram per kilogram
µg/L	microgram per liter
µrem/yr	microrem per year

EXECUTIVE SUMMARY

This annual Environmental Monitoring and Data Analyses Report for the St. Louis Sites (SLS) for calendar year 2000 (CY00) has been prepared to provide information about the public safety and environmental protection programs at the SLS within the Formerly Utilized Sites Remedial Action Program (FUSRAP). Environmental monitoring of various media at the St. Louis Downtown Site (SLDS), St. Louis Airport Site (SLAPS), and the Hazelwood Interim Storage Site (HISS) is required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and a commitment outlined in the Federal Facilities Agreement (FFA).

The purpose of this report is to summarize the data collection effort for CY00, report the current condition of the SLS, and provide an interpretation of the results of the CY00 environmental monitoring data. The United States Army Corps of Engineers (USACE), St. Louis District collects comprehensive environmental data for decision-making and planning purposes.

AIR MONITORING

Gamma radiation monitoring was performed at SLDS during CY00 at five locations around the perimeter of the Mallinckrodt plant. The average thermoluminescent dosimeter (TLD) measurement at the SLDS perimeter was approximately 8 millirem per year (mrem/yr) above background. Airborne radon monitoring was performed at SLDS using alpha track detectors (ATDs) placed around the site perimeter to measure radon emissions from the site. Five detectors were co-located with TLD locations. The average radon concentration measured at the SLDS perimeter was 0.0 picocuries per liter (pCi/L) above background which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L.

Gamma radiation monitoring was performed at SLAPS during CY00 at six locations around the perimeter of the site. The average TLD measurement at the SLAPS perimeter was approximately 71 mrem/yr above background. Airborne radon monitoring was performed at SLAPS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations. The average radon concentration measured at the SLAPS perimeter was approximately 0.1 pCi/L above background, which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L.

Air sampling for radiological particulates was conducted at the SLAPS perimeter locations starting in January 2000. The average gross alpha and beta air particulate concentration at the SLAPS perimeter were 3.5E-15 microcurie per milliliter (μCi/mL) and 4.1E-14 μCi/mL, respectively.

Gamma radiation monitoring was performed at HISS during CY00 at six locations around the perimeter of the site. The average TLD measurement at the HISS perimeter was approximately 33 mrem/yr above background.

Airborne radon monitoring was performed at HISS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations. The average radon concentration at the HISS perimeter was less than 0.1 pCi/L above background, which is below the 10 CFR 20 regulatory criterion of 0.3 pCi/L. Air sampling for radiological particulates was conducted at the HISS perimeter starting in October 2000. The average gross alpha and beta air particulate concentrations at the HISS perimeter were 2.0E-15 μCi/mL and 3.1E-14 μCi/mL, respectively.

Radon flux monitoring at HISS was performed in September 2000 using 10-inch diameter activated charcoal canisters placed approximately 25 feet (ft) apart on a pre-determined grid. The canisters were sealed to the storage pile's cover surface for 24 hours. The average of the measurements [0.9 and 0.4 picocuries per square meter per second ($pCi/m^2/s$), respectively] from the main and supplemental piles was well below the 40 CFR 192.02 regulatory criterion of 20 $pCi/m^2/s$.

WASTE-WATER DISCHARGE MONITORING AT SLDS

CY00 was the second year that waste-water discharges at SLDS were accurately monitored and recorded under the Metropolitan Sewer District (MSD) authorization letter. The total volume discharged during CY00 is 1,569,974 gallons and total activities discharged for CY00 are 1.15E-05 curies (Ci) for thorium, 6.25E-06 Ci for uranium, and 3.07E-06 Ci for radium. These results are consistent with the total activities for discharged water during CY99.

NPDES MONITORING

Concentration limits are set for water pollutants in the National Pollutant Discharge Elimination System (NPDES) permit at the HISS and the permit-equivalent document at the SLAPS. During CY00 storm-water discharges at SLAPS were monitored at PN01a, PN02, and PN03. Chemical sample data results indicated an exceedance of the allowable limit of 84 microgram per liter (μg/L) for total recoverable copper. At PN03 in February the results were 88.6 μg/L. The average release from all SLAPS outfalls flow-weighted for the year was 230 pCi/L. In CY00, storm-water discharge was monitored from three outfalls at HISS (Permit MO-0111252) HN01, HN02, and HN03. During CY00, storm-water discharges from each outfall were sampled for permit required parameters and no permit limits were exceeded at the HISS. In CY00 storm-water discharges from SLAPS and HISS complied with criteria contained in 10 CFR 20.1302, respectively.

COLDWATER COLD SURFACE-WATER MONITORING

For the CY00 surface water sampling events (March and May) from Coldwater Creek, the maximum activity-based concentration of radiological parameters occurred at sampling location C002 during May 2000. Isotopic uranium (U-234, U-238) values ranged from 0.67 pCi/L at environmental monitoring program (EMP) Station C002 to 2.45 pCi/L at EMP Station C007 in March 2000. In May, uranium isotopic values ranged from 0.42 pCi/L at EMP Station C005 to 3.64 pCi/L at EMP Station C002.

The sampling program included the detection of several metals in the surface water of Coldwater Creek. Detected contaminants in Coldwater Creek may be releases from properties other than FUSRAP. No other ambient water quality criteria (AWQC) were exceeded during the first sampling event.

The second sampling event in May 2000, resulted in the detection of aluminum and iron in exceedance of the AWQC. Aluminum [AWQC limit 0.75 milligrams per liter (mg/L)] was detected at EMP Stations C002-006 at values of 4.3, 5.5, 4.9, 1.3, and 2.3 mg/L, respectively. Iron (AWQC limit 1.0 mg/L) was detected at EMP Stations C002-006 at values of 3.6, 4.8, 5.0, 1.5, and 2.6 mg/L, respectively. No other AWQC were exceeded during the second sampling event.

Total suspended solids sampled during the second event in May 2000 resulted in elevated values from 13.2 mg/L at C007 to 69.3 mg/L at C003 and C004. In contrast, during the March 2000 sampling event, values for suspended solids ranged from 6.2 mg/L at C005 to 10.8 mg/L at C003. Comparing these values, the total suspended solids increased 2 to 7 times from March to May 2000. This may explain the elevated levels of metals detected during the second sampling event.

COLDWATER CREEK SEDIMENT SAMPLING

Sediment samples collected for the EMP were evaluated for radiological, chemical, and metal constituents.

Background sediment criteria listed in the Environmental Monitoring Implementation for FY01 (EMIFY01) were exceeded for seventeen inorganic and sixteen semivolatile organic analytes. Only one volatile organic analyte (methylene chloride) criterion was exceeded. The chemical exceedances are listed in the table below.

Inorganic Exceedances	
• Aluminum	• Lead
• Arsenic	• Magnesium
• Barium	• Manganese
• Boron	• Potassium
• Calcium	• Sodium
• Chromium	• Thallium
• Cobalt	• Vanadium
• Copper	• Zinc
• Iron	

Semi-Volatile Organic Exceedances	
• Anthracene	• Dibenzo(a,h)anthracene
• Benzo(a)anthracene	• Dibenzofuran
• Benzo(b)fluoranthene	• Fluoranthene
• Benzo(k)fluoranthene	• Fluorine
• Benzo(g,h,i)perylene	• Indeno(1,2,3-cd)pyrene
• Benzo(a)pyrene	• Naphthalene
• Bis(2-ethylhexyl)phthalate	• Phenanthrene
• Chrysene	• Pyrene

GROUND-WATER MONITORING

SLDS: The ground-water zones for SLDS are the shallow, hydrostratigraphic unit A (HU-A) and the protected, deeper Mississippi Alluvial Aquifer, hydrostratigraphic unit B (HU-B). In CY00, a total of twenty-two wells (11 shallow, HU-A and 11 deep, HU-B) were sampled for radionuclides and inorganic (arsenic and cadmium) constituents at SLDS. The concentrations of these contaminants of concern (COCs) were compared against site-specific investigative limits. These criteria consist of Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) and the following investigative levels specified in the Record of Decision (ROD): 50 µg/L for arsenic, 5 µg/L for cadmium, and 20 µg/L for total uranium (USACE, 1998d).

The CY00 results indicate that shallow, HU-A ground water at SLDS has been impacted by site contaminants. In particular arsenic and uranium were detected above their respective MCLs in two wells that were screened in HU-A, B16W11S and B16W02S. There is question as to the unit B16W11S is monitoring.

Eleven SLDS wells completed in the HU-B (Mississippi Alluvial Aquifer) were monitored during CY00. The CY00 sampling results indicate cadmium is not present above the evaluation criterion (5 µg/L) in samples collected from these deep ground-water wells. Arsenic was detected above the evaluation criterion of 50 µg/L in two deep wells: DW14 and DW15. The arsenic levels ranged from only slightly exceeding the investigative limit in DW15 (maximum 59.5) to over 3 times the evaluation criterion in DW14 (maximum 182 µg/L). Total uranium is present in samples collected from DW19 at concentrations ranging from 61.9 µg/L to 101.4 µg/L. Two other COCs were detected in HU-B at SLDS, thorium-230 (Th-230) and radium-226 (Ra-226). Ra-226 was detected at levels only slightly exceeding its evaluation criterion in wells monitoring HU-B at SLDS. Th-230 was detected in HU-B ground water at a maximum concentration of 3.28 pCi/L in DW14. The non-COCs iron, total dissolved solids (TDS), and manganese were also detected at elevated concentrations in HU-B but are interpreted to be naturally occurring.

SLAPS: The ground-water zones for SLAPS are: the shallow, hydrostratigraphic zone A (HZ-A, which comprises Unit 1 Fill, Unit 2 Loess, and Subunit 3T Silty Clay); the intermediate depth, hydrostratigraphic zone B (HZ-B, Subunit 3M Clay); the deep soil, hydrostratigraphic zone C (HZ-C, composed of Subunit 3B silty clay and Unit 4 clayey to sandy gravel); hydrostratigraphic zone D (HZ-D, Interbedded Pennsylvanian rock and Shale); and the protected, deep hydrostratigraphic zone E (HZ-E, Mississippian Limestone). A total of forty-six ground-water wells were sampled for various parameters in CY00 at SLAPS. Sampling was conducted between February 22 and March 28 (first quarter); May 1 to June 15 (second quarter);

August 8 to September 26 (third quarter); and November 14 to Nov 29 (fourth quarter). The analytical results were compared to investigative limits [MCLs or secondary maximum contaminant levels (SMCLs)] and to background concentrations.

The sampling results indicate that various metals, radionuclides, and organic compounds are present at elevated levels in HZ-A ground water at SLAPS. Based on the CY00 data, the principal contaminants in shallow, HZ-A ground water at the site are the inorganics arsenic, iron, manganese, nitrate, selenium, and uranium, and the radionuclides Ra-226, Th-230, U-234, U-235, and U-238. The organic compounds 1,2-dichloroethene (1,2-DCE) and trichloroethene (TCE) were also detected at concentrations above their MCLs in several shallow wells. However, these organic contaminants are not Manhattan Engineering District/Atomic Energy Commission (MED/AEC) related.

The CY00 ground-water sampling data indicate that elevated concentrations of arsenic, iron, manganese, and TDS were present in samples from the lower, HZ-C, HZ-D, and/or HZ-E ground-water units, but their occurrence is interpreted as due to natural conditions. The radionuclides Ra-226, U-234, and U-238 were also identified as present at elevated levels in a few samples collected from HZ-C ground-water during CY00. However, these radionuclides were generally present at levels below or only slightly exceeding background concentrations. The CY00 data supports the determination that HZ-B, Subunit 3M, a relatively impermeable clay layer, is preventing the migration of unacceptable levels of contamination to HZ-E. The localized contamination present in HZ-A ground water is not present in the deeper zones, indicating that mixing between HZ-A and HZ-C, HZ-D, and HZ-E ground-water zones is insignificant.

HISS: The ground-water zones for HISS are the same as SLAPS, except the hydrostratigraphic zone D (HZ-D, Interbedded Pennsylvanian rock and Shale) is locally absent. Sampling was conducted at eighteen ground-water monitoring wells at HISS during CY00. With the exception of monitoring wells HISS-05D and HW23, which are screened in HZ-C, all of the monitoring wells at HISS are screened in HZ-A. The analytical results were compared to investigative limits (MCLs or SMCLs) and to background concentrations.

The CY00 data indicate there are significant localized impacts to the upper, HZ-A ground water from site-related contaminants. Nine inorganics (antimony, arsenic, barium, iron, manganese, nitrate, selenium, sulfate, and uranium) were detected at concentrations exceeding investigative limits in HZ-A ground water. The most widely occurring of these inorganics were iron, manganese, nitrate, and selenium. In addition, the radionuclides uranium and Ra-226 were detected in HZ-A ground water at levels above their MCLs. Uranium exceeded the MCL of 30 µg/L in two HISS wells; HISS-05 and HISS-06, with the maximum concentration of 137.3 µg/L detected in HISS-05. The radionuclide Ra-226 slightly exceeded the MCL of 5 pCi/L in samples from four HZ-A wells at HISS. In general, the most significant levels of inorganic and radiological contamination were reported for monitoring wells HW21 (for barium, manganese, nitrates, and Ra-226) and HISS-19S (for arsenic, iron, and manganese). HW21 and HISS-19S are located east and northeast of the main storage pile at HISS, respectively. In addition, TCE and 1,2-DCE were detected at significant levels in two HZ-A ground-water wells located northeast of the Futura building. The source of this contamination is not known but is believed to be associated with non-FUSRAP-related activities.

Ground-water samples were collected from two deep HZ-C wells, HISS-5D and HW23, during CY00. The sampling results for HZ-C ground-water indicate that some metals are present at elevated concentrations. Analytes exceeding investigative limits, or background concentrations in samples from both deep HZ-C wells include arsenic, manganese, and iron. Based on the CY00 data and trend analysis of historical data, the elevated concentrations of arsenic, iron, and manganese in HZ-C ground water are not the result of contaminant migration from the HZ-A ground water, but are likely the result of natural conditions. The shallow HZ-A ground-water contaminants Ra-226, nitrates, uranium, and selenium were not detected above their background levels or investigative limits in deep HZ-C ground water.

DOSE ASSESSMENT

Based on the exposure scenario and assumptions described in Section 6.4.2, a maximally exposed individual working outside at the receptor location facility 50 m east of the HISS perimeter received 2.1 mrem/yr from airborne radioactive particulates, 0.2 mrem/yr from external gamma, and 0.4 mrem/yr from Rn-222 for a TEDE of 2.7 mrem/yr (SAIC, 2001a).

Based on the exposure scenario and assumptions described in Section 6.4.1, a maximally exposed individual working outside at the receptor facility 160 meters (m) south of the SLAPS perimeter received 6.4 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.1 mrem/yr from radon-222 (Rn-222) for a total effective dose equivalent (TEDE) of 6.6 mrem/yr (SAIC, 2001b).

Based on the exposure scenario and assumptions described in Section 6.4.3, a maximally exposed individual working outside at the receptor location facility 50 m southeast of the SLDS perimeter received less than 0.1 mrem/yr from airborne radioactive particulates, 0.0 mrem/yr from external gamma, and 0.0 mrem/yr from Rn-222 for a TEDE of less than 0.1 mrem/yr (SAIC, 2001c).

Based on the exposure scenario and assumptions described in Section 6.4.4, a maximally exposed individual using Coldwater Creek for recreational purposes received 0.03 mrem/yr from soil/sediment ingestion, and 0.15 mrem/yr from water ingestion for a TEDE of 0.18 mrem/yr (SAIC, 2001d).

Based on the exposure scenario and assumptions described in Section 6.4.5, the exposed transient receptor passing SLAPS along McDonnell Boulevard 25 m north of the SLAPS perimeter received 2.3 mrem/yr from airborne particulate radionuclides, 0.1 mrem/yr from external gamma, and 0.1 mrem/yr from Rn-222 for a TEDE of 2.5 mrem/yr.

1.0 HISTORICAL SITE BACKGROUND AND CURRENT SITE STATUS

1.1 INTRODUCTION

The Annual Environmental Monitoring Data and Analysis Report (EMDAR) for CY00 provides an evaluation of the data collected as part of the implementation of the EMP for the SLS within FUSRAP. Environmental monitoring of various media at each of the SLS locations is required under CERCLA and a commitment outlined in the FFA. SLS FUSRAP consist of four sites: SLDS with its attendant vicinity properties (VPs), SLAPS, SLAPS VPs, and the Latty Avenue Properties. The Latty Avenue Properties includes Futura and HISS besides other properties. During CY00, data collection activities were conducted at the three primary sites: SLDS, SLAPS, and HISS. Additional environmental data was collected along Coldwater Creek adjacent to SLAPS and near HISS.

1.2 PURPOSE

The purpose of this report is to summarize the data collection effort for CY00 and enhance the reader's awareness of the current condition of the four FUSRAP SLS, and provide professional interpretation of the results of the collection of the CY00 environmental monitoring data. This document presents the following information:

- Sample collection data for various media at each site and interpretation of CY00 EMP results;
- The compliance status of each site with federal and state applicable or relevant and appropriate requirements (ARARs) or other benchmarks;
- Dose assessments for radiological contaminants as appropriate at each site;
- A summary of trends based on changes in contaminant concentrations to support remedial actions, public safety, and maintain surveillance monitoring requirements at each site;
- An evaluation of the adequacy of the monitoring network; and
- The identification of data gaps and future EMP needs.

1.3 SLS PROGRAM AND SITE BACKGROUND

The FUSRAP program was initiated in CY74 by the AEC, the predecessor to the U.S. Department of Energy (DOE). FUSRAP was transferred to the USACE on October 13, 1997. The USACE is responsible for the characterization and remediation of contamination associated with the historical AEC facilities that supported the nation's early nuclear defense-related activities. On October 4, 1989, SLAPS, HISS, and Futura Coatings were listed on the National Priorities List (NPL) (EPA, 1989a).

The SLS (Figure 1-1) includes the primary activities at SLDS, SLAPS, and HISS. The three primary sites were involved in the refining of uranium ores, production of uranium metal and compounds, uranium recovery from residues and scrap, and the storage and disposal of associated process by-products. The processing activities were conducted in parts of SLDS under contract to the MED and AEC between the early 1940s and the mid 1950s.

Detailed descriptions and histories for each site can be found in *Remedial Investigation for the St. Louis Site, St. Louis, Missouri* (DOE, 1994); *Remedial Investigation Addendum for the St. Louis Site, St. Louis, Missouri* (DOE, 1995); Engineering Evaluation/Cost Analysis For St. Louis Airport Site (DOE, 1997 and USACE, 1998b); *Engineering Evaluation/Cost Analysis (EE/CA) for Hazelwood Interim Storage Site* (USACE, 1998c); *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri* (USACE, 1998d); and the *Environmental Monitoring Guide for the St. Louis Sites* (USACE, 1999a).

1.3.1 SLDS Background

SLDS and its VPs are an industrial plant within the easternmost portion of St. Louis and located approximately 300 ft west of the Mississippi River (Figure 1-2). The Mallinckrodt plant consists of a number of separate production complexes (plants) and auxiliary support buildings and offices engaged in the production of various chemical products. The VPs potentially impacted by the MED/AEC operations conducted at the Mallinckrodt plant include PSC Metals, Inc. (identified as DT-8) to the north, Archer Daniel Midland (ADM) (DT-1) and City of St. Louis properties to the east, and the Thomas and Proetz Lumber Company (DT-10), Gunther Salt (DT-4), Heintz Steel and Manufacturing (DT-6), and Midwest Waste (DT-7) to the south. The St. Louis Terminal Railroad Association (DT-9); Norfolk and Western Railroad (DT-3); and the Burlington Northern Santa Fe Railroad (DT-12) all have active rail lines passing through the Mallinckrodt plant. By-products from the MED/AEC-related production activities conducted at the Mallinckrodt plant included spent pitchblende ore; process chemicals; and uranium, radium, and thorium-bearing residues. The by-products of the production activities at the Mallinckrodt plant were staged or stored at various locations within the plant for subsequent transport to SLAPS.

In October CY98, the U.S. Environmental Protection Agency (EPA) Region VII and USACE signed the *Record of Decision for the St. Louis Downtown Site* (SLDS ROD) (USACE, 1998d). The SLDS ROD addresses contamination at the Mallinckrodt plant and the VPs related to the historical MED/AEC activities in the accessible soils and ground water. The selected remedy presented in the ROD involves excavation of approximately 100,000 cubic yards (yd^3) of radiologically contaminated accessible soils and long-term monitoring of HU-B. "If long-term monitoring of this unit shows significant exceedances of MCLs or the thresholds established in 40 CFR 192 by the COCs specified in the SLDS ROD, a Ground-water Remedial Action Alternative Assessment (GRAAA) will be initiated" (USACE, 1998d). Inaccessible soils at SLDS will be addressed in a separate ROD.

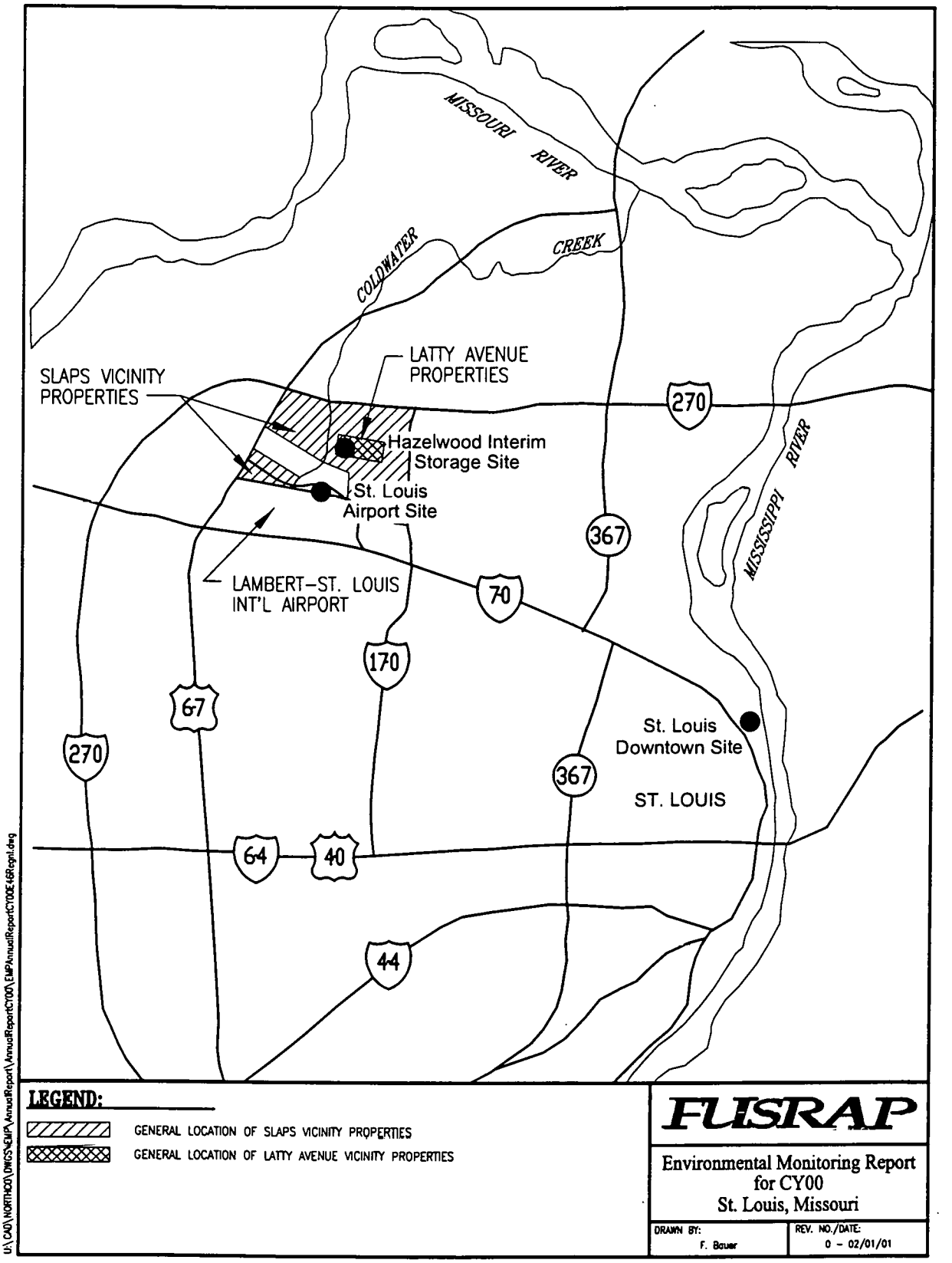

Figure 1-1. Location Map of the St. Louis Sites

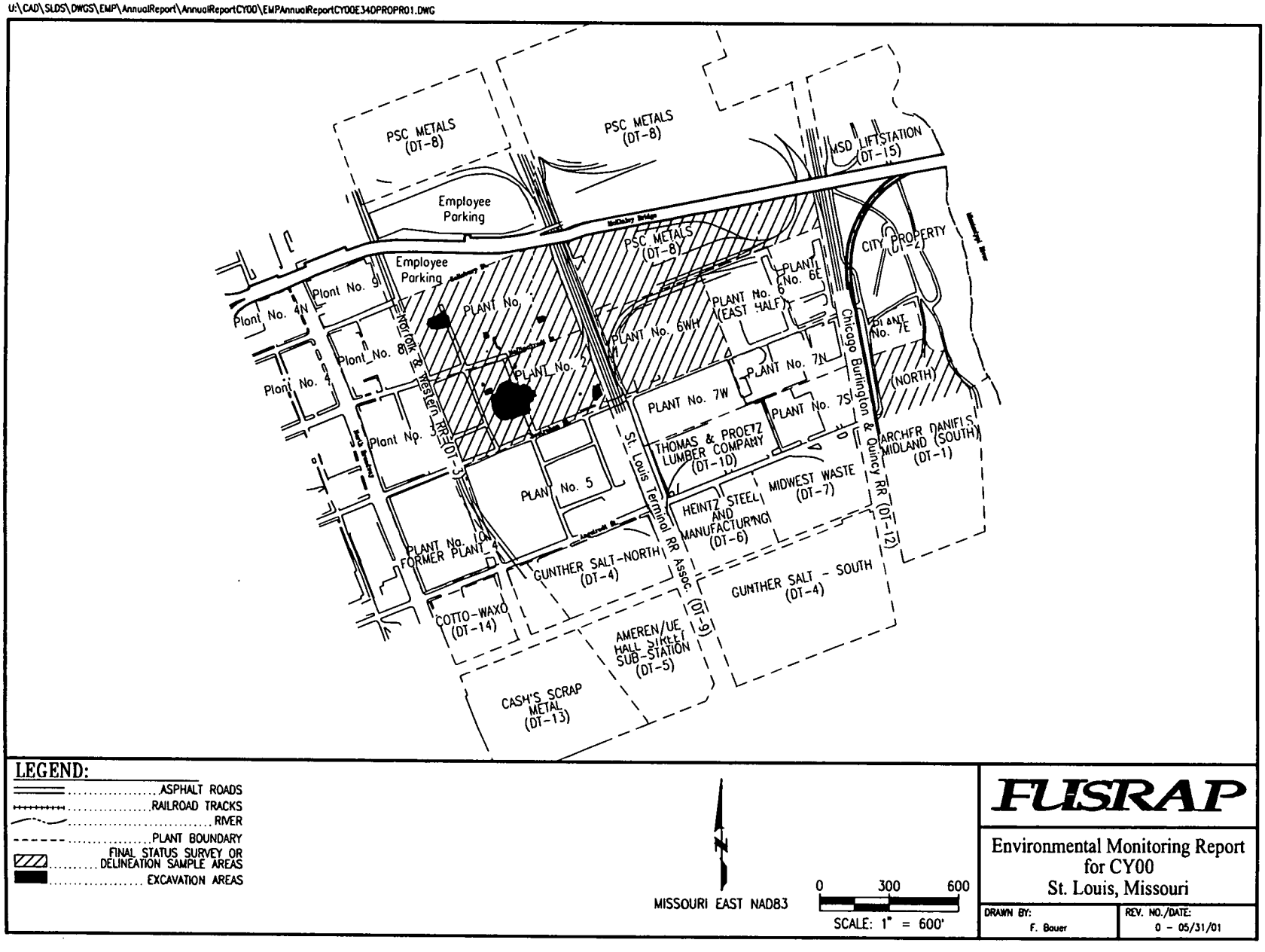

Figure 1-2. Plan View of SLDS

1.3.2 SLDS' Current Site Status

During CY00, the final status surveys for the various excavation areas of Plant 2 and Plant 1 were completed. 1,569,974 gallons of water were treated to drinking water standards in accordance with the MSD site permit. The total amount of water treated since installation of the onsite treatment system is 3,192,970 gallons. Work conducted at SLDS during CY00 also included the excavation, transportation, and disposal of 3,338 yd^3 of loose soil from Plant 2 and 1,623 yd^3 of loose soil from Plant 1. Soil was transported by railcars to Envirocare in Utah for proper disposal.

Pre-design investigation delineation sampling and/or final status surveys were completed on Plant 6 west, Plant 7 west, MSD Lift Station (DT-15), Midwest Waste (DT-7), PSC Metals (DT-8), McKinley Bridge shadow (DT-11), Heintz Steel and Manufacturing (DT-6), Gunther Salt North (DT-4), and ADM South (DT-1). These field activities assisted in determining the extent and magnitude of radiological contamination resulting from past MED/AEC activities conducted at the Mallinckrodt plant.

1.3.3 SLAPS' Background

SLAPS is a 21.7-acre site located in St. Louis County approximately 11 miles northwest of SLDS. The site is immediately north of the Lambert St. Louis International Airport and is bordered by McDonnell Boulevard and inactive recreational areas (ballfields) to the north and east, and by Coldwater Creek to the west (Figure 1-3).

The property was acquired by the MED, which used the site for storing raffinate, radium bearing residues, uranium contaminated dolomite and magnesium fluoride slag, uranium bearing sand, and other process wastes from SLDS. The AEC inventoried the property and found 121,000 tons of uranium refinery residues and contaminated materials on the open ground at the site.

Most of the stored residues were sold to Continental Mining and Milling Company, removed from the site, and transported to HISS. After most of the residuals were removed, site structures were demolished and buried on the property along with approximately 60 truckloads of scrap metal and a vehicle that had become contaminated (EPA, 1989a). One to three feet of fill was spread over the disposal area to achieve surface radioactivity levels that were acceptable at that time.

1.3.4 SLAPS VPs' Current Site Status

Excavation of VP-38 was begun and completed during CY00. A total of 7,082 yd^3 of loose soil was safely, transported to Envirosafe in Idaho for proper disposal. The excavation site was backfilled and the USACE offices were relocated from HISS to this site along Latty Avenue in Hazelwood. Characterization sampling was begun and completed on VPs 9-12 and Investigative Areas (IAs) 9 and 10. Characterization is now complete for VPs 9-12, 56-59, and 1C.

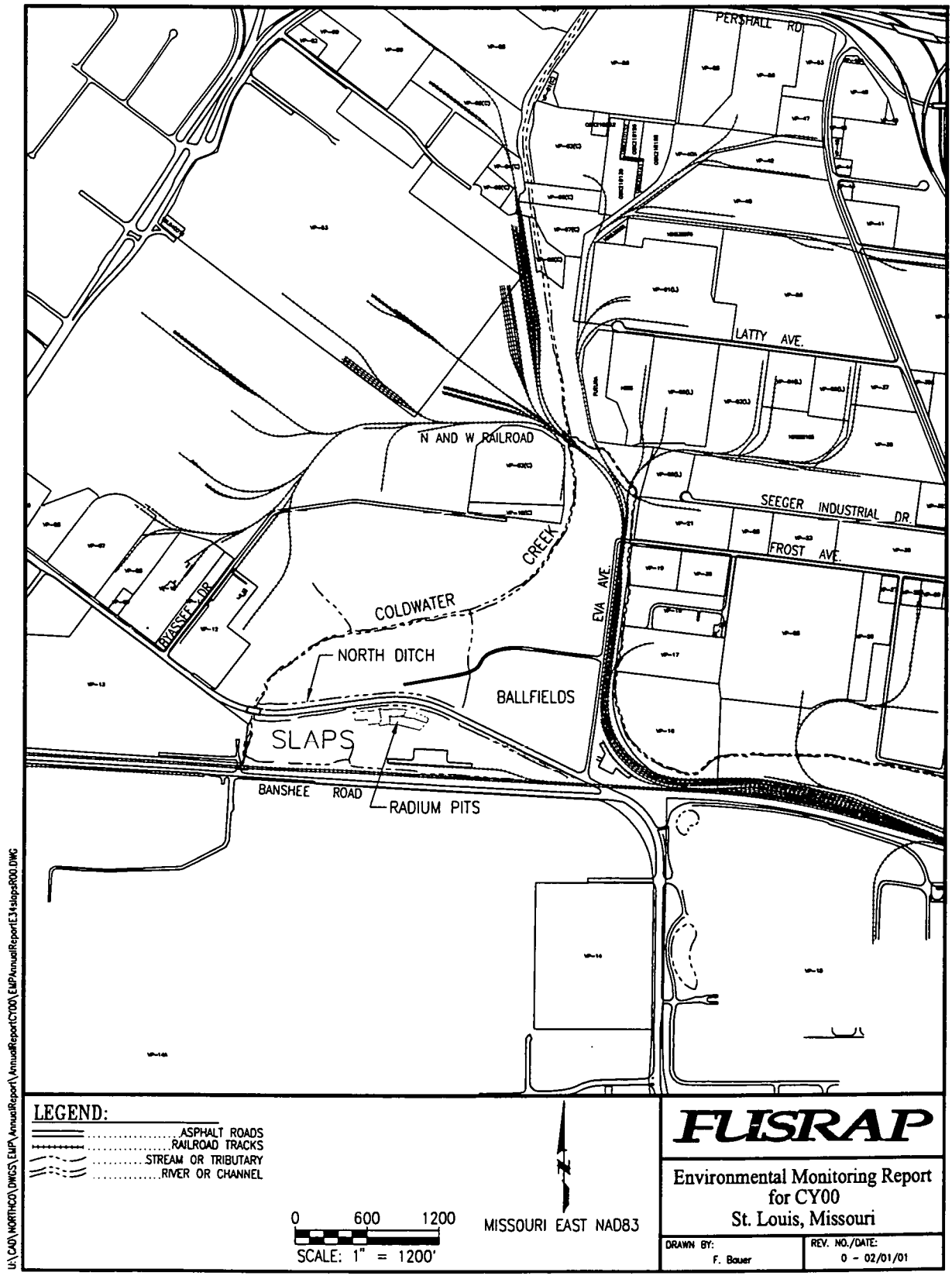

Figure 1-3. Plan View of SLAPS

Five new groundwater-monitoring wells were installed at various locations at SLAPS to support the ongoing EMP. A total of 1,245 yd^3 of asbestos contaminated soil was removed and transported for disposal to Envirocare in Utah.

The excavation of the Radium Pits was begun and mostly completed during CY00. A total of 49,822 yd^3 of loose soil was removed and transported to Envirocare in Utah for proper disposal. Most of the area has been completely surveyed and is scheduled to be backfilled with clean soils. Grading and erosion controls are in place in the North Ditch area of SLAPS.

1.3.5 Coldwater Creek

Coldwater Creek and a number of VPs, including the ballfields, Norfolk and Western Railroad, Banshee Road to the south, and former transportation routes between HISS and SLAPS (Latty Avenue, McDonnell Road, Pershall Road, Hazelwood Avenue, Eva Avenue, and Frost Avenue), were included in the SLS EMP. The property surrounding SLAPS and vicinity is currently zoned light industrial.

The nearest residential areas are located about 0.5 miles to the west in an industrial zoned area of Hazelwood. Residential areas are also located approximately 0.7 miles northeast of the SLAPS.

1.3.6 Hazelwood Interim Storage Sites (HISS) Background

HISS is an 11-acre industrial site located in northern St. Louis County approximately 1 mile northeast of SLAPS. The site is located on Latty Avenue and is bordered to the east by the Stone Container property (known as Latty Ave VP-2L). HISS is bordered to its north by Latty Avenue and other VPs, to the south by undeveloped lots, and to the west by Futura Coatings (Figure 1-4). Multiple rail lines owned by the Norfolk and Western Railroad also lie to the west and south of the site.

The primary waste materials that were historically stored at the HISS were uranium extraction and refining residues. These materials included an estimated 106,000 tons of barium sulfate cake and 350 tons of miscellaneous waste.

The initial Remedial Investigation (RI), completed by DOE in CY94, addressed SLAPS and provided limited characterization of radioisotopic contamination in the ballfields (DOE, 1994). EE/CA Reports were performed for these two sites (DOE, 1997; USACE, 1998b and 1998c).

1.3.7 Latty Avenue Properties' Current Status

In CY00, the USACE laboratory equipment that supports the EMP was relocated from HISS to a new laboratory located on the southern portion of VP-38. The mobile laboratory trailers were relocated to SLAPS to expand analytical sampling capabilities on site. 15,912 yd^3 of loose soil from the east pile and Rail Spur spoils piles were excavated and safely transported for proper disposal. Excavation, transportation, and disposal operations were initiated on the HISS supplemental pile. To date, 6,952 yd^3 of loose soil has been transported and properly disposed of from this area. (Removal of the HISS Supplemental Pile was completed prior to the e/o CY00.

An excavation, transportation, and disposal effort was completed on the VP-2L property along Latty Avenue. 1,454 yd^3 of loose soil was safely transported to Idaho for disposal. A final status survey of this property was completed last year.

Excavation of the HISS main pile was begun during CY00. 4,581 yd^3 of loose soil was excavated, transported, and disposed of from the northeastern quadrant of the main pile during the fourth quarter. Three ground-water monitoring wells and four air-particulate monitoring stations were installed at HISS to enhance the EMP.

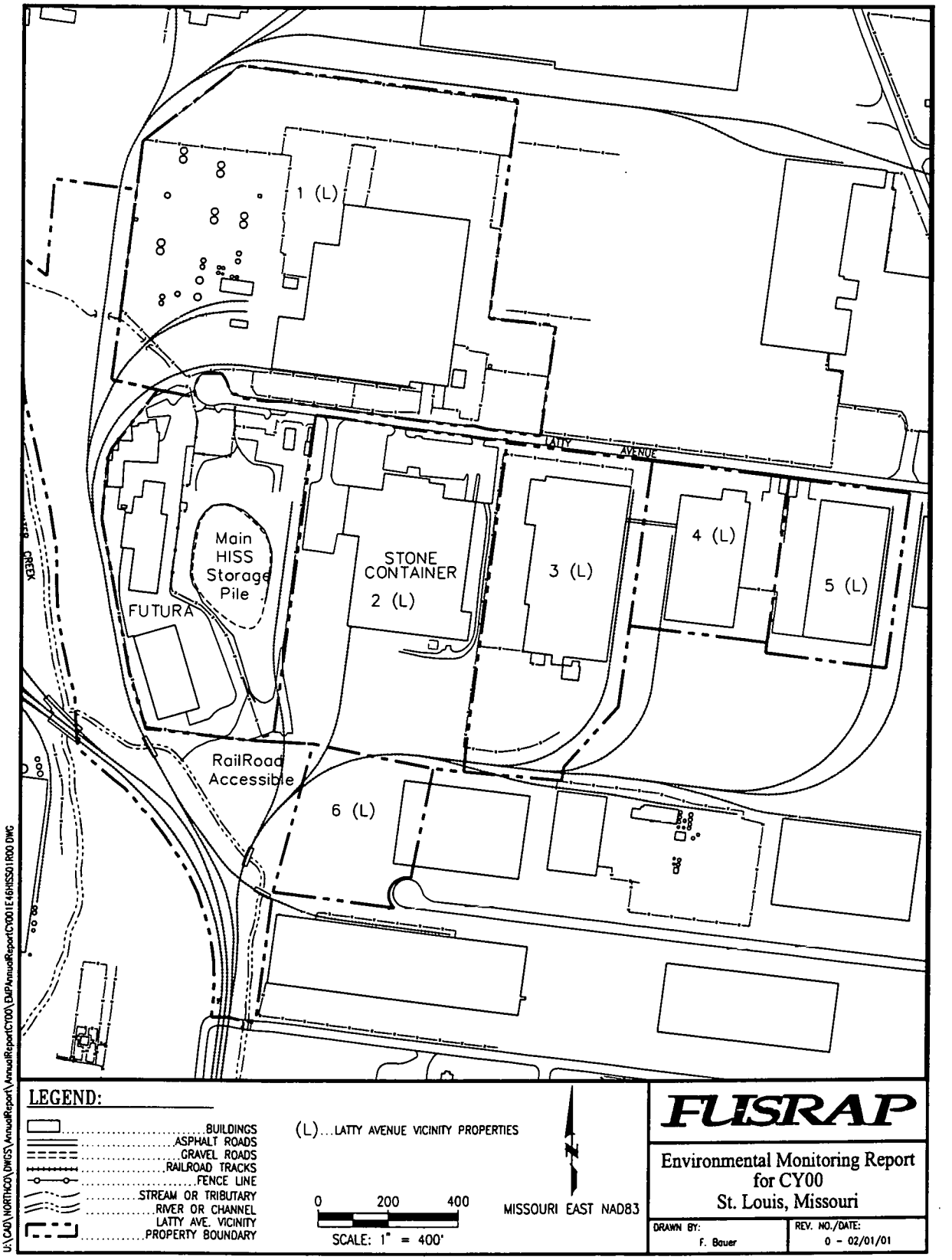

Figure 1-4. Plan View of HISS and Latty Avenue Vicinity Properties

2.0 SITE PERIMETER RADIOLOGICAL MONITORING

Site perimeter radiological monitoring is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of radiological contamination in environmental media at the SLS boundaries in contaminant migration pathways, and in pathways subject to regulatory compliance [e.g., National Emission Standards for Hazardous Air Pollutants (NESHAPs)]. Environmental surveillance consists of analyzing environmental conditions within or outside the site boundaries for the presence and concentrations of contaminants. Surveillance data are used to assess the presence and magnitude of radiological exposures and to assess the potential effects to the general public and the environment. The following sections discuss the type of radiological measurements taken at each site boundary, and the results of the data collected during CY00 for various environmental media.

2.1 RADIOLOGICAL MEASUREMENTS

The radiological measurements taken at the SLS facility boundaries are conducted as part of the EMP. Sections 2.1.1 through 2.1.3 describe the types of radiological measurements conducted at SLS, potential sources of the contaminants to be measured (including natural background), and measurement techniques employed during CY00.

2.1.1 Gamma Radiation

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation emitting substances, such as uranium, thorium, and potassium-40 (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources comprise the majority of natural gamma background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates the typical gamma radiation dosc is 35 mrem/yr from the earth and 30 mrem/yr from cosmic sources (UNSCEAR, 1982). The total estimated naturally occurring background radiation dose equivalent due to gamma exposure is thus 65 mrem/yr. At the SLS, above background concentrations of radionuclides in the uranium and thorium decay series may be a source of gamma radiation exposure at or outside site boundaries.

Gamma radiation was measured at the SLS (in CY00) using TLDs located at site boundaries as shown on Figure 2-1. The TLDs were placed at the monitoring location approximately 3 ft above the ground surface inside a housing shelter. The TLDs were collected quarterly and sent to an off-site vendor for analysis.

2.1.2 Airborne Radioactive Particulates

2.1.2.1 Air Sampling

Airborne radioactive particulates result from radioactive contamination in soil (or other sources) that become suspended in the air. The radioactive material normally becomes airborne as a result of wind erosion of the soil surface or as a result of the soil becoming disturbed (e.g., remediation).

The earth contains naturally occurring radioactive materials, such as uranium, thorium, and K-40. This naturally occurring radioactive material, as well as the above background concentrations of radioactive materials present at SLS, may contribute to emissions of airborne radioactive particulates.

Airborne radioactive particulates are measured at SLS by drawing air through a filter membrane with an air sampling pump placed approximately 3 ft above the ground and then analyzing the material contained on the filter. The results of the analysis, when compared to the amount of air drawn through the filter, is reported as a radioactive contaminant concentration [i.e., microcuries per milliliter (μCi/mL)]. Particulate air monitors are located at site perimeter locations in predominant wind directions and/or in areas accessible to members of the public as shown on Figure 2-1. Air particulate samples are collected weekly.

2.1.2.2 Estimation of Emissions in Accordance with NESHAP

The St. Louis FUSRAP Sites CY00 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

Air sampling data, soil characterization data, and other site specific information are used at the SLS as inputs to the CAP88-PC modeling code to demonstrate compliance with the emission standard in 40 CFR 61, Subpart I. The CY00 NESHAPs Report is located in Attachment 1 of this document. The results of calculations performed for SLS are reported in Sections 2.2 through 2.4, as appropriate.

2.1.3 Airborne Radon

Uranium-238 (U-238) is a naturally occurring radionuclide in soil and rock. Radon gas (Rn-222) is a naturally occurring radioactive gas found in the uranium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the SLS from this natural source as well as from the contaminated waste materials present at the sites.

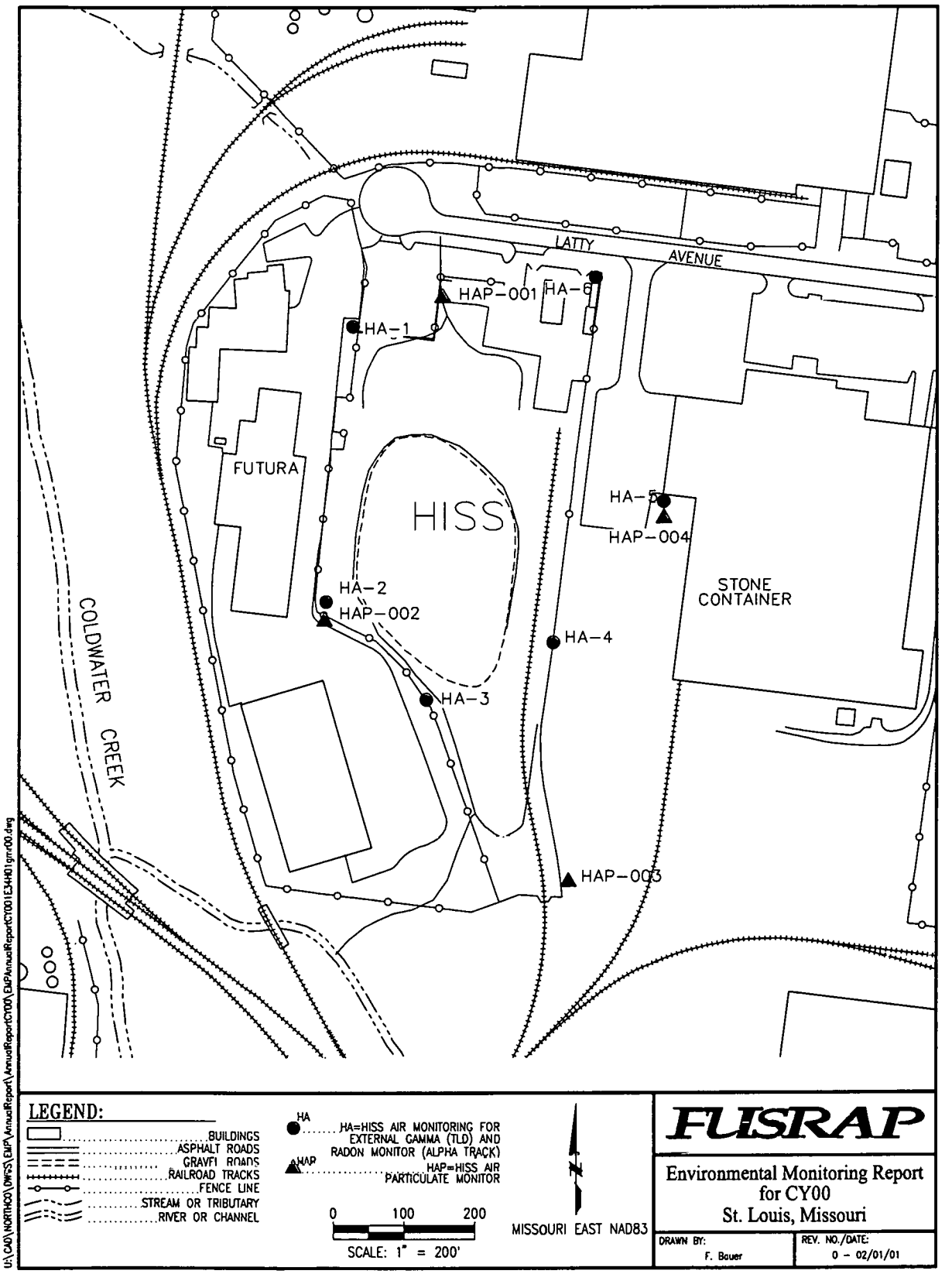

Figure 2-1. Gamma Radiation, Radon-222, and Particulate Air Monitoring Locations at the HISS

Airborne radon concentration is governed by emission rate and dilution factors, both of which are strongly affected by meteorological conditions. The soil surface radiological constituents are the largest source of radon. Secondary contributors include oceans, natural gas, geothermal fluids, volcanic gases, ventilation from caves and mines, and coal combustion. Radon levels in the atmosphere have been observed to vary with height above the ground, season, time of day, and location. The chief meteorological parameter governing airborne radon concentration is atmospheric stability; however, the largest variations in atmospheric radon occur spatially (EPA, 1987).

Radon ATDs are used at the SLS to measure alpha particles emitted from radon (primarily Rn-222) and its associated decay products. Radon ATDs are generally co-located with EMP TLDs 3 ft above the ground surface in housing shelters at the site boundaries.

2.2 HISS

2.2.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at HISS during CY00 at six locations around the perimeter of the site (see Figure 2-1). In addition to these locations, one background location in the North County area was utilized to compare on-site exposure and off-site background exposure. In January 2000, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for annual exposure. The program utilizes two TLDs at monitoring Station 1 (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring data for CY00 is found in Table 2-1. All quarterly monitoring data reported from the vendor was normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption for each monitoring location.

Table 2-1. External Gamma Radiation at HISS

Monitoring Location	Monitoring Station	First Quarter TLD Data[a] (mrem) Reported/Corrected	Second Quarter TLD Data[a] (mrem) Reported/Corrected	Third Quarter TLD Data[a] (mrem) Reported/Corrected	Fourth Quarter TLD Data[a] (mrem) Reported/Corrected	CY00 Net TLD Data[b] (mrem/yr)
HISS Perimeter	HA-1	0/0	26/5	31/0	25/6	11
	HA-2	24/26	34/15	34/0	29/10	51
	HA-3	14/15	30/10	42/0	33/16	42
	HA-4	15/16	32/13	52/5	40/25	59
	HA-5	18/20	32/13	22/0	20/0	32
	HA-6	0/0	18/0	20/0	17/0	0
Duplicate[c]	HA-6	0	18	22	17	---
Background		0/0	22/11	20[d]/0	20/8	---
Conference Room		0/0	20/0	21/0	16/0	0

[a] All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.
[b] CY00 Net TLD data are corrected for background and shelter absorption (s/a = 1.075).
[c] Duplicate sample results were not included in calculations.
[d] Background detector was lost for third quarter. Value is assumed to be equal to fourth quarter CY00 result (historically third and fourth quarter background values are similar).

Gamma radiation exposure measured at the perimeter fenceline assumes that a hypothetical public individual would be at the same locations 24 hours/day, 365 days/year. Off-site dose to the nearest member of the public is significantly affected based on their proximity to the gamma source and amount of time spent at the affected site. A more realistic approach to project dose is to evaluate members of the public as either residence-based or off-site worker-based receptors. A residence-based off-site exposure assumes a 100 percent occupancy rate at a given location. There are no public areas or residences near HISS, therefore, exposure to a residence-based receptor is greatly reduced due to the distance relative to the site. An off-site worker exposure assumes that a worker's occupancy rate is 23 percent, based on an 8 hour/day, 5 day/week, 50 week/year. The off-site worker-based receptor is a more realistic choice to represent the hypothetical maximally exposed individual because of the proximity of the receptor, approximately 50 m east of the HISS perimeter, and the time the individual will spend at this location. A realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 50 m east of the site) has been calculated at approximately 0.2 mrem/yr (SAIC, 2001a).

2.2.2 Evaluation of Airborne Radioactive Particulate Data

2.2.2.1 Air Sampling

Air sampling for particulate radionuclides was conducted at the HISS perimeter locations beginning in October 2000. Air particulate monitoring data is presented in Table 2-2 below. The monitoring locations are shown on Figure 2-1. Perimeter stations are located in accordance with the *Environmental Monitoring Implementation for the St. Louis Sites for Fiscal Year 01* (EMIFY01) (SAIC, 2000).

Table 2-2. Summary of HISS Air Particulate Data

Monitoring Location	Average Concentration (µCi/mL)	
	Gross Alpha	Gross Beta
HAP-001	2.03E-15	2.91E-14
HAP-002	2.02E-15	3.15E-14
HAP-003	2.09E-15	2.99E-14
HAP-004	1.96E-15	3.16E-14
Average Concentration	**2.02E-15**	**3.05E-14**

2.2.2.2 Estimation of Emissions in Accordance with the NESHAP

The St. Louis FUSRAP Sites CY00 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

The annual dose from radiological particulates to the hypothetical maximally exposed individual (50 m east of the site) has been calculated at approximately 2.1 mrem/yr (SAIC, 2001a and 2001f).

2.2.3 Evaluation of Airborne Radon Data

Radon emissions at HISS were monitored using two sampling methods during CY00. Perimeter monitoring using ATDs was used to evaluate ambient air concentrations of radon at the fenceline. Radon flux sampling was used to measure emission rates of radon from the surface of the contaminated soil piles. Descriptions of the methods are contained in Sections 2.2.3.1 and 2.2.3.2 and the monitoring results are summarized in Tables 2-3 and 2-4.

2.2.3.1 Radon-222 Monitoring

Airborne radon monitoring was performed at HISS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations as identified in Figure 2-1. In addition, one duplicate detector was placed at Station HA-6 for quality control purposes; one background detector located in the North County area and one detector was located within the HISS main trailer conference room to measure radon levels near high occupancy areas. The ATDs were installed in January 2000 at each monitoring location, collected for analysis after approximately 6 months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B, of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background at the site perimeter.

Although the average annual radon monitoring results (Table 2-3) are consistent with measured concentrations found in previous environmental monitoring data, the results from third and fourth quarters (including the background location) are slightly elevated. The elevated third and fourth quarter results are consistent with measurements observed in previous years and are assumed to be due to atmospheric conditions during the monitoring period. The monitoring data at the background station was also elevated during this time, which supports the hypothesis of the increase being due to atmospheric conditions. The average annual radon concentrations at HISS are below the 10 CFR 20 Appendix B regulatory criterion of 0.3 pCi/L.

Radon exposure to the receptor outlined in Section 2.2.1 (off-site worker 50 m east of the site perimeter) has been calculated at approximately 0.4 mrem/yr (SAIC, 2001a).

Table 2-3. Radon Gas (Rn-222) Concentrations at HISS

Monitoring Location	Monitoring Station	Average Annual Concentration (pCi/L)		
		01/20/00 to 07/03/00[a]	07/03/00 to 01/16/01[a]	Average Annual Concentration [b]
HISS Perimeter	HA-1	0.3	0.6	0.2
	HA-2	0.2	0.4	0.0
	HA-3	0.4	0.3	0.0
	HA-4	0.2	0.3	0.1
	HA-5	0.3	0.4	0.0
	HA-6	0.2	0.2	0.0
Duplicate[c]	HA-6	0.3	0.4	---
Background		0.4	0.2	---
Conference Room		0.2	0.2	0.0

[a] Detectors were installed and removed on the dates listed. Data is as reported from the vendor.
[b] Results reported from vendor for two periods are time-weighted and averaged to estimate year long average radon concentration (pCi/L) above background.
[c] A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

2.2.3.2 Radon Flux Monitoring

Radon flux monitoring was performed in September 2000 using 10-inch diameter activated charcoal canisters placed approximately 25 ft apart on a pre-determined grid. The canisters were sealed to the storage pile's cover surface for 24 hours, and then the canisters were retrieved and sent to an off-site laboratory for analysis in accordance with Appendix B of 40 CFR 61. Ninety-nine (99) locations were sampled on the HISS Main and Supplemental piles (Figure 2-2). Results from the sampling event are shown in Table 2-4.

The averages of the measurements (0.9 and 0.4 $pCi/m^2/s$, respectively) from the Main and Supplemental piles were well below the 40 CFR 192.02 regulatory criterion of 20 $pCi/m^2/s$. Rn-222 flux sampling results for CY00 at the storage piles are consistent with measured concentrations found in previous flux sampling data taken at HISS.

Table 2-4. Radon-222 Flux at HISS

Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)
MP-001	0.24	MP-029	0	MP-058	0.27	SP-009	0.09
MP-002	0.01	MP-030	0.1	MP-059	-0.45	SP-010	0
MP-003	0.81	MP-031	0.24	MP-060	0.67	SP-011	-0.04
MP-004	-0.09	MP-033	1.25	MP-061	0.01	SP-012	0.11
MP-005	0.01	MP-033[a]	-0.06	MP-062	-0.56	SP-013	-0.19
MP-005[a]	-0.24	MP-034	0.08	MP-063	-0.61	SP-014	0.08
MP-006	-0.02	MP-035	-0.07	MP-064	-0.1	SP-015	-0.08
MP-007	-0.27	MP-036	0.27	MP-065	0.14	SP-016	0.07
MP-008	-0.48	MP-037	0.27	MP-066	-0.15	SP-017	0.05
MP-009	0.2	MP-038	-0.22	MP-066[a]	0.01	SP-018	0.21
MP-010	1.65	MP-039	0.37	MP-067	0.13	SP-019	0.13
MP-011	2.72	MP-040	0.37	MP-068	-0.19	SP-020	-0.01
MP-012	0.1	MP-041	1.31	MP-069	-0.08	SP-021	0.28
MP-013	0.53	MP-042	0.08	MP-070	-0.02	SP-022	0.05

Table 2-4. Radon-222 Flux at HISS (Cont'd)

Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)	Sample Location/ID	Radon-222 Flux ($pCi/m^2/s$)
MP-014	0.87	MP-043	-0.1	MP-071	-0.15	SP-023	0.15
MP-015	0.41	MP-044	-0.36	MP-072	0.16		
MP-016	14.88	MP-045	-0.38	MP-073	-0.08		
MP-017	3.19	MP-045[a]	-0.09	MP-074	-0.13		
MP-018	0.27	MP-046	-0.19	MP-075	0.01		
MP-019	0.1	MP-047	-0.13	MP-076	0.12		
MP-020	-0.14	MP-048	0.15	MP-077	0.14		
MP-021	0.06	MP-049	-0.17	SP-001	0.09		
MP-022	0.19	MP-050	-0.11	SP-002	0.09		
MP-023	0.92	MP-051	0.09	SP-003	-0.13		
MP-024	0.4	MP-052	0.4	SP-004	0.13		
MP-025	0.5	MP-053	0.2	SP-005	0.17		
MP-025[a]	0.56	MP-054	0.26	SP-006	-0.12		
MP-026	-0.03	MP-055	0.17	SP-007	0.01		
MP-027	0.18	MP-056	-0.02	SP-008	0.05		
MP-028	0.03	MP-057	0.11	SP-008[a]	-0.19		

[a] The canisters are counted twice in the laboratory as quality control duplicates to evaluate analytical precision.

2.3 SLAPS

2.3.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at SLAPS during CY00 at six locations around the perimeter of the site (Figure 2-3). In addition to these locations one background monitoring station located in the North County area was utilized to compare on-site exposure and off-site background exposure.

In January 2000, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for the annual exposure. The program utilizes two TLDs at monitoring Station PA-4 (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring results for CY00 are found in Table 2-5. All quarterly monitoring data reported from the vendor was normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption for each monitoring location.

As at HISS, the off-site worker-based receptor is a more realistic choice to represent the hypothetically maximally exposed individual because of the proximity of the receptor, approximately 160 m south of the SLAPS perimeter, and the time the individual will spend at this location. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 160 m south of the site) has been calculated at approximately 0.1 mrem/yr (SAIC, 2001b).

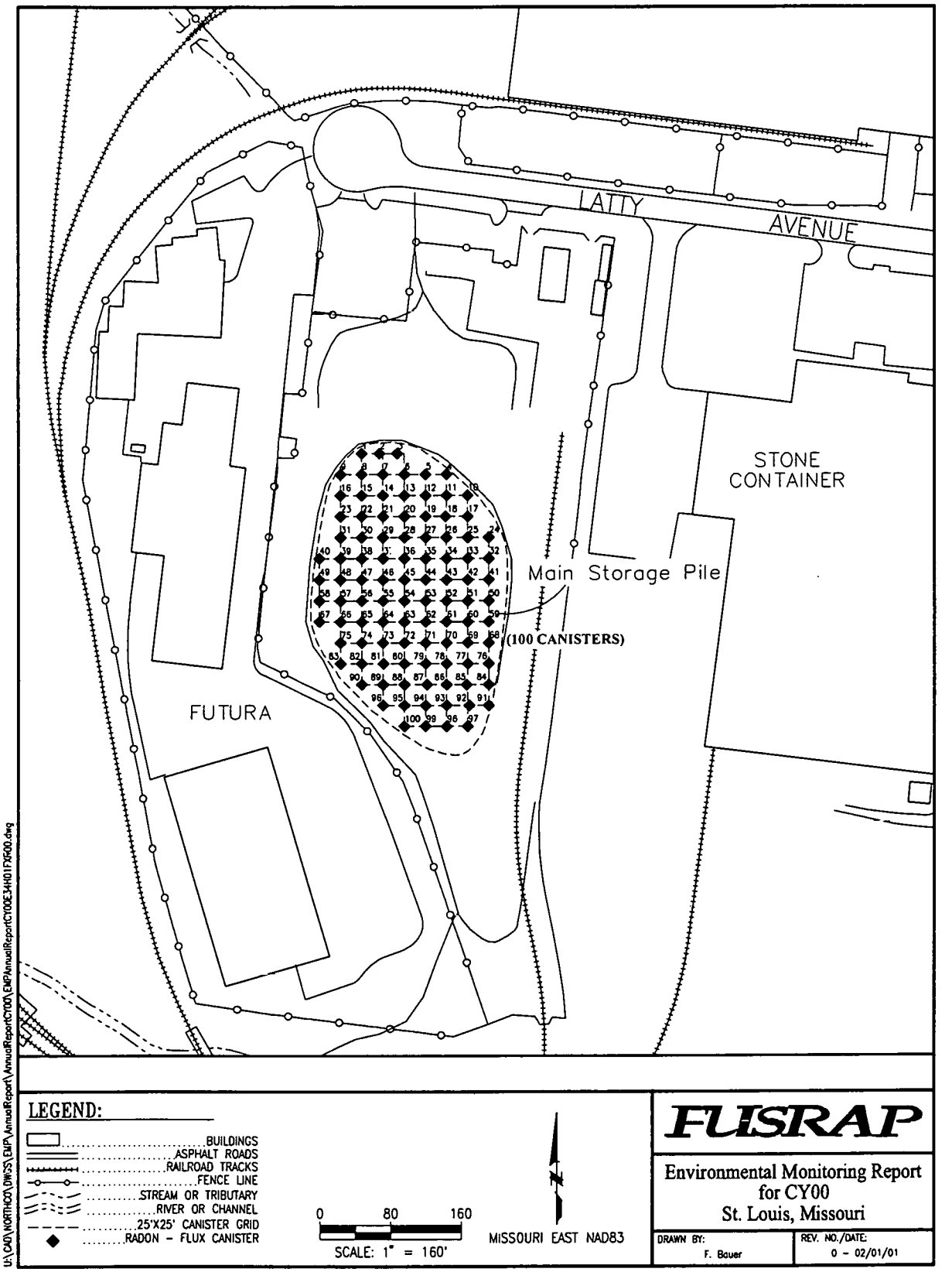

Figure 2-2. Radon Flux Monitoring Stations at the HISS

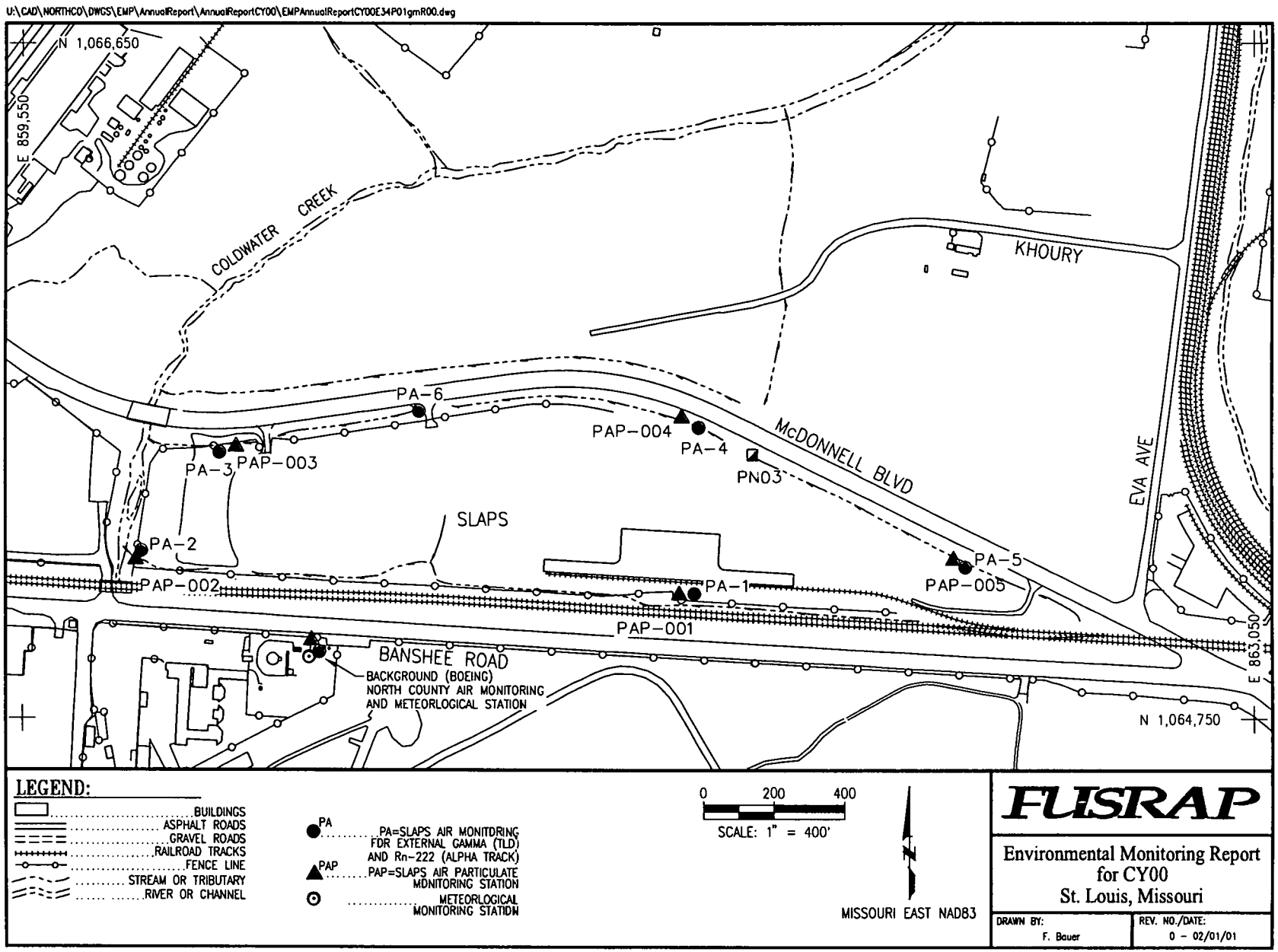

Figure 2-3. Gamma Radiation, Radon-222, and Particulate Air Monitoring Locations at the SLAPS

Table 2-5. External Gamma Radiation at SLAPS

Monitoring Location	Monitoring Station	First Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Second Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Third Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Fourth Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	CY00 TLD Data[b] (mrem/yr)
SLAPS Perimeter	PA-1	15/16	32/13	69/44	52/39	112
	PA-2	0/0	21/0	26/5	22/2	6
	PA-3	0/0	23/1	37/15	32/15	31
	PA-4	38/41	67/57	54/30	32/14	142
Duplicate[c]	PA-4	32	61	46	32	---
	PA-5	10/11	30/10	26/5	21/1	27
	PA-6	25/27	42/25	51/27	42/27	106
Background	---	0/0	22/28	20[d]/8	20/13	---

[a] All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.
[b] CY00 Net TLD data are corrected for background and shelter absorption (s/a = 1.075).
[c] Duplicate sample results were not included in calculations.
[d] Background detector was lost for third quarter. Value is assumed to be equal to fourth quarter CY00 result. Historically third and fourth quarter background values are similar.

2.3.2 Evaluation of Airborne Radionuclide Data

2.3.2.1 Air Sampling

Air sampling for radiological particulates was conducted at the SLAPS perimeter locations starting in January 2000. Air particulate monitoring data is presented in Table 2-6. The monitoring locations are shown on Figure 2-3.

Table 2-6. Summary of SLAPS Air Particulate Data

Monitoring Location	Average Concentration (µCi/mL)	
	Alpha	Beta
PAP-001	5.88E-15	4.02E-14
PAP-002	2.04E-15	3.74E-14
PAP-003	2.18E-15	4.11E-14
PAP-004	4.83E-15	4.04E-14
PAP-005	2.73E-15	4.60E-14
Average Concentration	**3.53E-15**	**4.10E-14**

2.3.3 Estimation of Emissions in Accordance with the NESHAP

The St. Louis FUSRAP Sites CY00 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

The annual dose from radiological air particulates to the hypothetical maximally exposed individual (160 m south of the site perimeter) has been calculated at approximately 6.4 mrem/yr (SAIC, 2001b and 2001f).

2.3.4 Evaluation of Airborne Radon Data

Airborne radon monitoring was performed at SLAPS using ATDs placed around the site perimeter to measure radon emissions from the site. Six detectors were co-located with TLD locations as identified in Figure 2-3. One additional detector was located at monitoring Station PA-4 as a quality control duplicate and one background detector was located in the North County area. The track etch detectors were placed at all monitoring locations in January 2000. The detectors were collected for analysis after approximately 6 months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B, of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background.

Although significant remediation activities occurred at SLAPS during CY00, Rn-222 monitoring results at SLAPS (see Table 2-7) show minimal impact from these activities and are consistent with measured concentrations found in previous environmental monitoring data taken at the site.

Radon exposure to the receptor outlined in Section 2.2.1 (off-site worker 160 m south of the sitc perimeter) has been calculated at approximately 0.1 mrem/yr (SAIC, 2001b).

Table 2-7. Radon Gas (Rn-222) Concentrations at SLAPS

Monitoring Location	Monitoring Station ID#	Average Annual Concentration (pCi/L)		
		01/20/00 to 07/03/00[a] (uncorrected)	07/03/00 to 01/16/01[a] (uncorrected)	Average Annual Concentration[b]
SLAPS perimeter	PA-1	0.5	0.3	0.1
	PA-2	0.3	0.3	0.0
	PA-3	0.2	0.4	0.0
	PA-4	0.9	0.4	0.3
Duplicate[c]	PA-4	0.8	0.4	---
	PA-5	0.2	0.8	0.2
	PA-6	0.3	0.4	0.0
Background		0.3	0.2	---

[a] Detectors were installed and removed on the dates listed. Data is as reported from the vendor.
[b] Results reported from vendor for two periods are time-weighted and averaged to estimate year long average radon concentration (pCi/L) above background.
[c] A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

2.4 SLDS

2.4.1 Evaluation of Gamma Radiation Data

Gamma radiation monitoring was performed at SLDS during CY00 at five locations around the perimeter of the Mallinckrodt plant (see Figure 2-4). In addition to these locations, one background monitoring station located in the North County area was utilized to compare on-site and off-site background exposure.

In January 2000, one environmental TLD was placed at each monitoring location and replaced quarterly to provide input for annual exposure. The program utilizes two TLDs at monitoring Station DA-1 (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring results for CY00 are presented in Table 2-8. All quarterly monitoring data reported from the vendor has been normalized to exactly one quarter's exposure. Net monitoring results (average normalized location reading minus average normalized background reading) were also corrected for shelter absorption at each monitoring location.

Table 2-8. External Gamma Radiation at SLDS

Monitoring Location	Monitoring Station	First Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Second Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Third Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	Fourth Quarter TLD Data[a] (mrem/qtr) Reported/ Corrected	CY00 TLD Data[b] (mrem/yr)
SLDS Perimeter	DA-1	10/11	23/1	25/4	22/2	18
Duplicate[c]	DA-1	10	23	24	24	---
	DA-2	0/0	20/0	23/2	20/0	2
	DA-3	28/30	26/6	37/15	28/9	15
	DA-4	0/0	22/0	26/5	21/1	6
	DA-5	0/0	20/0	15/0	19/0	0
Background	---	0	22	20[d]	20	---

[a] All quarterly data reported from the vendor has been normalized to exactly one quarter's exposure above background.
[b] CY00 Net TLD data are corrected for background and shelter absorption (s/a = 1.075).
[c] Duplicate sample results were not included in calculations.
[d] Background detector was lost for third quarter. Value is assumed to be equal to fourth quarter CY00 result (historically third and fourth quarter background values are similar).

As at HISS and SLAPS, the off-site worker-based receptor is a more realistic choice to represent the hypothetical maximally exposed individual because of the proximity of the receptor, approximately 50 m southeast of the SLDS, and the time the individual will spend at this location. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source. Based on this methodology, the annual dose from external gamma radiation to the hypothetical maximally exposed individual (the nearest off-site worker, 50 m southeast of the site perimeter) has been calculated at 0.0 mrem/yr (SAIC, 2001c).

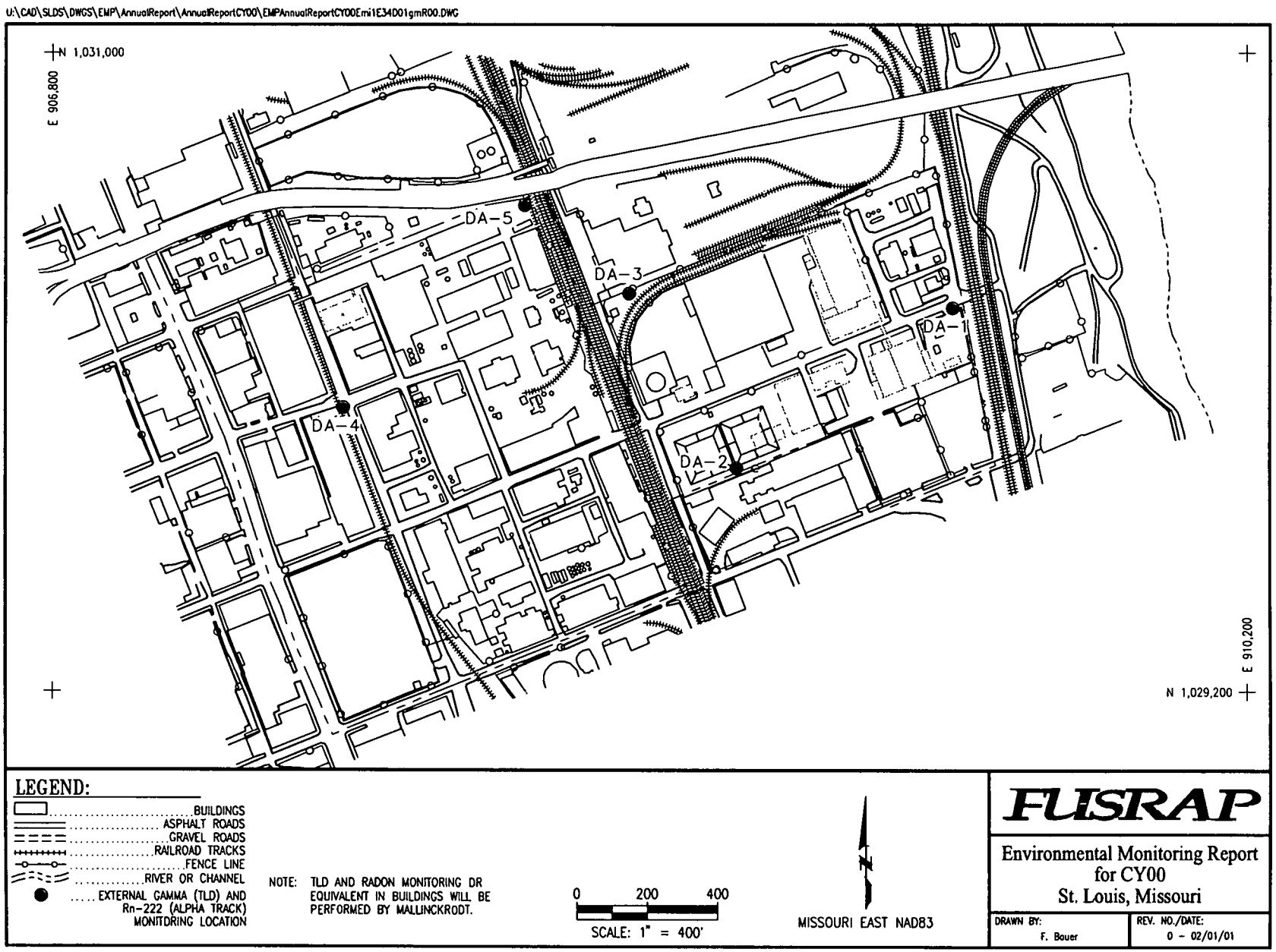

Figure 2-4. Gamma Radiation, Radon-222 Locations at the SLDS

2.4.2 Evaluation of Airborne Radionuclide Data

2.4.2.1 Air Sampling

Air sampling for radiological particulates was not conducted at SLDS perimeter locations during CY00 due to the insignificant potential for material to become airborne at the site. The ground surface at SLDS is generally covered with asphalt or concrete, which limits the potential for material to become airborne. Air sampling for radiological particulates is conducted at the perimeter of each excavation within the SLDS. Air particulate monitoring data from excavation perimeters is presented in Table 2-9.

Table 2-9. Summary of SLDS Air Particulate Data

Monitoring Location	Average Concentration (µCi/mL)	
	Alpha	Beta
Plant 1	1.36E-14	1.30E-13
Plant 2	1.03E-14	1.21E-13
Average Concentration (excavations)[1]	**1.2E-14**	**1.26E-13**

[1] Average of all excavation perimeter monitoring at Plant 1 and Plant 2 during CY00.

2.4.2.2 Estimation of Emissions in Accordance with NESHAP

The St. Louis FUSRAP Sites CY00 NESHAPs Report presents results from calculations of the effective dose equivalent from radionuclide emissions to critical receptors in accordance with the NESHAPs. The report follows the requirements and procedures contained in 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

The annual dose from radiological air particulates to the hypothetical maximally exposed individual (50 m southeast of the site) has been calculated at less than 0.1 mrem/yr (SAIC, 2001c and 2001f).

2.4.3 Evaluation of Airborne Radon Data

Airborne radon monitoring was performed at SLDS using ATDs placed around the perimeter of the Mallinckrodt plant to measure radon emissions. Five detectors were co-located with TLD locations as identified previously in Figure 2-4. One additional detector was located at monitoring Station DA-1 as a quality control duplicate, and one background detector was located in the North County area. The track etch detectors were placed at each monitoring location in January 2000 and were collected for analysis after approximately 6 months of exposure, and replaced with another set that would represent radon exposure for the rest of the year. Recorded radon concentrations are listed in picocuries per liter (pCi/L), and are evaluated based on the regulatory criterion listed in 10 CFR 20, Appendix B of 0.3 pCi/L (at 30% equilibrium) average annual concentration above background at the site perimeter.

Although significant remediation activities occurred at SLDS during CY00, radon monitoring results at SLDS (Table 2-10) show minimal impact from these activities and are consistent with measured concentrations found in previous environmental monitoring data collected at the site.

Radon exposure to the receptor outlined in Section 2.4.1 (off-site worker 50 m southeast of the site perimeter) has been calculated at approximately 0.0 mrem/yr (SAIC, 2001c).

Table 2-10. Radon Gas Concentrations at SLDS during CY00

Monitoring Location	Monitoring Station ID#	Average Annual Concentration (pCi/L)		
		01/19/00 to 06/30/00[a]	06/30/00 to 01/16/01[a]	Average[b]
SLDS perimeter	DA-1	0.2	0.2	0.0
Duplicate [c]	DA-1	0.3	0.3	---
	DA-2	0.3	0.2	0.0
	DA-3	0.2	0.2	0.0
	DA-4	0.2	0.3	0.0
	DA-5	0.2	0.2	0.0
Background	---	0.3	0.2	---

[a] Detectors were installed and removed on the dates listed. Data is as reported from the vendor.

[b] Results reported from vendor for two periods are time-weighted and averaged to estimate year long average radon concentration (pCi/L) above background.

[c] A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

3.0 CY00 WASTE-WATER, STORM-WATER, SURFACE-WATER, AND SEDIMENT SAMPLING

This section will provide a description of the storm-water monitoring activities at SLS, the Coldwater Creek sediment monitoring activities, and the Coldwater Creek surface-water monitoring activities for CY00. The results obtained from these monitoring activities are presented and evaluated with respect to historical data and the appropriate investigative limits.

3.1 WASTE-WATER AND STORM-WATER DISCHARGE MONITORING RESULTS DURING CY00

This section provides a description of the storm-water monitoring activities conducted at the SLS during CY00. The monitoring results obtained from these activities are presented and compared with the investigative limits presented in the EMIFY01 (SAIC, 2000). The purpose of storm-water and waste-water discharge sampling at SLS, is to maintain compliance with the storm-water discharge requirements. These requirements are set by the Missouri Department of Natural Resources (MDNR) - NPDES permit number MO-0111252 for HISS, the MDNR-NPDES ARAR (permit equivalent) document dated October 2, 1998, for SLAPS (permit equivalent document), and MSD discharge authorization letter, dated October 30, 1998 for SLDS. The storm-water sampling results for HISS and SLAPS demonstrate compliance with 10 CFR 20.1302, 10 CSR 20-7.031, and with permitted requirements and conditions. Waste-water sampling results for SLDS demonstrate compliance with 10 CFR 20.2003 and requirements listed in the MSD discharge authorization letter for SLDS.

3.1.1 Evaluation of the CY00 Waste-water Discharge Monitoring Results at SLDS

Storm-water and waste-water effluents at the Mallinckrodt plant are discharged via combined sewers to the Bissell Point Sewage Treatment Plant under a local use permit for a significant industrial user. Monitoring of the combined effluent for compliance with permit limits is the responsibility of Mallinckrodt, Inc. and is not addressed under the EMP. In October CY98, the St. Louis MSD issued a separate local use permit for discharges of run-off, ground-water infiltration, or treated water from other accumulated waste water that result from USACE remedial activities. The purpose of the storm-water and waste-water discharge sampling at SLDS is to verify compliance with the MSD discharge authorization letter.

The pollutants identified in the local permit include: pH, settleable solids, chemical oxygen demand (COD), and metal parameters (total values), with numeric limits established in Ordinance 8472 Article V, Section Two, B. Also identified in the local permit are volatile organic compounds, (VOCs) by waste-water Method 624; semivolatile organic compounds (SVOCs) by Method 625; polychlorinated biphenyls (PCBs) by Method 608; gross alpha radioactivity; gross beta radioactivity; U-235; U-238; Ra-226; Ra-228; Th-230; and Th-232.

During CY00, approximately 1,457,504 gallons of waste water were discharged to MSD Base Map Inlet 17D3-022C (see Figure 3-1). All batches were discharged in accordance with the MSD authorization letter, which specifies application of treatment to achieve drinking water standards before release to the MSD sewer system. During all four quarters with discharge during CY00, gross beta values were observed at concentrations greater than the MSD limit of 50 picocuries per gram (pCi/g). This was the only parameter to exceed the MSD authorization letter limit during CY00 (Appendix A, Table A-1). These elevated beta results at SLDS were due to the presence of naturally occurring K-40 in the surface water pumped from the excavations. The presence of K-40 is also attributed to discharges by Mallinckrodt, Inc. during routine maintenance at their potassium-chloride facility.

The waste-water discharges from SLDS to the sanitary sewer system complied with the four criteria required in 10 CFR 20.2003. The criteria are as follows:

- The material is readily soluble in water;
- The monthly average concentration released does not exceed the concentration listed in 10 CFR 20, Appendix B, Table 3;
- The sum of the fractions for each radionuclide does not exceed unity; and
- The total quantity of radioactive material released into the sanitary sewer does not exceed one curie (Ci).

CY00 was the second year that waste-water discharges at SLDS were monitored and recorded under the MSD authorization letter. Therefore, a historical comparison for SLDS data can be made. Total activity discharge for the CY00 is 1.15E-05 curies for thorium, 6.25E-06 curies for uranium, and 3.07E-06 curies for radium. Results from CY99 yielded similar values, with a total activity discharge of 1.65E-05 curies for thorium, 8.72E-06 curies for uranium, and 2.75E-06 curies for radium. Data indicates that the nature of the waste water has been consistent for the past two years.

3.1.2 Evaluation of the CY00 Storm-water Discharge Monitoring Results at SLAPS

During CY00, storm-water sampling at SLAPS was conducted to meet the NPDES ARAR discharge limits. Currently, there are three NPDES outfalls at SLAPS: Outfalls 001, 002, and 003 (Figure 3-2). For environmental monitoring purposes, these outfalls have been assigned the station identifications PN01 for Outfall 001, PN02 for Outfall 002, and PN03 for Outfall 003. In the fall of CY98, the MDNR issued discharge requirements for three outfalls at SLAPS, in conjunction with the proposed construction of a sedimentation basin at the site. The first outfall covers the discharge requirements from the normal discharge conveyance for the sedimentation basin located at the southwest corner of the site and the emergency spillway located in the northwest portion of the site near historical Outfall STW-001 (Figure 3-3). To distinguish discharge points at Outfall PN01, a designation of "a" or "b" is given. Location PN01a designates normal discharge from the sedimentation basin, while PN01b designates discharge from the emergency spillway. PN02 is located at the termination of a drainage way that parallels McDonnell Boulevard along its north side. The third outfall, PN03, addressed by these discharge requirements, drains the eastern end of SLAPS and conveys this run-off to Coldwater Creek in a drainage ditch that travels northward through the ballfields. The monitoring station, for this outfall, is located just before the drainage ditch crosses under McDonnell Boulevard, after leaving the site.

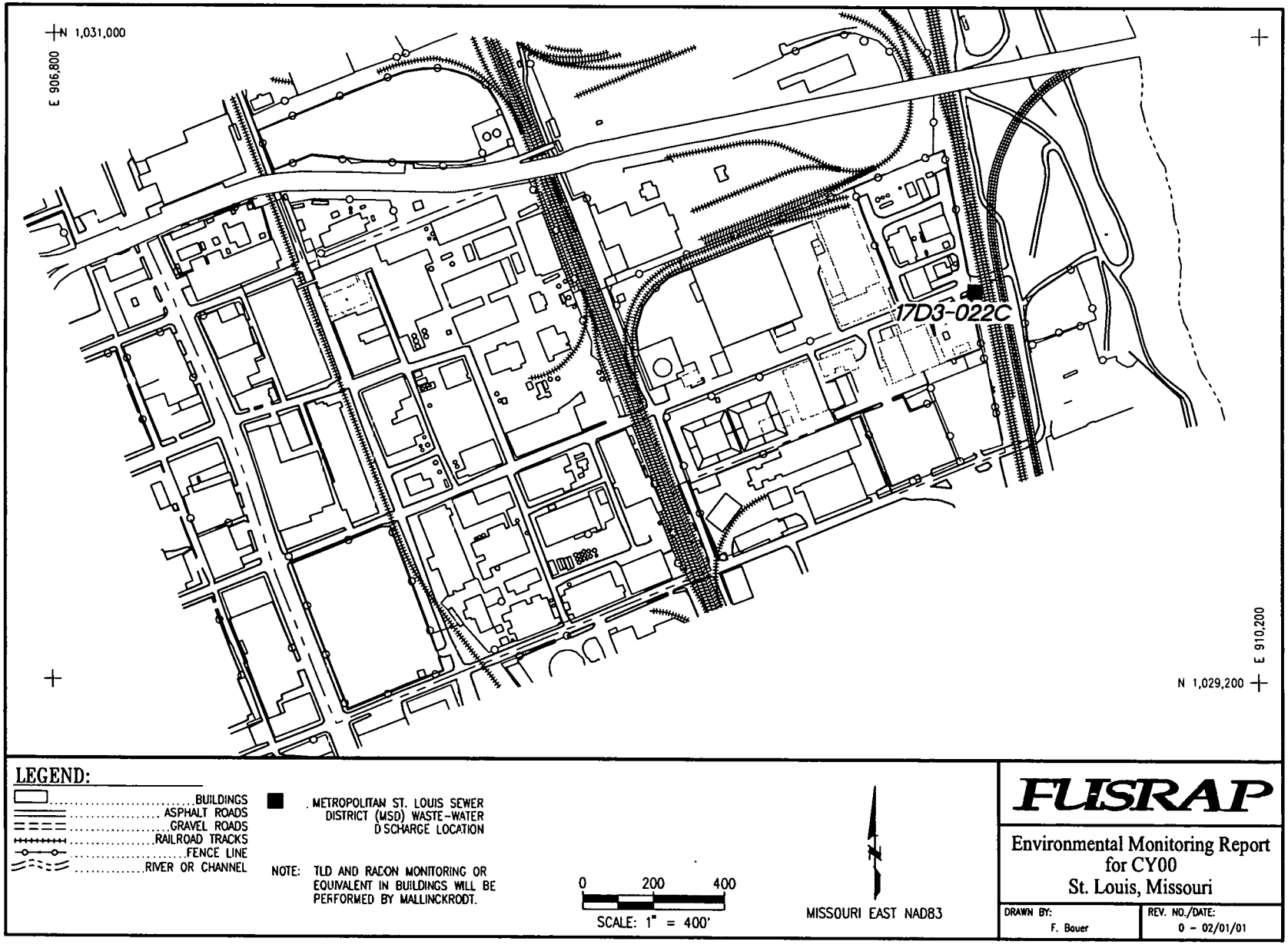

Figure 3-1. Waste-water Discharge Station at the SLDS

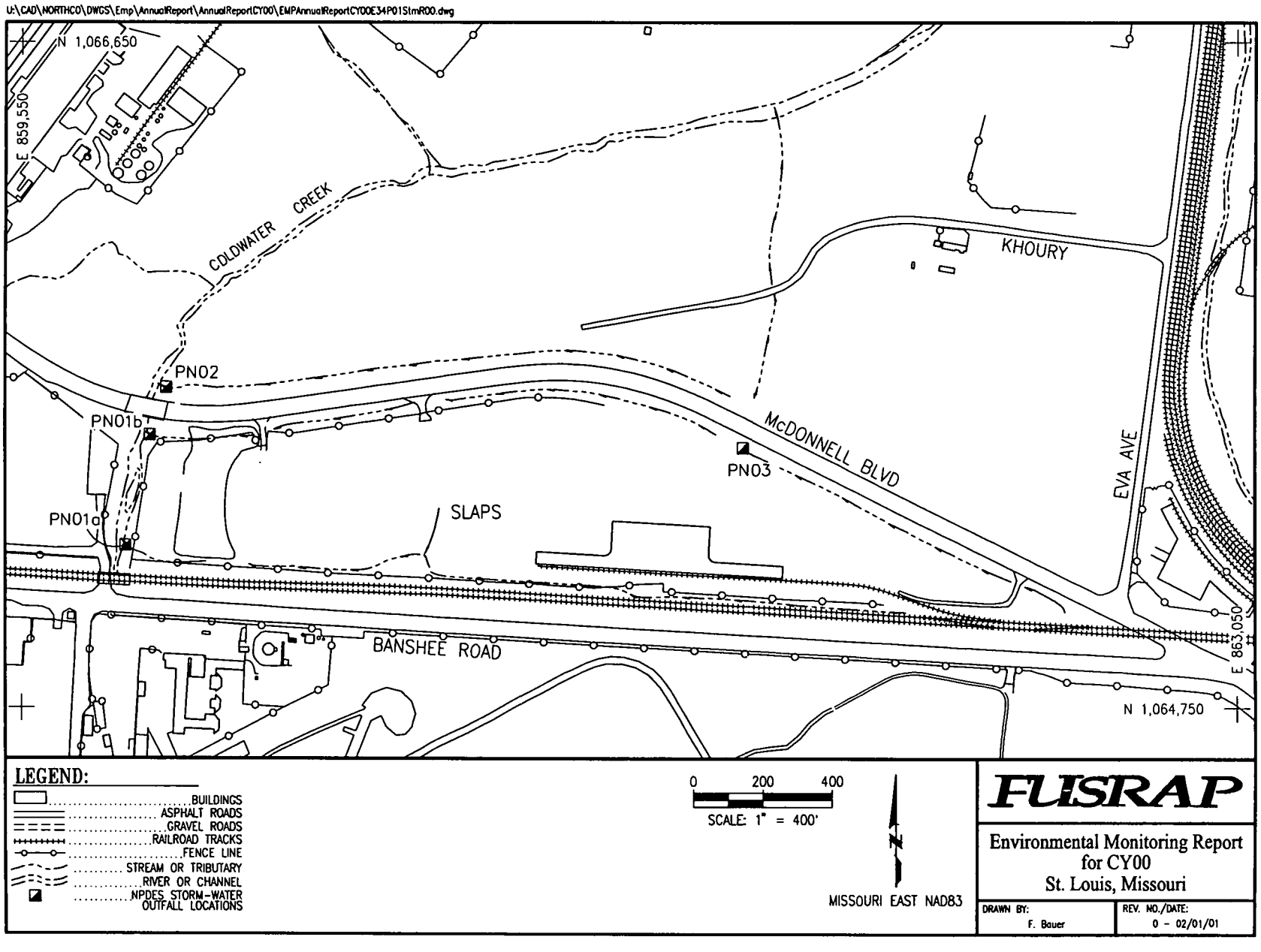

Figure 3-2. Current Storm-water Outfalls at the SLAPS

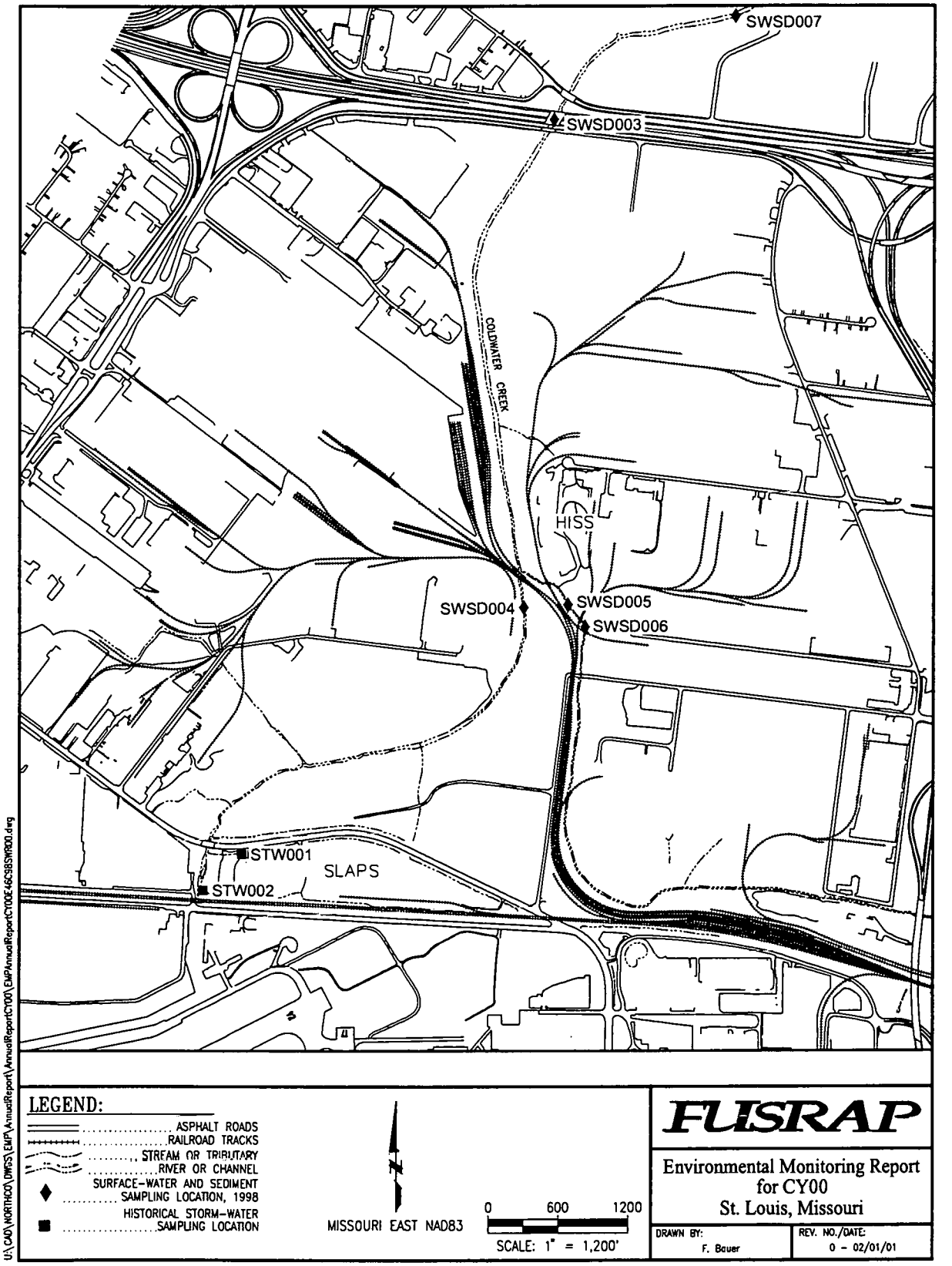

Figure 3-3. Historical Storm-water, Surface-water and Sediment Sampling Locations for SLAPS

Under the discharge limits issued by the MDNR in October of CY98, monthly monitoring is required for oil and grease (no longer done), total petroleum hydrocarbons, pH, COD, total settleable solids, arsenic, lead, chromium, copper, cadmium, PCBs, total uranium, total thorium, gross alpha, gross beta, protactinium-231 (Pa-231), and actinium-227 (Ac-227). In addition, effluent monitoring for gross alpha, gross beta, Pa-231, Ac-227, radium, thorium, and uranium is required for each discharge event. Radon monitoring is required twice a year. Monthly monitoring of oil and grease is no longer conducted as the laboratory has difficulties in completing this analysis. The client decided that the monitoring of this parameter was not critical to the project. This information may be referenced in the letter dated October 23, 1999, from USACE to MDNR (USACE, 1999c). Tables 3-1 through 3-4 present quarterly SLAPS monitoring for CY00. Rainfall and flow data can be found in Table A-5 of Appendix A. A summary of CY00 events for SLAPS storm-water monitoring follows.

First Quarter Summary

During the first quarter of CY00, there were three rainfall events recorded. No events were recorded for January. Compliance samples were collected during the first event on February 18, 2000, from PN01a, PN02, and PN03. The combination of excessive rainfall volume and velocity disabled the water management practices in effect at the time. Sediment curtains and filter bales were either eroded or washed away. Further, the lack of ground cover exacerbated this condition, resulting in an exceedance of the allowable limit for settleable solids. Corrective measures followed the engineering on-site controls cited in the *Water Management Plan FUSRAP SLAPS* (USACE, 2000d).

For all three outfalls, sample data results indicated an exceedance of the daily maximum limit of 1.5 milliliter per liter per hour (ml/L/hr) for settleable solids. Reported results were as follows: 10.7 ml/L/hr for PN01a, 40 ml/L/hr for PN02, and 8 ml/L/hr for PN03. At the time of this event, holding tanks for potentially contaminated water were being placed and leveled. No ground cover was in place. This activity exacerbated the sediment load, which had already overwhelmed normal conditions due to the magnitude of the rain event. Chemical sample data results indicated that total recoverable copper, reported as 88.6 µg/L, exceeded the allowable limit of 84 µg/L. Both USACE and MDNR agreed that the exceedance was marginal and therefore required no written notification. All other parameters measured during the first quarter sampling events were within discharge limits. Samples were collected when flow permitted.

Second Quarter Summary

During the second quarter of CY00, there were seven rainfall events, with record rainfall experienced in the month of June. Three separate non-compliances were reported in the second quarter for the settleable solids at PN03. Corrective measures were undertaken to avoid future non-compliances from occurring. The corrective measures included flushing the culvert pipe at the discharge point; upgrading the sampling access area; replacing the rock check dam near the outfall and adding additional silt flencing. Chemical sample data results were all within the permit specified limits.

Table 3-1. First Quarter Storm-water Discharge Monitoring for Parameters at SLAPS during CY00

PN01a					
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results		
			Event 1 2/18/00-2/22/00	Event 2 3/19/00-3/20/00	Event 3 3/27/00-3/29/00
Uranium, Total[1,2,3]	µg/L	*	210	200	300
Radium, Total[1,2,3]	µg/L	*	1.8E-04	5E-06	4E-06
Thorium, Total[1,2,3]	µg/L	*	6.0	1.0	4.0
Gross Alpha[1]	pCi/L	*	0.03	90	200
Gross Beta[1]	pCi/L	*	34	40	25
Protactinium-231[1]	pCi/L	*	2.0	0.07	0.03
Actinium-227[1]	pCi/L	*	2.0	0.07	0.03
Radon (semi-annual monitoring)[1]	pCi/L		210	NS	NS

PN01a					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			January	February	March
Oil and Grease	mg/L	10	NF	ND	ND
Total Petroleum Hydrocardons	mg/L	10	NF	ND	ND
pH	SU	6-9.0	NF	7.9	7.6
Chemical Oxygen Demand	mg/L	90	NF	30	ND
Settleable Solids[4]	ml/L/hr	1.0	NF	ND	ND
Arsenic, Total Recoverable	µg/L	100	NF	8.3	ND
Lead, Total Recoverable	µg/L	190	NF	35.3	ND
Chromium, Total Recoverable	µg/L	280	NF	18.3	ND
Copper, Total Recoverable	µg/L	84	NF	31	ND
Cadmium, Total Recoverable	µg/L	94	NF	ND	ND
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	ND

PN02				
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results	
			Event 1 2/18/00	Event 2 3/19/00-3/20/00
Uranium, Total[1,2,3]	µg/L	*	21	7.0
Radium, Total[1,2,3]	µg/L	*	8E-06	1E-06
Thorium, Total[1,2,3]	µg/L	*	11	6.0
Gross Alpha[1]	pCi/L	*	13	7.0
Gross Beta[1]	pCi/L	*	24	11
Protactinium-231[1]	pCi/L	*	0.06	0.03
Actinium-227[1]	pCi/L	*	0.06	0.03
Radon (semi-annual monitoring)[1]	pCi/L		5.37[7]	NS

PN02					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			January	February	March
Oil and Grease	mg/L	10	NF	ND	ND
Total Petroleum Hydrocarbons	mg/L	10	NF	ND	ND
pH	SU	6-9.0	NF	Not reported[6]	7.1
Chemical Oxygen Demand	mg/L	90	NF	6.0	30
Settleable Solids[4]	ml/L/hr	1.0	NF	4.2	ND
Arsenic, Total Recoverable	µg/L	100	NF	15.2	ND
Lead, Total Recoverable	µg/L	190	NF	21.1	ND
Chromium, Total Recoverable	µg/L	280	NF	43.3	0.008
Copper, Total Recoverable	µg/L	84	NF	37.1	0.014
Cadmium, Total Recoverable	µg/L	94	NF	ND	ND
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	ND

Table 3-1. First Quarter Storm-water Discharge Monitoring for Parameters at SLAPS during CY00 (Cont'd)

PN03			
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results
			Event 1 2/18/00
Uranium, Total[1,2,7]	µg/L	*	49
Radium, Total[1,2,7]	µg/L	*	13
Thorium, Total[1,2,7]	µg/L	*	14
Gross Alpha[1]	pCi/L	*	17.3
Gross Beta[1]	pCi/L	*	51
Protactinium-231[1]	pCi/L	*	12
Actinium-227[1]	pCi/L		12
Radon (semi-annual monitoring)[1]	pCi/L		52.9[7]

PN03					
Monitoring Parameter	Units	Effluent Limitations	Chemical Results		
			January	February	March
Oil and Grease	mg/L	10	NF	ND	NF
Total Petroleum Hydrocarbons	mg/L	10	NF	ND	NF
pH	SU	6-9.0	NF	ND	NF
Chemical Oxygen Demand	mg/L	90	NF	22	NF
Settleable Solids[4]	ml/L/hr	1.0	NF	13.5	NF
Arsenic, Total Recoverable	µg/L	100	NF	35.2	NF
Lead, Total Recoverable	µg/L	190	NF	45	NF
Chromium, Total Recoverable	µg/L	280	NF	83.9	NF
Copper, Total Recoverable	µg/L	84	NF	88.6	NF
Cadmium, Total Recoverable	µg/L	94	NF	ND	NF
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	NF

[1]* Discharge requirements for radionuclides only require monitoring.

[2] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of the Health Physics and Radiological Health Handbook (Schleien, 1992).

[3] Calculated Estimates

[4] Detection Limit = 0.1 ml/L/hr

[5] Detection Limit = 1.0 µg/L

[6] Lab did not report the data as requested on the chain of custody. Total volume of sample was utilized and this error could not be corrected. Data from onsite lab used for reporting.

[7] For radiological data reported by the laboratory as a non-detect, the information has been given the minimum detectable activity number for this report.

NS = not sampled during this reporting period. Semi-annual reporting requirement only.

NF = No Flow

ND = Non-detect

SU = Standard Unit

Table 3-2. Second Quarter Storm-water Discharge Monitoring for Parameters at SLAPS During CY00

PN01a							
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results				
			Event 1 4/7/00-4/10/00	Event 2 5/7/00-5/12/00	Event 3 5/23/00-5/26/00	Event 4 5/27/00-6/01/00	Event 5 6/5/00-6/6/00
Uranium, Total[1,2,3]	µg/L	*	270	440	290	650	1500
Radium, Total[1,2,3]	µg/L	*	2E-06	8E-04	2E-04	3E-04	1E-06
Thorium, Total[1,2,3]	µg/L	*	2.0	2.0	2.0	0.01	0.002
Gross Alpha[1]	pCi/L	*	130	1000	340	450	840
Gross Beta[1]	pCi/L	*	50	200	50	70	150
Protactinium-231[1]	pCi/L	*	0.1	7.0	2.0	3.0	0.05
Actinium-227[1]	pCi/L	*	0.1	7.0	2.0	3.0	0.05

PN01a				
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results	
			Event 6 6/11/00-6/17/00	Event 7 6/21/00-6/30/00
Uranium, Total[1,2,3]	µg/L	*	670	390
Radium, Total[1,2,3]	µg/L	*	8E-06	3E-06
Thorium, Total[1,2,3]	µg/L	*	2.0	5.0
Gross Alpha[1]	pCi/L	*	400	290
Gross Beta[1]	pCi/L	*	40	30
Protactinium-231[1]	pCi/L	*	0.05	0.2
Actinium-227[1]	pCi/L	*	0.05	0.02

PN01a					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			April	May	June
Oil Grease	mg/L	10	1.1	0.00	1.8
Total Petroleum Hydrocarbons	mg/L	10	1.1	0.00	ND
pH	SU	6-9.0	7.6	7.8	7.4
Chemical Oxygen Demand	mg/L	90	5.0	10.8	19.1
Settleable Solids[4]	ml/L/hr	1.0	0.1	0.2	0.1
Arsenic, Total Recoverable	µg/L	100	0.03	0.00	ND
Lead, Total Recoverable	µg/L	190	0.03	0.00	ND
Chromium, Total Recoverable	µg/L	280	0.01	0.01	ND
Copper, Total Recoverable	µg/L	84	0.01	0.03	0.01
Cadmium, Total Recoverable	µg/L	94	0.01	0.00	ND
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	ND	ND	ND

PN02							
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results				
			Event 1	Event 2 5/7/00	Event 3	Event 4 5/27/00	Event 5
Uranium, Total[1,2,3]	µg/L	*	NF	7.0	NF	0.00[7]	NF
Radium, Total[1,2,3]	µg/L	*	NF	1. E-06	NF	1E-06	NF
Thorium, Total[1,2,3]	µg/L	*	NF	6.0	NF	4.0	NF
Gross Alpha[1]	pCi/L	*	NF	2.0	NF	1.01	NF
Gross Beta[1]	pCi/L	*	NF	6.0	NF	0.00[7]	NF
Protactinium-231[1]	pCi/L	*	NF	0.03	NF	0.02	NF
Actinium-227[1]	pCi/L	*	NF	0.03	NF	0.02	NF

Table 3-2. Second Quarter Storm-water Discharge Monitoring for Parameters at SLAPS During CY00 (Cont'd)

PN02				
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results	
			Event 6 6/12/00	Event 7 6/24/00-6/26/00
Uranium, Total[1,2,3]	µg/L	*	0.00[7]	0.00[7]
Radium, Total[1,2,3]	µg/L	*	0.00[7]	5E-07
Thorium, Total[1,2,3]	µg/L	*	2.0	2.0
Gross Alpha[1]	pCi/L	*	8.0	5.0
Gross Beta[1]	pCi/L	*	3.0	0.4
Protactinium-231[1]	pCi/L	*	0.01	0.03
Actinium-227[1]	pCi/L	*	0.01	0.03

PN02					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			April	May	June
Oil Grease	mg/L	10	NF	0.00	1.9
Total Petroleum Hydrocarbons	mg/L	10	NF	0.00	ND
pH	SU	6-9.0	NF	7.2	6.4
Chemical Oxygen Demand	mg/L	90	NF	0.00	ND
Settleable Solids[4]	ml/L/hr	1.0	NF	0.4[6]	0.1[6]
Arsenic, Total Recoverable	µg/L	100	NF	0.00	ND
Lead, Total Recoverable	µg/L	190	NF	0.00	ND
Chromium, Total Recoverable	µg/L	280	NF	0.01	ND
Copper, Total Recoverable	µg/L	84	NF	0.01	0.02
Cadmium, Total Recoverable	µg/L	94	NF	0.00	ND
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	ND

PN03							
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results				
			Event 1	Event 2 5/7/00-5/10/00	Event 3 5/23/00-5/24/00	Event 4 5/27/00-5/29/00	Event 5
Uranium, Total[1,2,3]	µg/L	*	NF	30	95	70	NF
Radium, Total[1,2,3]	µg/L	*	NF	3E-05	7E-05	8E-05	NF
Thorium, Total[1,2,3]	µg/L	*	NF	6.0	2.0	8.0	NF
Gross Alpha[1]	pCi/L	*	NF	60	160	100	NF
Gross Beta[1]	pCi/L	*	NF	30	33	30	NF
Protactinium-231[1]	pCi/L	*	NF	0.2	0.68	0.7	NF
Actinium-227[1]	pCi/L	*	NF	0.2	0.68	0.2	NF

Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results	
			Event 6 6/14/00-6/16/00	Event 7 6/21/00, 6/24/00-6/28/00
Uranium, Total[1,2,3]	µg/L	*	47	110
Radium, Total[1,2,3]	µg/L	*	1. E-06	3.9E-06
Thorium, Total[1,2,3]	µg/L	*	2.0	2.0
Gross Alpha[1]	pCi/L	*	50	130
Gross Beta[1]	pCi/L	*	0.00[7]	20
Protactinium-231[1]	pCi/L	*	0.1	0.7
Actinium-227[1]	pCi/L	*	0.1	0.6

Table 3-2. Second Quarter Storm-water Discharge Monitoring for Parameters at SLAPS During CY00 (Cont'd)

PN03					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			April	May	June
Oil Grease	mg/L	10	NF	0.00	2.4
Total Petroleum Hydrocarbons	mg/L	10	NF	0.00	1.5
pH	SU	6-9.0	NF	7.5	7.2
Chemical Oxygen Demand	mg/L	90	NF	0.00	5.00
Settleable Solids[4]	ml/L/hr	1.0	NF	14.0[6]	0.1[6]
Arsenic, Total Recoverable	µg/L	100	NF	0.00	0.03
Lead, Total Recoverable	µg/L	190	NF	0.00	0.09
Chromium, Total Recoverable	µg/L	280	NF	0.02	0.01
Copper, Total Recoverable	µg/L	84	NF	0.02	0.05
Cadmium, Total Recoverable	µg/L	94	NF	0.00	0.01
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	ND

[1]* Discharge requirements for radionuclides only require monitoring.
[2] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of the Health Physics and Radiological Health Handbook (Schleien, 1992).
[3] Calculated Estimates
[4] Detection Limit = 0.1 ml/L/hr
[5] Detection Limit = 1.0 µg/L
[6] Lab did not report the data as requested on the chain of custody. Total volume of sample was utilized and this error could not be corrected. Data from onsite lab used for reporting.
[7] Number reported as zero for purposes of this report. Value was reported as a negative for both the NPDES and FFA quarterly reports.
ND = Non-detect
NF = No flow
SU = Standard Unit

During the third quarter of CY00, permit-specific parameters were measured in July, August, and September (Table 3-3). Due to lack of flow, samples were not taken in the third quarter for PN02 during the month of July nor for PN03 during the months of July and August. Six rainfall events were recorded for this period. No radiological exceedances were observed during this third quarter. Chemical sample data results were all within the permit specified limits.

Table 3-3. Third Quarter Storm-water Discharge Monitoring for Parameters at SLAPS during CY00

PN01a								
Monitoring Parameter	**Units**	**Effluent Limitations[1]**	**Radiological Results**					
			Event 1 7/19/00-7/20/00	**Event 2 7/28/00-8/1/00**	**Event 3 8/8/00-8/10/00**	**Event 4 8/18/00-8/21/00**	**Event 5 8/24/00-8/27/00**	**Event 6 9/25/00-9/28/00**
Uranium, Total[1,2,3]	µg/L	*	460	530	650	400	460	330
Radium, Total[1,2,3]	µg/L	*	3E-06	6 E-06	2E-06	0.00	6E-06	2E-06
Thorium, Total[1,2,3]	µg/L	*	2E-04	3.0	2.0	0.00	3E-04	8E-05
Gross Alpha[1]	pCi/L	*	290	380	290	0.00	320	220
Gross Beta[1]	pCi/L	*	9.00	30	80	0.00	20	5.0
Protactinium-231[1]	pCi/L	*	0.06	0.08	0.07	0.00	0.1	0.03
Actinium-227[1]	pCi/L	*	0.06	0.08	0.07	0.00	0.1	0.03
Radon	pCi/L		81	NS	NS	NS	NS	NS

Monitoring Parameter	**Units**	**Effluent Limitations[1]**	**Chemical Results**		
			July	**August**	**September**
Oil Grease	mg/L	10	0.0	0.0	0.0
Total Petroleum Hydrocarbons	mg/L	10	0.0	0.0	0.0
pH	SU	6-9.0	7.1	7.1	7.8
Chemical Oxygen Demand	mg/L	90	22.6	0.0	26.0
Settleable Solids[4]	ml/L/hr	1.0	0.0	0.0	0.0
Arsenic, Total Recoverable	µg/L	100	0.0	0.0	0.0
Lead, Total Recoverable	µg/L	190	0.0	0.0	0.0
Chromium, Total Recoverable	µg/L	280	0.0	0.0	0.0
Copper, Total Recoverable	µg/L	84	0.0	0.0	0.0
Cadmium, Total Recoverable	µg/L	94	0.0	0.0	0.0
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	0.0	0.0	0.0

PN02								
Monitoring Parameter	**Units**	**Effluent Limitations[1]**	**Radiological Results**					
			Event 1	**Event 2**	**Event 3**	**Event 4**	**Event 5 8/27/00**	**Event 6 9/25/00**
Uranium, Total[1,2,3]	µg/L	*	NF	NF	NF	NF	0.00	7.6
Radium, Total[1,2,3]	µg/L	*	NF	NF	NF	NF	3E-09	0.00
Thorium, Total[1,2,3]	µg/L	*	NF	NF	NF	NF	5E-05	0.6
Gross Alpha[1]	pCi/L	*	NF	NF	NF	NF	0.00	0.00
Gross Beta[1]	pCi/L	*	NF	NF	NF	NF	0.00	0.00
Protactinium-231[1]	pCi/L	*	NF	NF	NF	NF	0.01	0.02
Actinium-227[1]	pCi/L	*	NF	NF	NF	NF	0.01	0.02

Table 3-3. Third Quarter Storm-water Discharge Monitoring for Parameters at SLAPS during CY00 (Cont'd)

Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			July	August	September
Oil Grease	mg/L	10	NF		0.00
Total Petroleum Hydrocarbons	mg/L	10	NF		0.00
pH	SU	6-9.0	NF		7.6
Chemical Oxygen Demand	mg/L	90	NF		49.2
Settleable Solids[4]	ml/L/hr	1.0	NF	0.00[6]	0.20
Arsenic, Total Recoverable	µg/L	100	NF		0.00
Lead, Total Recoverable	µg/L	190	NF		0.00
Chromium, Total Recoverable	µg/L	280	NF		0.00
Copper, Total Recoverable	µg/L	84	NF		0.00
Cadmium, Total Recoverable	µg/L	94	NF		0.00
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF		0.00

PN03

Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results					
			Event 1	Event 2 8/1/00	Event 3	Event 4	Event 5 8/24/00	Event 6
Uranium, Total[1,2,3]	µg/L	*	NF	420	NF	NF	140	NF
Radium, Total[1,2,3]	µg/L	*	NF	6 E-07	NF	NF	1E-06	NF
Thorium, Total[1,2,3]	µg/L	*	NF	1E-05	NF	NF	2.00	NF
Gross Alpha[1]	pCi/L	*	NF	210	NF	NF	70	NF
Gross Beta[1]	pCi/L	*	NF	60	NF	NF	10	NF
Protactinium-231[1]	pCi/L	*	NF	5E-03	NF	NF	0.08	NF
Actinium-227[1]	pCi/L	*	NF	28	NF	NF	0.08	NF

Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			July	August	September
Oil Grease	mg/L	10	NF	1.80	NF
Total Petroleum Hydrocarbons	mg/L	10	NF	0.00	NF
pH	SU	6-9.0	NF	7.0	NF
Chemical Oxygen Demand	mg/L	90	NF	39.3	NF
Settleable Solids[4]	ml/L/hr	1.0	NF	0.0	NF
Arsenic, Total Recoverable	µg/L	100	NF	39	NF
Lead, Total Recoverable	µg/L	190	NF	0.00	NF
Chromium, Total Recoverable	µg/L	280	NF	0.00	NF
Copper, Total Recoverable	µg/L	84	NF	0.00	NF
Cadmium, Total Recoverable	µg/L	94	NF	0.00	NF
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	0.00	NF

[1] * Discharge requirements for radionuclides only require monitoring.
[2] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of the Health Physics and Radiological Health Handbook (Schleien, 1992).
[3] Calculated Estimates
[4] Detection Limit = 0.1 ml/L/hr
[5] Detection Limit = 1.0 µg/L
[6] Sample Lost
NF = No Flow
NS = not sampled during this reporting period. Semi-annual reporting requirement only.
SU = Standard Unit

Fourth Quarter Summary

During the fourth quarter of CY00, permit specific parameters were measured during the months of October and November. No samples were taken in December due to lack of flow. There were four rainfall events recorded for this period (Table 3-4). No releases above state limits for the fourth quarter were recorded. Based upon information provided by the remediation contractor CY00 stormwater monitoring at SLAPS resulted in no exceedances. The monitoring conducted met requirements and permit specifications.

Table 3-4. Fourth Quarter Storm-water Discharge Monitoring at SLAPS during CY00

PN01a						
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results			
			Event 1 10/5/00-10/9/00	Event 2 10/15/00-10/18/00	Event 3 11/7/00-11/16/00	Event 4 11/25/00-11/27/00
Uranium, Total[1,2,3]	µg/L	*	230	420	460	560
Radium, Total[1,2,3]	µg/L	*	8E-07	4E-06	2E-06	4E-06
Thorium, Total[1,2,3]	µg/L	*	0.3	1.00	4.00	2.00
Gross Alpha[1]	pCi/L	*	20	280	260	500
Gross Beta[1]	pCi/L	*	1	50	50	30
Protactinium-231[1]	pCi/L	*	0.02	0.06	0.07	0.07
Actinium-227[1]	pCi/L	*	0.02	0.06	0.07	0.07
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results			
			October	November	December[2]	
Oil Grease	mg/L	10	ND	ND	NF	
Total Petroleum Hydrocarbons	mg/L	10	ND	ND	NF	
pH	SU	6-9.0	7.4	7.5	NF	
COD	mg/L	90	5.8	ND	NF	
Settleable Solids[4]	ml/L/hr	1.0	ND	ND	NF	
Arsenic, Total Recoverable	µg/L	100	ND	ND	NF	
Lead, Total Recoverable	µg/L	190	ND	ND	NF	
Chromium, Total Recoverable	µg/L	280	ND	ND	NF	
Copper, Total Recoverable	µg/L	84	ND	0.025	NF	
Cadmium, Total Recoverable	µg/L	94	ND	ND	NF	
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	ND	ND	NF	
PN02						
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results			
			Event 1 10/5/00	Event 2	Event 3 11/6/00, 11/9/00	Event 4
Uranium, Total[1,2,3]	µg/L	*	140	NF	0.67	NF
Radium, Total[1,2,3]	µg/L	*	4E-06	NF	2E-07	NF
Thorium, Total[1,2,3]	µg/L	*	3E-05	NF	9E-05	NF
Gross Alpha[1]	pCi/L	*	80	NF	0.00	NF
Gross Beta[1]	pCi/L	*	20	NF	0.00	NF
Protactinium-231[1]	pCi/L	*	0.01	NF	0.03	NF
Actinium-227[1]	pCi/L	*	0.01	NF	0.03	NF
Radon[1]	pCi/L	*	ND			

Table 3-4. Fourth Quarter Storm-water Discharge Monitoring at SLAPS during CY00 (Cont'd)

PN02					
Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			October	November	December
Oil Grease	mg/L	10	NF	0.00	1.9
Total Petroleum Hydrocarbons	mg/L	10	NF	0.00	ND
pH	SU	6-9.0	NF	7.2	6.4
COD	mg/L	90	NF	0.00	ND
Settleable Solids[4]	ml/L/hr	1.0	NF	0.4[10]	0.1[10]
Arsenic, Total Recoverable	µg/L	100	NF	0.00	ND
Lead, Total Recoverable	µg/L	190	NF	0.00	ND
Chromium, Total Recoverable	µg/L	280	NF	0.01	ND
Copper, Total Recoverable	µg/L	84	NF	0.01	0.02
Cadmium, Total Recoverable	µg/L	94	NF	0.00	ND
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	NF	ND	ND

PN03						
Monitoring Parameter	Units	Effluent Limitations[1]	Radiological Results			
			Event 1 10/5/00-10/6/00	Event 2	Event 3 11/4/00, 11/17/00	Event 4 11/28/00
Uranium, Total[1,2,3]	µg/L	*	50	NF	160	1.1E-06
Radium, Total[1,2,3]	µg/L	*	2E-06	NF	2E-06	5.00
Thorium, Total[1,2,3]	µg/L	*	2.0	NF	1.0	40
Gross Alpha[1]	pCi/L	*	90	NF	80	5.0
Gross Beta[1]	pCi/L	*	30	NF	20	6E-02
Protactinium-231[1]	pCi/L	*	1.5E-01	NF	4E-02	6E-02
Actinium-227[1]	pCi/L	*	1.5E-01	NF	4E-02	6E-02

Monitoring Parameter	Units	Effluent Limitations[1]	Chemical Results		
			October	November	December
Oil Grease	mg/L	10	ND	ND	NF
Total Petroleum Hydrocarbons	mg/L	10	ND	ND	NF
pH	SU	6-9.0	7.3	7.6	NF
COD	mg/L	90	23.1	21.5	NF
Settleable Solids[4]	ml/L/hr	1.0	ND	ND	NF
Arsenic, Total Recoverable	µg/L	100	4.8	ND	NF
Lead, Total Recoverable	µg/L	190	8.4	ND	NF
Chromium, Total Recoverable	µg/L	280	9.8	0.005	NF
Copper, Total Recoverable	µg/L	84	10.0	ND	NF
Cadmium, Total Recoverable	µg/L	94	ND	ND	NF
Polychlorinated Biphenyls[5]	µg/L	<0.5 ppb	ND	ND	NF

[1] * Discharge requirements for radionuclides only require monitoring.
[2] Total nuclide values in µg/L units were calculated using the activity concentration values reported by the laboratory and values for specific activity listed in Table 8.4.1 of the Health Physics and Radiological Health Handbook (Schleien, 1992).
[3] Calculated Estimates
[4] Detection Limit = 0.1 ml/L/hr
[5] Detection Limit = 1.0 µg/L
[6] Lab did not report the data as requested on the chain of custody. Total volume of sample was utilized and this error could not be corrected. Data from onsite lab used for reporting.

ND = Non-detect
NF = No Flow
SU = Standard Unit

3.1.3 Evaluation of the CY00 Storm-water Discharge Monitoring Results at HISS

In CY00, storm-water discharge was monitored from three outfalls at HISS (NPDES Permit MO-0111252). For environmental monitoring purposes, these outfalls have been assigned the station identifications HN01 for Outfall 001; HN02 for Outfall 002; and HN03 for Outfall 003, as depicted in Figure 3-4. The permit requires monthly monitoring at the outfalls for total settleable solids. It establishes the daily maximum limit for settleable solids at 1.5 ml/L/hr and a cumulative daily average limit per month of 1.0 ml/L/hr for settleable solids. In addition it establishes a quarterly monitoring of pH, specific conductance, settleable solids, total organic compound (TOC), total organic halogen (TOX), and radiological parameters. Monitoring of storm-water discharges at HISS has been conducted to comply with these discharge requirements.

During CY00, storm-water discharges from Outfalls HN01, HN02, and HN03 were sampled for settleable solids each month that flow occurred. During the months of January and December, settleable solids samples were not taken at Outfall HN03 due to insufficient flow. The average annual concentration of settleable solids for all outfalls was 0.11 ml/L/hr. In all four quarters for CY00, settleable solids results never exceeded the allowable maximum daily concentration of 1.5 ml/L/hr per outfall. Results for storm-water discharge monitoring at HISS during CY00 are presented in Table 3-5.

Table 3-5. Total Settleable Solids Results from CY00 Storm Water Discharge Monitoring at HISS (ml/L/hr)

Month Collected	HN01	HN02	HN03
January	0.1	0.1	NS[2]
February	0.1	0.1	0.1
March	0.1	0.1	0.1
April	0.1	0.1	0.1
May	0.1	0.1	0.1
June	0.1	0.1	0.1
July	0.1	0.1	0.4
August	0.1	0.1	0.1
September	0.1	0.2[1]	0.1
October	0.1	0.1	0.1
November	0.1	0.1	0.1
December	0.1	0.1	NS[2]

[1] Reported as 0.1ml/L/hr in the letter, dated October 27, 2000, from Sharon Cotner, to MDNR, for the Third Quarter CY00 Discharge Report, for NPDES Permit MO-0111252, and ARARs, for Discharges to the Waters of the State at SLAPS. Actual result is 0.2 ml/L/hr.

[2] NS = Not Sampled due to lack of flow at this Outfall for the specified period.

Settleable Solids Limit = 1.0 mg/L/hr

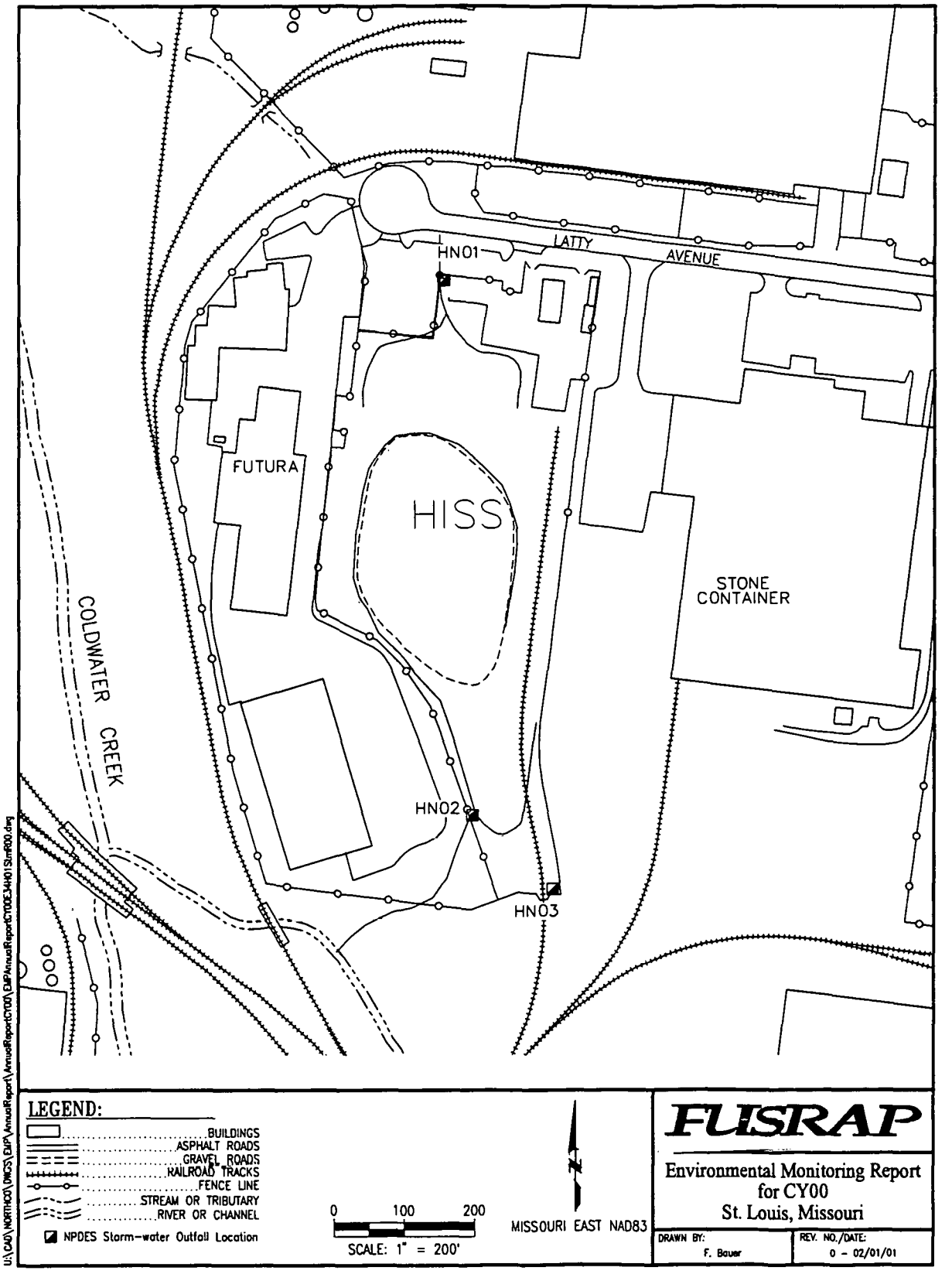

Figure 3-4. Current Storm-water Outfalls at the HISS

In addition to monthly monitoring for settleable solids, storm-water discharges at HISS were sampled quarterly for pH, specific conductance, TOX, TOC, gross alpha, gross beta, and isotopic analysis for radium, thorium, and uranium. The HISS NPDES Permit states that if/when a "positive" value for TOX is recorded, then the permitee shall identify the specific compound. As a result, VOCs and SVOCs are tested for when TOX results are positive. TOX results were positive for all outfalls in the first quarter; were positive for HN01 during the second and fourth quarter; were positive for HN02 during the third and fourth quarter; and for HN03 during the third quarter. Samples for HN03 were not taken in January and December due to insufficient discharge during these months. A summary of CY00 events involving HISS stormwater monitoring follows.

First Quarter

During the first quarter of CY00, the above permit specified parameters were measured in January, February and March (see Table 3-6). Methylene chloride was detected above its reported detection limit in samples from Outfalls HN02 and HN03; this constituent, however, is often associated with laboratory contamination. No other halogenated organics were detected above the quantitative limits (Appendix A, Table A-2).

Compared to previous years, CY00 data results for gross alpha and gross beta are higher in value. This is a direct result of increased excavation at HISS. A combination of excessive rainfall and increased activity which allowed for a larger area to be exposed, contributed to higher concentrations of parameters in storm water samples. First quarter sampling resulted in a total uranium value of 48.13 pCi/L at HN01, 15.12 pCi/L at HN02, and 2.44 pCi/L at HN03. HN01 and HN02 results were twice last years values. All permit-specified parameters were within permit requirements and all contaminants were within 10 CFR 20 guidelines.

Table 3-6. Results from First Quarter CY00 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	0.58[1]	2.13[1]	1.65
Thorium-230	pCi/L	1.94	2.38	1.91
Thorium-232	pCi/L	0.58[1]	0.71	0.74[1]
Uranium-234	pCi/L	24.1	8.63	1.08
Uranium-235	pCi/L	1.63	1.15	0.72[1]
Uranium-238	pCi/L	22.4	5.34	0.64
Radium-226	pCi/L	1.61	4.13	4.0
Radium-228[2]	pCi/L	0.58[1]	2.13[1]	1.65
Gross Alpha	pCi/L	58.1	32.2	7.39
Gross Beta	pCi/L	25.5	24.0[1]	24.0[1]
pH	SU	7.36	7.31	7.74
Specific Conductance	µmhos/cm	0.32	0.48	0.30
Total Organic Carbon	mg/L	6.20	4.80	26.5
Total Organic Halogen	µg/L	12.6	11.1	18.5
Lead-210[3]	pCi/L	1.61	4.13	4.0

[1] Result reported is less than the minimum detectable activity (MDA). Value is assumed to be MDA for calculation purposes.

[2] Assumes secular equilibrium with Th-228.

[3] Assumes secular equilibrium with Ra-226

SU = Standard Unit

Second Quarter

The HISS storm-water samples were taken for the second quarter of CY00 in April, May, and June (see Table 3-7). All permit-specified parameters were within permit requirements and all contaminants were within federal guidelines. Positive values for TOX were detected at both HN01 (11.6 µg/L) and HN02 (4.4 µg/L) during this quarter. In addition, HNO3, now up and running also indicated a positive result for TOX with a reading of 5.5 µg/L. VOC and SVOC analyses were conducted for each of the outfalls, but no specific organic was identified. All results were reported as non-detect in Appendix A, Table A-6.

Table 3-7. Results from Second Quarter CY00 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	0.70[1]	1.44[1]	1.05[2]
Thorium-230	pCi/L	14.2	5.06	1.05[1]
Thorium-232	pCi/L	14.2	0.65[1]	0.56[1]
Uranium-234	pCi/L	11.8	3.79	1.52[1]
Uranium-235	pCi/L	1.01[1]	1.18[1]	1.01[1]
Uranium-238	pCi/L	7.54	6.0	1.80
Radium-226	pCi/L	2.44[1]	3.25	2.1[1]
Radium-228[3]	pCi/L	0.70[1]	1.44[1]	1.05[2]
Gross Alpha	pCi/L	31.0	13.61	16.0[1]
Gross Beta	pCi/L	26.15[1]	26.0[2]	26.1[1]
pH	SU	6.4	6.7	6.8
Specific Conductance	µmhos/cm	0.45	0.2	0.4
Total Organic Carbon	mg/L	9.4	17.3	6.6
Total Organic Halogen	µg/L	11.6	4.4	5.0
Lead-210[4]	pCi/L	2.44[1]	3.25	2.1[1]

[1] Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes.
[2] Result reported is negative. Value is assumed to be the MDA for calculation purposes.
[3] Assumes secular equilibrium with Th-228
[4] Assumes secular equilibrium with Ra-226
SU = Standard Unit

Third Quarter

For the third quarter of CY00, permit specified parameters were measured during the months of July, August and September (see Table 3-8). TOX values were positive for both Outfalls HN02 and HN03. Subsequently, VOCs and SVOCs were sampled for as required with positive TOX readings. No compounds were found above reported detection limits (Appendix A, Table A-6).

Table 3-8. Results from Third Quarter CY00 Storm-water Sampling at HISS

Monitoring Parameter	Units	HN01	HN02	HN03
Thorium-228	pCi/L	1.38[1]	0.86	1.26
Thorium-230	pCi/L	4.46	1.63	4.62
Thorium-232	pCi/L	0.60[1]	1.41[1]	0.59[1]
Uranium-234	pCi/L	5.23	5.29	1.69[1]
Uranium-235	pCi/L	0.80[1]	0.84[1]	1.85[2]
Uranium-238	pCi/L	5.45	5.77	1.25[1]
Radium-226	pCi/L	3.22[2]	3.0[1]	1.1[1]
Radium-228[3]	pCi/L	1.38[1]	0.86	1.26
Gross Alpha	pCi/L	19.3	13.1[1]	13.1[1]
Gross Beta	pCi/L	26.7[1]	23.1[1]	26.8[1]
pH	SU	6.48	6.89	6.20
Specific Conductance	µmhos/cm	0.45	0.12	0.35
Total Organic Carbon	mg/L	5.6[1]	10.8	7.4
Total Organic Halogen	µg/L	5.0[1]	14.0	10.1
Lead-210[4]	pCi/L	3.22[2]	3.0[1]	1.1[1]

[1] Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes.
[2] Result reported is negative. Value is assumed to be the MDA for calculation purposes..
[3] Assumes secular equilibrium with Th-228.
[4] Assumes secular equilibrium with Ra-226
SU = Standard Unit

Fourth Quarter

Samples to measure permit specified parameters were taken in October, November and December for CY00. Quarterly samples were not taken at HN03 in the fourth quarter due to insufficient discharge. TOX values were positive for Outfalls IIN01, and HN02. VOC and SVOC analyses, however resulted in a non-detect (Appendix A, Table A-6). Gross alpha results for HN01, recorded as 113 pCi/L, is higher than for any other quarter of CY00. Increased excavation activity exposing a larger, uncovered area of subsurface soil, is a factor. Table 3-9 summarizes the radiological data results for fourth quarter of CY00. CY00 storm-water monitoring at SLAPS resulted in no exceedances. The monitoring conducted met requirements and permit specifications.

Table 3-9. Results from Fourth Quarter CY00 Storm-water Sampling at HISS

Monitoring Parameter	Units	Analytical Results 12/11/00
HN01		
Gross Alpha	pCi/L	113
Gross Beta	pCi/L	17.7
Radium-226	pCi/L	5.45
Thorium-228	pCi/L	1.8[1]
Thorium-230	pCi/L	2.2
Thorium-232	pCi/L	0.66[1]
Uranium-234	pCi/L	48.2
Uranium-235	pCi/L	1.56[1]
Uranium-238	pCi/L	45.7
pH	SU	6.08
Settleable solids	mL/l	0.1
Specific Conductance	µmhos/cm	0.88
Total Organic Carbon	mg/L	16.7
Total Organic Halogen	µg/L	25
Lead-210[3]	pCi/L	5.45
Monitoring Parameter	**Units**	**Analytical Results 12/11/00**
HN02		
Gross Alpha	pCi/L	1.55
Gross Beta	pCi/L	1.56[1]
Radium-226	pCi/L	1.91[1]
Thorium-228	pCi/L	1.92[1]
Thorium-230	pCi/L	5.35
Thorium-232	pCi/L	1.43[2]
Uranium-234	pCi/L	2.23
Uranium-235	pCi/L	0.76[1]
Uranium-238	pCi/L	3.64
pH	SU	6.87
Settleable Solids	mL/l	0.1
Specific Conductance	µmhos/cm	0.34
Total Organic Carbon	mg/L	9.7
Total Organic Halogen	µg/L	26.2
Lead-210[3]	pCi/L	1.91[1]

[1] Result reported is less than the MDA. Value is assumed to be MDA for calculation purposes

[2] Result reported as negative. Value is assumed to be the MDA for calculation purposes

[3] Assumes secular equilibrium with Ra-226

SU = Standard Unit

During CY00 rainfall was measured by the ISCO rain gauge at HN01. Flow was detected and recorded by flow meter sensors at HN01, HN02, and HN03. Rainfall was measured in inches and flow was recorded as million gallons per day. (During the fourth quarter unusually high flow readings were recorded at both HN01 and HN02. This resulted due to overflows of an on-site reservoir managed by a previous contractor.) Flow and rainfall data can be referenced in Appendix A in Tables A-7 through A-10.

3.2 CY00 SLS PERMIT RENEWALS

The following permits were renewed for the HISS facility in the CY00.

3.2.1 HISS Permit Renewal

The NPDES Discharge Permit, MO-0111252 required renewal pursuant to the Federal Water Pollution Control Act and the Missouri Clean Water Law Chapters 10 CSR 20-6.010, 10 CSR 20-7.015, and 10 CSR 20-7.031. The permit authorizes only water discharges from HISS under the Missouri Clean Water Law and NPDES to the designated receiving stream, Coldwater Creek. The Hiss Permit Request for Renewal was originally submitted in June of CY99. Permit renewal would accomplished three objectives: (1) renew the permit; (2) transfer ownership of this permit from the DOE to the USACE; and (3) add an Outfall HN03 to the HISS.

Additional data was submitted on May 3, 2000 to support the renewal process. This information included: supporting documentation detailing the methodology for determining the maximum mass of each respective constituent from the outfalls; and changes to the watershed specific to Outfall HN03. Supporting data results can be found in Appendix A, Table A-11.

3.2.2 MSD Permit Renewal for Radiological Laboratory

The permit renewal is required to comply with MSD discharge requirements (under ordinance 8472, 10177, and 10082). The approval for special discharge is granted on a yearly basis and requires renewal. USACE owns the Radiological Laboratory located at 8945 Latty Avenue. The lab operates under a Special Discharge Permit granted by MSD. Renewal, for the permit in CY00, required Group 1 data analysis in addition to radiological analysis. The group 1 classification was necessary as the CY98 application outlined this data which included: pH, total solids, total suspended solids, COD, cadmium, chromium, copper, iron, lead, nickcl, zinc, the volatile organic priority pollutants, as well as radionuclides of concern.

Results indicated non-detects for all volatile priority pollutants, with the exception being 2-butanone. This result is due to lab contamination (Appendix A, Table A-12).

The radiological parameter results did not exceed the respective health criteria. These parameters are monitored only for reporting purposes. Results indicated a non-detect for uranium (Appendix A, Table A-12).

The discharge water from the HISS laboratory tested positive for the presence of the following parameters: cadmium, chromium, copper, iron, lead, nickel, and zinc (Appendix A, Table A-12). There are no discharge limits or criteria regulating these parameters.

As part of the permit renewal, a request to increase the operation discharge volume from 25 gallons per week to 400 gallons per week was issued. The properties of the discharge (waste water from the cleanup of laboratory glassware) remained the same.

3.3 CY00 COLDWATER CREEK SURFACE-WATER MONITORING RESULTS

The environmental monitoring of Coldwater Creek continues to focus on the evaluation of radium isotopes, thorium isotopes, total uranium, and certain general water quality parameters such as dissolved oxygen, pH, and turbidity. The CY00 surface-water data for Coldwater Creek has been evaluated relative to risk-screening levels and guidelines derived from environmental regulatory programs (SAIC, 2000). Regulatory guidelines selected for evaluation of the surface-water monitoring data are the AWQC for Class I (Protection of Aquatic Life) and Class V (Livestock, Wildlife Watering) streams as designated in 10 CSR 20-7.031. The AWQC for Class I and Class V streams are listed in Table 3-10.

Table 3-10. Surface-water Ambient Water Quality Criteria (AWQC)

Monitoring Parameter	Units	Ambient Water Quality Criteria
Ra-226	pCi/L	5.0 [1]
Ra-228	pCi/L	5.0 [1]
Oil and Grease	mg/L	10
Aluminum	mg/L	0.75
Arsenic	mg/L	0.02
Beryllium	mg/L	0.005
Cadmium	mg/L	0.094
Copper	mg/L	0.084
Chromium	mg/L	0.28
Iron	mg/L	1
Lead	mg/L	0.15
Mercury	mg/L	0.0024
Nickel	mg/L	6.9
Selenium	mg/L	0.005
Silver	mg/L	0.011
Zinc	mg/L	2.073
Chloride	mg/L	860
Ethyl Benzene	mg/L	0.32
2,4-Dichlorophenol	mg/L	0.007
2-Chloronaphthalene	mg/L	4.3
Fluoranthene	mg/L	0.3
Hexachlorocyclopentadiene	mg/L	0.0005

[1] AWQC is established in 10CSR60-4.060 for radionuclides.

In CY00, sampling of surface water at Coldwater Creek increased significantly compared to the CY99 program. The environmental monitoring of Coldwater Creek surface water included all AWQC parameters and additional inorganics and organics (USACE, 2000a). Sampling of all Coldwater Creek monitoring stations (C002 through C007) was conducted in the months of March and May 2000. Monitoring station C002 is upgradient to the SLS locations and provides a data result comparison reference for the downgradient stations located in Coldwater Creek. Figure 3-5 details the locations of the six monitoring stations along Coldwater Creek.

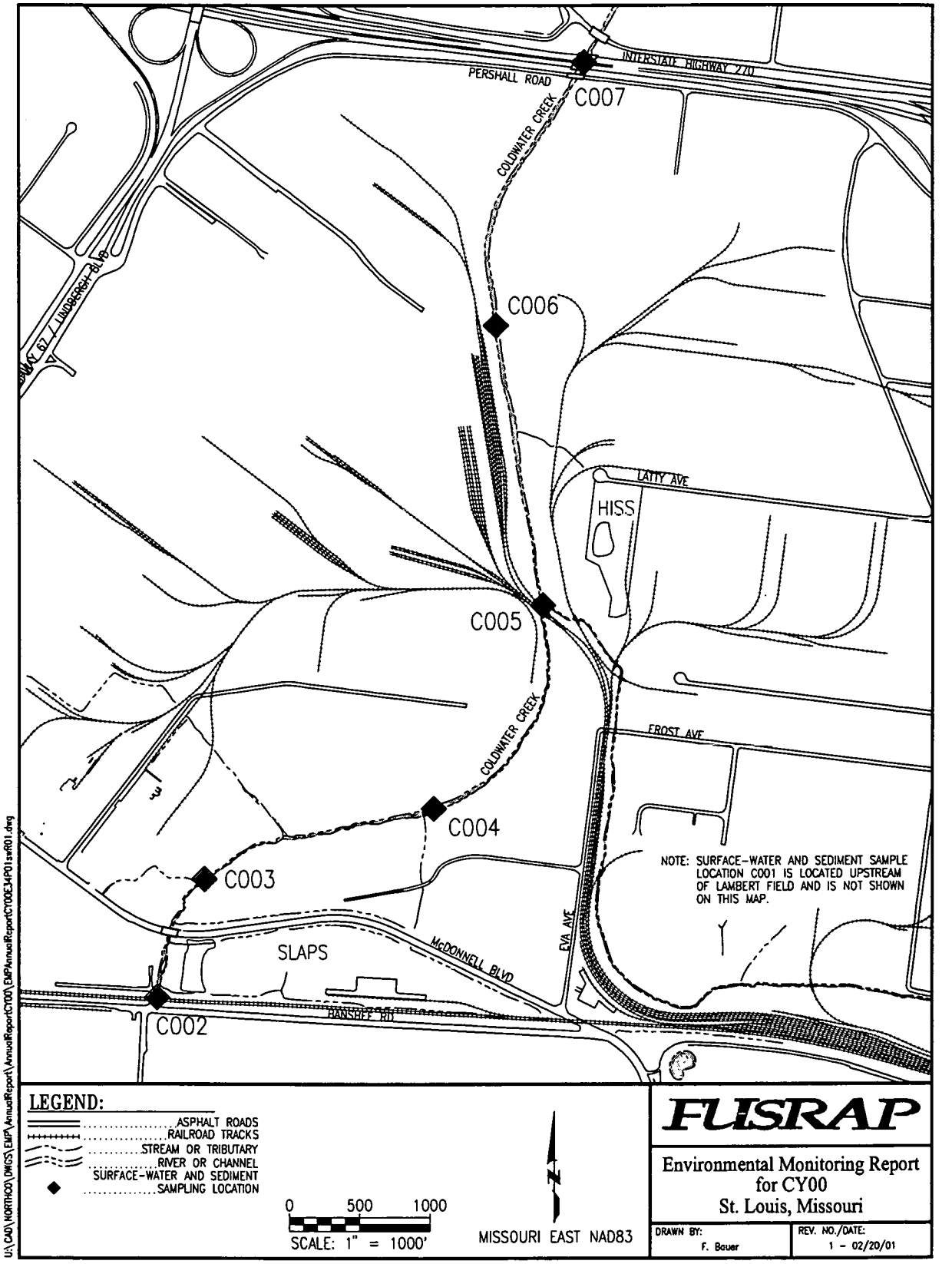

Figure 3-5. Surface-water and Sediment Sampling Locations at Coldwater Creek

Table 3-11 provides a summary of the detected AWQC constituents found in these surface-water samples. Historically, these surface-water samples include unfiltered water samples for the radiological parameters Ra-226, Th-228, Th-230, Th-232, U-234, U-235, and U-238. All EMP surface water stations were sampled along Coldwater Creek. The March and May 2000 surface-water sampling events were collected as grab samples for the indicated parameters as well as organics and metals (Appendix B, Table B-1). Results for radiological and chemical parameters are presented in Table 3-10. The only AWQC's for which surface water was not monitored was Ra-228. 10 CSR 60-4.060 requires sampling of water for Ra-228 only if the gross alpha activity sample exceeds 5 pCi/L. The regulation then requires the analysis of Ra-226 from the same or an equivalent sample. If the Ra-226 concentration exceeds 3 pCi/L then the sample must be analyzed for Ra-228. The concentration levels for Ra-226 never exceeded the 3 pCi/L maximum limit therefore, Ra-228 was not included in the surface water analysis.

For the CY00 surface water sampling events, the maximum activity-based concentration of radiological parameters occurred at sampling location C007 (Th-230, 4.67 pCi/L) during March 2000. Detected isotopic uranium (U-234, U-235, U-238) values ranged from 1.6 pCi/L at EMP Station C006 to 2.45 pCi/L at EMP Station C007 in March 2000. In May, detected uranium isotopic values ranged from 1.21 pCi/L at EMP Station C007 to 3.64 pCi/L at EMP Station C002. The source of this uranium detection is unknown as station C002 is upgradient from the SLS.

The second sampling event in May 2000, resulted in the detection of aluminum and iron in exceedance of the AWQC. Aluminum (AWQC limit 0.75 mg/L) was detected at EMP Stations C002 through C005 at values of 4.3, 5.5, 4.9, and 1.3 mg/L, respectfully. Iron (AWQC limit 1.0 mg/L) was detected at EMP Stations C002 through C006 at values of 3.6, 4.8, 5.0, 1.5, and 2.6 mg/L, respectfully. No other AWQC were exceeded during the second sampling event.

Total suspended solids sampled during the second event in May 2000 resulted in elevated values from 13.2 mg/L at C007 to 69.3 mg/L at C003 and C004. In contrast, during the March 2000 sampling event, values for suspended solids ranged from 6.2 mg/L at C005 to 10.8 mg/L at C003. Comparing these values, the total suspended solids increased 2 to 7 times from March to May 2000. This may explain the elevated levels of metals detected during the second sampling event.

Similar elevated metals occurred in CY99 during the June Ecological Risk Study. Exceedances for iron, aluminum, and selenium were detected at values of 9.32, 7.05, and 0.027 mg/L, respectfully. During the sampling event, total suspended solids were also elevated ranging from 14.8 mg/L at C002 to 152 mg/L at C003. Comparing the results for the two years suggests a seasonal pattern where elevated or heavy solids flow into Coldwater Creek. The sampling events for both years were conducted within 30 days of each other (mid May-mid June) and levels of suspended solids were significantly higher than the early year (March) sampling event. Weather patterns of heavy rainfall cause soils and sediments to be mobilized and enter into surface water conveyance systems like Coldwater Creek. April, May, and June exhibit severe weather in the form of thunderstorms and heavy rainfall in the St. Louis area and is most likely the source for the increase in suspended solids in Coldwater Creek which may explain the increase in metal concentrations.

Table 3-11. CY00 Coldwater Creek Surface Water Radiological and Chemical Monitoring Results

First Sample Event							
Monitoring Parameter	**Units**	**C002 (upgradient) (sampled 3/23/00)**	**C003 (sampled 3/9/00)**	**C004 (sampled 3/14/00)**	**C005 (sampled 3/2/00)**	**C006 (sampled 3/30/00)**	**C007 (sampled 3/30/00)**
U-234	pCi/L	1.73[1]	1.98	0.75[2]	0.61[1]	1.6	2.45
U-235	pCi/L	0.93[1]	0.94[1]	0.84[1]	0.75[1]	0.77[1]	0.82[1]
U-238	pCi/L	0.75[1]	0.76[1]	0.68[1]	0.61[1]	1.44[1]	1.95
Th-228	pCi/L	1.73[1]	1.71[1]	0.25	0.54	2.36	0.9[1]
Th-230	pCi/L	0.67[1]	1.44	0.49	0.66[1]	3.1	4.67
Th-232	pCi/L	1.28[1]	0.65[1]	0.66[1]	0.65[1]	1.78[1]	2.1[1]
Ra-226	pCi/L	2.92[1]	4.58[1]	3.46[1]	3.47[1]	2.32[1]	2.57[1]
Aluminum	µg/L	41.8[1]	19.7[1]	73.3	6	107	63.3
Arsenic	µg/L	2.2[1]	1.1[1]	2.4	1.1[1]	2.6	3.2
Beryllium	µg/L	0.9[1]	0.2[1]	0.2[1]	0.2[1]	0.9[1]	0.9[1]
Cadmium	µg/L	0.8[1]	0.2[2]	0.2[1]	0.2[1]	0.8[1]	0.8[1]
Chromium	µg/L	1.1[1]	0.6[1]	0.6[1]	0.6[1]	1.1[1]	1.1[1]
Copper	µg/L	2[1]	0.8[1]	0.8[1]	0.8[1]	3.3	2[1]
Iron	µg/L	686	774	10.6[1]	10.6[1]	744	526
Lead	µg/L	2.8[1]	0.6[1]	0.6[1]	0.6[1]	2.8[1]	2.8[1]
Mercury	µg/L	0.2[1]	0.1[1]	0.1[1]	0.1[1]	0.1[1]	0.1[1]
Nickel	µg/L	1[1]	13.4[1]	13.4[1]	13.4[1]	1[1]	1[1]
Selenium	µg/L	1.8[1]	1.4	3.7	3.1[1]	1.8[1]	1.8[1]
Silver	µg/L	1[1]	0.8[1]	0.8[1]	0.8[1]	1[1]	1[1]
Zinc	µg/L	2.9[1]	27.4	0.6[1]	21.6	18.4	12.5
Chloride	mg/L	168	136	339	149	161	156
Ethyl Benzene	µg/L	5[1]	5[1]	5[1]	5[1]	5[1]	5[1]
2,4-Dichlorophenol	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
2-Chloronaphthalene	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
Fluoranthene	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
Hexachlorocyclopentadiene	µg/L	50[1]	50[1]	50[1]	50[1]	50[1]	50[1]
Oil and Grease	mg/L	3.5[1]	3.6[1]	5	4	3.5	4.1
Total Suspended Solids	mg/L	8.8	10.8	8.7	6.2	7.5	7.5

[1] Undetected. Value shown is the minimum detection limit.
[2] Data result rejected due to negative result for Cadmium in laboratory blank.
[3] Data result rejected due to analytical uncertainties not met.

Table 3-11. CY00 Coldwater Creek Surface Water Radiological and Chemical Monitoring Results (Cont'd)

Second Sample event							
Monitoring Parameter	**Units**	**C002 (upgradient) (sampled 5/23/00)**	**C003 (sampled 5/23/00)**	**C004 (sampled 5/23/00)**	**C005 (sampled 5/18/00)**	**C006 (sampled 5/18/00)**	**C007 (sampled 5/18/00)**
U-234	pCi/L	3.64	2.27	2.77	1.7[1]	1.09[1]	1.21
U-235	pCi/L	0.8[1]	0.82[1]	0.73[1]	1.76[1]	0.72[1]	0.81[1]
U-238	pCi/L	1.9	1.96	2.16	0.76[1]	1.29	0.65[1]
Th-228	pCi/L	0.6[1]	1.85[1]	1.31[1]	1.75[1]	1.3[1]	1.34[1]
Th-230	pCi/L	0.6[1]	3.31	0.72[1]	3.65	2	1.34[1]
Th-232	pCi/L	0.6[1]	0.6[1]	1.31[1]	1.75[1]	0.7[1]	0.72[1]
Ra-226	pCi/L	1.21[1]	1.12[1]	2.84[1]	3.02[1]	2.25[1]	2.15[1]
Aluminum	µg/L	4260	5520	4920	1260	13.9[1]	499
Arsenic	µg/L	3.8	4.3	7.2	2.2[1]	2.9	2.2[1]
Beryllium	µg/L	0.9[1]	0.9[1]	0.9[1]	0.9[1]	0.9[1]	0.9[1]
Cadmium	µg/L	0.8[1]	0.8[1]	0.8[1]	0.8[1]	0.8[1]	0.8[1]
Chromium	µg/L	10.2	12.7	8.8	1.1[1]	1.1[1]	1.1[1]
Copper	µg/L	15.5	14.8	15.3	2[1]	2[1]	2[1]
Iron	µg/L	3630	4780	4980	1510	2620	902
Lead	µg/L	3.1	8.4	4.7	2.8[1]	2.8[1]	2.8[1]
Mercury	µg/L	0.1[1]	0.1[1]	0.1[1]	0.1[1]	0.1[1]	0.1[1]
Nickel	µg/L	15.4[1]	15.4[1]	15.4[1]	15.4[1]	15.4[1]	15.4[1]
Selenium	µg/L	1.8[1]	1.8[1]	1.8[1]	1.8[1]	1.8[1]	1.8[1]
Silver	µg/L	1[1]	1[1]	1[1]	1[1]	1[1]	1[1]
Zinc	µg/L	26.3	39.9	27.7	3.1[1]	43.3	3.1[1]
Chloride	mg/L	66.4	72.6	65.1	192	165	170
Ethyl Benzene	µg/L	5[1]	5[1]	5[1]	5[1]	5[1]	5[1]
2,4-Dichlorophenol	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
2-Chloronaphthalene	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
Fluoranthene	µg/L	10[1]	10[1]	10[1]	10[1]	10[1]	10[1]
Hexachlorocyclopentadiene	µg/L	50[1]	50[1]	50[1]	50[1]	50[1]	50[1]
Oil and Grease	mg/L	7.2	6.6	3.6	4.2	4.2	3.9
Total Suspended Solids	mg/L	39.5	69.3	69.3	17.6	41.6	13.2

[1] Undetected. Value shown is the minimum detection limit or activity

Table 3-12 shows historical results for surface-water sampling (radiological parameters) at Coldwater Creek at the EMP sampling locations. The March 2000 values for Th-228 at C006 and Th-230 at C007 represent the highest levels at these two Coldwater Creek stations since sampling began in CY92. Th-228 and Th-230 were detected at station C003 in CY99 at their highest levels. These results may indicate a small mobile source is being transported via suspended solids movement in Coldwater Creek and distributed non-uniformly along the creek bed. Supporting data indicates positive detections of Th-228 and Th-230 in surface water samples at stations C003, C004, C005, C006, and C007 during CY00.

Total uranium activity was at an all time high at station C002 in May 2000. The SLS are not the source of this activity as this station is upgradient from both HISS and SLAPS. As discussed earlier in the section, total suspended solids sampled during the second event in May 2000 resulted in elevated values. The increase in suspended solids is likely to have contributed to the increased total uranium activity results.

3.3.1 CY00 COLDWATER CREEK SEDIMENT MONITORING RESULTS

Environmental monitoring of Coldwater Creek sediments for CY00 is summarized in this section. The results obtained from these monitoring activities are presented and evaluated with respect to historical data and the appropriatc investigative limits.

The EMP has historically conducted semi-annual monitoring of Coldwater Creek sediments during each calendar year. Environmental monitoring data for Coldwater Creek sediments are compared to the results of the concurrent surface water sampling results for each location and with respect to established background concentrations. The background concentrations considered for evaluation of sediment data were presented in EMIFY01 (SAIC, 2000). Sediment samples were collected from each of the six previously described surface-water locations (Figure 3-5) and analyzed for radionuclides, metals, and organics. Sediment sampling in accordance with this protocol was conducted during March and May of 2000 at all EMP Coldwater Creek locations (C002-C007).

Sediment samples collected for the EMP were evaluated for radiological, chemical, and metal constituents (Appendix B, Table B-2). The radiological results are summarized in Table 3-13. The number of radionuclides targeted for analysis on Coldwater Creek increased during the CY00. Americium-241 (Am-241), Ac-227, cesium-137 (Cs-137), K-40, and Pa-231 were added to the program protocols. The addition of these parameters will enable the program to better understand the contaminant source location and to predict the movement of any potential radiological contamination in Coldwater Creek sediments. This information will be vital in determining a specific remediation action if one is needed in the future. Table 3-14 shows historical results (radiological) for sediment sampling at Coldwater Creek at the EMP sampling locations.

Table 3-12. Comparison of Historical Radiological Parameter Surface-water Results for Coldwater Creek

Historical Location	Radionuclide	Units	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98	06/17/99	03/00	05/00
C002	Uranium	µg/L	1.63	1.5	1.7	1.47	NS	0.46	1.1	0.69	1.82	0.66	1.36	2.05	<135	<3.41	5.54
C002	Ra-226	pCi/L	0.35	<0.32	<0.14	0.27	NS	<0.12	<0.3	0.67	0.35	0.28	0.88	<0.2	<0.25	<2.92	<1.21
C002	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.05	<0.09	0.34	<0.1	NS	NS	NS
C002	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.05	<0.09	0.34	<0.1	3.12	<1.73	<0.6
C002	Th-230	pCi/L	0.19	<0.26	<-0.01	<0.05	NS	0.15	<0.06	<0.2	<0.18	0.56	0.43	<0.15	4.65	<0.67	<0.6
C002	Th-232	pCi/L	NS	NS	<0.02	<0	NS	<0.07	<0.02	<0.14	<0.04	<0.22	<0.1	<0.05	<0.62	<1.28	<0.6
C003	Uranium	µg/L	5.35	3.3	9.7	6.01	13.65	0.96	3.7	3.04	9.17	3.03	3.78	16.41	<135	<3.68	<5.05
C003	Ra-226	pCi/L	1.07	0.34	<0.07	<0.08	0.3	0.3	<0.02	0.5	0.41	0.26	<0.63	<0.21	<0.69	<4.58	<1.12
C003	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.17	<0.09	<0.09	<0.08	NS	NS	NS
C003	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.17	<0.09	<0.09	<0.08	5.05	<1.71	<1.85
C003	Th-230	pCi/L	0.51	<0.04	<0.1	<0.02	<0.17	0.33	0.13	0.25	0.68	0.92	0.6	<0.3	6.99	1.44	3.31
C003	Th-232	pCi/L	NS	NS	<0.14	<-0.01	<0.01	<0.1	<0.07	<0.17	<0.14	<0.09	<0.19	<0.54	1.21	<0.65	<0.6
C004	Uranium	µg/L	6.99	3.9	11.8	9.52	1.52	1.0	4.8	3.74	13.11	3.78	4.71	22.97	NS	<2.27	<5.66
C004	Ra-226	pCi/L	0.38	0.35	0.38	0.24	<0.06	0.23	0.28	<0.46	0.18	<0.16	0.66	<0.47	NS	<3.46	<2.84
C004	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.07	0.36	<0.14	<0.31	NS	NS	NS
C004	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.07	0.36	<0.14	<0.31	NS	0.25	<1.31
C004	Th-230	pCi/L	0.22	<0.27	<-0.04	<0.03	<0.06	<0.16	0.24	0.51	<0.14	0.4	0.42	<0.25	NS	0.49	<0.72
C004	Th-232	pCi/L	NS	NS	<-0.01	<0.03	<0.06	<0.11	<0.02	<0.05	<0.17	<0.13	<0.05	0.25	NS	<0.66	<1.31
C005	Uranium	µg/L	4.77	3.3	1.5	1.73	NS	0.68	1.6	2.48	1.61	1.63	1.43	1.99	NS	<1.97	<4.22
C005	Ra-226	pCi/L	1.01	0.25	0.21	<-0.01	NS	<0.09	<0.17	0.35	0.52	0.34	<0.18	0.19	NS	<3.47	<3.02
C005	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	0.33	0.43	<0.09	<0.18	NS	NS	NS
C005	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	0.33	0.43	<0.09	<0.18	NS	0.54	<1.75
C005	Th-230	pCi/L	0.32	<0.4	0.31	0.19	NS	0.18	5.2	0.39	<0.24	0.42	0.55	<0.35	NS	<0.66	3.65
C005	Th-232	pCi/L	NS	NS	<-0.1	<0	NS	<0.14	<0.07	<0.14	<0.04	<0.05	<0.18	<0.12	NS	<0.65	<1.75
C006	Uranium	µg/L	3.75	2.7	1.4	1.65	NS	0.68	1.5	2.55	1.84	1.61	1.46	1.58	NS	<3.81	<3.1
C006	Ra-226	pCi/L	3.01	0.41	<0.09	<0.13	NS	<0.08	<0.1	0.64	0.15	0.3	0.25	<0.07	NS	<2.32	<2.25
C006	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.11	<0.18	<0.17	<0.05	NS	NS	NS
C006	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.11	<0.18	<0.17	<0.05	NS	2.36	<1.3
C006	Th-230	pCi/L	0.18	<0.48	<-0.05	<0.06	NS	<0.02	<0.09	0.25	0.32	0.43	0.92	<0.31	NS	3.1	<0.7
C006	Th-232	pCi/L	NS	NS	<-0.01	<0.02	NS	<0.07	<0.04	<0.1	<0.14	<0.04	<0.12	<0.1	NS	<1.78	<0.7
C007	Uranium	µg/L	5.9	5.0	9.4	5.46	10.28	NS	2.8	3.44	10.45	2.54	4.1	16.02	NS	<5.22	<2.67
C007	Ra-226	pCi/L	0.87	<0.17	<0.13	<0.15	<0.09	0.16	<0.1	0.42	<0.2	0.54	<0.28	<0.22	NS	<2.57	<2.15
C007	Ra-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.09	<0.31	<0.05	<0.1	NS	NS	NS
C007	Th-228	pCi/L	NS	NS	NS	NS	NS	NS	NS	NS	<0.09	<0.31	<0.05	<0.1	NS	<0.9	<1.34
C007	Th-230	pCi/L	0.19	<1.7	<0.08	<0.1	<0.05	<0.23	<0.08	0.27	<0.09	0.4	0.55	<0.24	NS	4.67	<1.34
C007	Th-232	pCi/L	NS	NS	<0.03	<0	<0.01	<-0.02	<0.01	<0.04	<0.29	<0.04	<0.2	<0.1	NS	<2.1	<0.72

NS= Not included in sample analysis.

Table 3-13. Radiological Results for CY00 Coldwater Creek Sediment Sampling

First Sampling Event							
Radionuclide	Background[4]	Station/Result					
		EMP C002	EMP C003	EMP C004	EMP C005	EMP C006	EMP C007
Date of Sampling		3/23/00	3/9/00	3/14/00	3/2/00	3/30/00	3/30/00
Americium-241 (pCi/g)	N/A	0.06[1]	0.08[1]	0.07[1]	0.15[1]	0.12[1]	0.07[1]
Actinium-227 (pCi/g)	N/A	0.1[1]	0.14[1]	0.12[1]	0.26[1]	0.21[1]	0.11[1]
Cesium-137 (pCi/g)	0.39	0.02[1]	0.03[1]	0.02[1]	0.05[1]	0.04[1]	0.02[1]
Potassium-40 (pCi/g)	17.3	6.18[2]	8.48[2]	5.26[2]	10.45[2]	15.21[2]	6.27[2]
Protactium-231 (pCi/g)	N/A	0.5[1]	0.59[1]	0.55[1]	1.15[1]	0.93[1]	0.53[1]
Radium-226 (pCi/g)	0.91	0.6[2]	2[3]	0.81[2]	23.47[3]	0.98[2]	0.72[2]
Radium-228 (pCi/g)	1.08	0.23[2]	0.38[2]	0.23[2]	0.91[2]	1.1[2]	0.23[2]
Thorium-228 (pCi/g)	1.93	0.23[2]	0.78[3]	1.07[3]	1.12[3]	1.26[3]	0.62[3]
Thorium-230 (pCi/g)	2.89	0.97[3]	1.81[3]	2.45[3]	17.14[3]	1.58[3]	4.82[3]
Thorium-232 (pCi/g)	1.52	0.42[3]	0.32[3]	0.55[3]	0.61[3]	1.16[3]	0.65[3]
Total Uranium (mg/kg)	7.52	2.24[1]	1.85[1]	1.82[1]	21.8[1]	2.65[1]	2.2[1]
Uranium-235 (pCi/g)	0.25	0.11[1]	0.14[2]	0.13[1]	0.25[1]	0.2[1]	0.12[1]
Uranium-238 (pCi/g)	1.72	2.08[1]	2.96[1]	2.81[1]	5.47[1]	4.72[1]	2.31[1]
Second Sampling Event							
Radionuclide	Background[4]	Station/Result					
		EMP C002	EMP C003	EMP C004	EMP C005	EMP C006	EMP C007
Date of Sampling		3/23/00	3/9/00	3/14/00	3/2/00	3/30/00	3/30/00
Americium-241 (pCi/g)	N/A	0.06[1]	007[1]	0.07[1]	0.1[1]	0.1[1]	0.06[1]
Actinium-227 (pCi/g)	N/A	0.1[1]	0.12[1]	0.12[1]	0.19[1]	0.18[1]	0.1[1]
Cesium-137 (pCi/g)	0.39	0.02[1]	0.02[1]	0.02[1]	0.03[1]	0.03[1]	0.02[1]
Potassium-40 (pCi/g)	17.3	7.08[2]	8.5[2]	5.48[2]	8.94[2]	14.99[2]	6.8[2]
Protactinium-231 (pCi/g)	N/A	0.49[1]	0.55[1]	0.54[1]	0.81[1]	0.74[1]	0.49[1]
Radium-226 (pCi/g)	0.91	0.56[2]	0.7[2]	0.8[2]	1.52[2]	0.97[2]	0.68[2]
Radium-228 (pCi/g)	1.08	0.21[2]	0.4[2]	0.21[2]	0.78[2]	0.96[2]	0.25[2]
Thorium-228 (pCi/g)	1.93	0.21[2]	0.48[3]	0.98[3]	1.07[3]	1[3]	0.86[3]
Thorium-230 (pCi/g)	2.89	0.5[3]	1.41[3]	1.11[3]	12.47[3]	1.46[3]	1.86[3]
Thorium-232 (pCi/g)	1.52	0.21[2]	0.75[3]	0.21[2]	1.14[3]	1.04[3]	0.25[2]
Total Uranium (mg/kg)	7.52	14.8[1]	15.7[1]	16.4[1]	17.4[1]	18.2[1]	14.3[1]
Uranium-235 (pCi/g)	0.25	0.11[1]	0.12[1]	0.13[1]	0.18[1]	0.19[2]	0.11[1]
Uranium-238 (pCi/g)	1.72	2.42[1]	2.73[1]	2.31[1]	3.42[1]	2.06[1]	1.98[1]

Notes:
[1] Not detected. Data results listed as minimum detection limit.
[2] Data results for Gross Gamma activity.
[3] Data results for Gross Alpha activity.
[4] Background concentrations derived from Feasibility Study for the North County Site
N/A= Not Applicable

Table 3-14. Comparison of Historical Radiological Parameter Sediment Results for Coldwater Creek

Historical Location	Radionuclide	Units	03/28/92	09/30/92	04/07/93	10/12/93	04/19/94	10/13/94	04/04/95	10/24/95	04/25/96	10/29/96	05/15/97	04/06/98	06/99	03/00	05/00
C002	Uranium	pCi/g	6.24[1]	2.6	3.7	1.7	2.7	<2.4	3	<1.73	1.51	2.12	1.63	2.75	<15.7	<2.19	<2.53
C002	Radium-226	pCi/g	1	1.1	0.85	1.5	0.95	1.8	<1.2	<-0.01	1.6	0.83	4.87	0.96	0.51	0.6[2]	0.56[2]
C002	Radium-228	pCi/g	NS	NS	NS	NS	<0.76	NS	NS	NS	1.32	0.43	0.78	1.22	0.21	0.23[2]	0.21[2]
C002	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.69	1.32	0.43	0.78	1.22	0.25	0.23[2]	0.21[2]
C002	Thorium-230	pCi/g	0.88	0.57	<0.38[3]	0.7	2.04	<1.6	2.2	0.95	2.17	0.92	1.48	1.61	1.11	0.97	0.5
C002	Thorium-232	pCi/g	NS	NS	0.38	0.94	1.1	0.64	0.96	0.37	0.86	0.42	0.71	1.19	0.50	0.42	0.21[2]
C003	Uranium	pCi/g	6.28	3.3	4.7	1.8	2.8	3.4	3.2	<2.81	3.14	3.14	2.67	3.25	<16.4	<3.1	<2.85
C003	Radium-226	pCi/g	0.56	0.9	0.62	0.63	0.98	2	<1.8	<0.22	0.54	1.06	1.11	1.54	<0.59	2	0.7[2]
C003	Radium-228	pCi/g	NS	NS	NS	NS	0.61	NS	NS	NS	0.65	1.12	0.76	1.02	0.32	0.38[2]	0.4[2]
C003	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.42	0.65	1.12	0.76	1.02	1.09	0.78	0.48
C003	Thorium-230	pCi/g	2.82	3.3	2.5	0.87	2.43	4.6	6.2	4.61	6.1	5.09	2.15	3.5	5.98	1.81	1.41
C003	Thorium-232	pCi/g	NS	NS	<0.41	<0.39	0.59	1.1	0.74	0.4	0.81	1.31	0.62	0.87	0.48	0.32	0.75
C004	Uranium	pCi/g	7.9	3.3	3.3	1.9	5.1	2.9	3.3	3.95	2.47	2.51	2.32	3.3	<16.2	<2.94	<2.44
C004	Radium-226	pCi/g	0.72	0.88	0.78	0.95	1.2	2.1	<1.5	1.63	0.64	1.14	1.66	1.57	<0.61	0.81[2]	0.8[2]
C004	Radium-228	pCi/g	NS	NS	NS	NS	1.1	NS	NS	NS	0.54	0.68	0.4	0.96	<0.33	0.23[2]	0.21[2]
C004	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	0.46	0.54	0.68	0.4	0.96	<1.02	1.07	0.98
C004	Thorium-230	pCi/g	21.9	4	3	2.5	3.5	3.5	4.4	2.6	3.61	2.59	1.51	3.34	3.02	2.45	1.11
C004	Thorium-232	pCi/g	NS	NS	0.72	<0	1.3	0.54	0.81	0.44	0.72	0.49	0.36	0.96	<1.02	0.55	0.21[2]
C005	Uranium	pCi/g	5.93	3.2	5.2	17.2	2.2	3.1	2.7	<1.98	2.76	11.62	2.33	10.23	<17	<5.72	<3.6
C005	Radium-226	pCi/g	1.4	0.84	1.9	0.76	1.3	3.7	<1.7	2.77	2.72	5.66	3.29	5.14	0.67	23.47	1.52[2]
C005	Radium-228	pCi/g	NS	NS	NS	NS	1.1	NS	NS	NS	1.02	1	1.7	1.17	0.31	0.91[2]	0.78[2]
C005	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	1.39	1.02	1	1.7	1.17	0.51	1.12	1.07
C005	Thorium-230	pCi/g	5.33	2.4	4	14.5	1.76	10.1	12.7	1.34	7.23	229.7	8.12	201.2	<2.32	17.14	12.47
C005	Thorium-232	pCi/g	NS	NS	0.92	<0.61	1.1	0.84	1.4	0.93	0.9	1.65	0.75	1.63	<0.69	0.61	1.14
C006	Uranium	pCi/g	6.56	2.8	4.4	1.7	2.5	3.1	2.7	<2.74	2.54	2.8	1.95	2.18	<17	<4.92	0.19[2]
C006	Radium-226	pCi/g	1.3	0.81	0.91	0.84	1.4	1.9	<1.4	1.34	0.89	1.5	1.93	1.88	0.35	0.98[2]	0.97[2]
C006	Radium-228	pCi/g	NS	NS	NS	NS	1.5	NS	NS	NS	0.89	1.44	1.04	0.96	0.26	1.1	0.96[2]
C006	Thorium-228	pCi/g	NS	NS	NS	NS	NS	NS	NS	1.32	0.89	1.44	1.04	0.96	1.09	1.26	1
C006	Thorium-230	pCi/g	1.42	0.78	<0	0.49	1.57	2.8	2.7	1.65	1.83	3.48	1.41	2.21	<2.04	1.58	1.46
C006	Thorium-232	pCi/g	NS	NS	1.3	0.93	1.5	0.86	1.5	0.96	1.3	1.25	1.34	1.36	0.35	1.16	1.04
C007	Uranium	pCi/g	7.2	2.9	4.4	5.1	2.3	5.5	3	<3.43	3.23	5.04	2.88	3.84	<19.9	<2.43	<2.09
C007	Radium-226	pCi/g	1.3	0.62	0.88	1.7	0.95	1.5	<1.6	1.03	1.75	1.43	1.18	2.16	0.96	0.72[2]	0.68[2]
C007	Radium-228	pCi/g	NS	NS	NS	NS	0.69	NS	NS	NS	0.81	1.18	0.94	0.94	0.95	0.23[2]	0.25[2]
C007	Thorium-228	pCi/g	NS	NS	NS	NS	NS	1.2	NS	<0.78	0.81	1.18	0.94	0.94	1.31	0.62	0.86
C007	Thorium-230	pCi/g	11.6	0.85	1.4	44.96	2.68	31.4	2.9	4.53	5.64	32.38	4.52	23.8	8.24	4.82	1.86
C007	Thorium-232	pCi/g	<0.00	<0.00	0.56	<0.00	<0.64	1.2	0.86	0.82	0.76	1.12	1.24	1.07	1.7	0.65	0.25[2]

[1] Results listed in table are reported as gross alpha activity unless stated otherwise.

[2] Results are reported for gross gamma activity.

[3] Results reported as less than (<) were non-detects and number shown is minimum detection limit or activity.

NS= Not included in analysis.

The EMIFY01 background sediment criteria were exceeded for seventeen inorganic and sixteen semivolatile organic analytes. Background concentration were taken from *Feasibility Study for the North County Site* (USACE, 2000a). Only one volatile organic analyte criterion methylene chloride, a common laboratory contaminant, was exceeded. The chemical results are listed in Table 3-15.

Inorganic Exceedances	
• Aluminum • Arsenic • Barium • Boron • Calcium • Chromium • Cobalt • Copper • Iron	• Lead • Magnesium • Manganese • Potassium • Sodium • Thallium • Vanadium • Zinc
Semi-Volatile Organic Exceedances	
• Anthracene • Benzo(a)anthracene • Benzo(b)fluoranthene • Benzo(k)fluoranthene • Benzo(g,h,i)perylene • Benzo(a)pyrene • Bis(2-ethylhexyl)phthalate • Chrysene	• Dibenzo(a,h)anthracene • Dibenzofuran • Fluoranthene • Fluorine • Indeno(1,2,3-cd)pyrene • Naphthalene • Phenanthrene • Pyrene

EMP Station C006 was the only station to exceed background for aluminum although C005 matched the background criterion in March 2000. C007 had the highest arsenic concentration at 46 milligrams per kilograms (mg/kg), exceeding the National Oceanic and Atmospheric Administration (NOAA) threshold effects level (5.9 mg/kg) and the probable effects level (17 mg/kg). Station C002 and C005 had arsenic results at 24.2 and 22.2 mg/kg that exceeded NOAA criterion.

Copper background levels were exceeded at EMP stations C002, C003, C005, and C007. The highest copper value was at C002 (342 mg/kg) during the May 2000 sampling. This level exceeds the established NOAA threshold level limit of 35.7 mg/kg. Iron was detected at C002, C005, and C007 at concentrations greater than the background level. C007 had the highest concentration at 43,300 mg/kg. Iron has no established EPA or NOAA evaluation criterion. Lead was found only at station C005 (118/81.2 mg/kg) in concentrations exceeding background levels. The March 2000 concentration exceeds the NOAA threshold and probable criteria, while the May value exceeds the threshold criterion only.

Table 3-15. Chemical Results for CY00 Coldwater Creek Sediment Sampling

Analyte	Background[1]	Station/Result											
		EMP C002		EMP C003		EMP C004		EMP C005		EMP C006		EMP C007	
Date of Sampling (CY00)		3/23	5/23	3/9	5/23	3/14	5/23	3/2	5/18	3/30	5/18	3/30	5/18
Aluminum	11,300 mg/kg							11,300		12,700			
Arsenic	18 mg/kg	24.2							22.2				46
Barium	279 mg/kg							353	409				
Boron	9.9 mg/kg							11.8					
Calcium	28,900 mg/kg			176,000	69,500	148,000	249,000	38,400	40,000			92,500	126,000
Chromium	15.7 mg/kg	47.1				17.1		46.2	28.5	18.4		16.2	64.7
Cobalt	11.9 mg/kg						17.8	17.8	21.4			13.3	
Copper	20 mg/kg		342	44.4				57.7	40.4			99.3	25.4
Iron	25,800 mg/kg	27,500						26,500	26,000				43,300
Lead	79.7 mg/kg							118	81.2				
Magnesium	18,400 mg/kg						47,800						
Manganese	4,690 mg/kg						6,150						
Potassium	1,220 mg/kg							1,270					
Sodium	268 mg/kg						405	410	295				
Thallium	0 mg/kg						0.22						
Vanadium	30.5 mg/kg	42.8					51	40	43.3				45.7
Zinc	278 mg/kg							294					
Anthracene	230 µg/kg	2,000		320	2,600		1,700	1,000	890				290
Benzo(a)anthracene	300 µg/kg	410		930	6,700		2,500	4,100	3,500			610	670
Benzo(b)fluoranthene	310 µg/kg	2,500		920	5,300		1,700	3,800	3,000			570	630
Benzo(k)fluoranthene	290 µg/kg	1,900	620	740	4,800		1,800	3,400	3,100			610	600
Benzo(g,h,i)perylene	390 µg/kg	1,500		660	3,800		1,400	2,600	2,100				
Benzo(a)pyrene	340 µg/kg	2,600		950	5,400		2,000	3,900	3,300			630	650
Bis(2-ethylhexyl) phthalate	230 µg/kg				630			610				380	250
Chrysene	570 µg/kg		770	1,600	7,400		2,500	6,200	4,300			1,000	860
Dibenzo (a,h) anthracene	230 µg/kg	640			630		470	570	520				
Dibenzofuran	N/A µg/kg	900			490								
Fluoranthene	700 µg/kg		1,100	2900	13,000		5,900	12,000	9,100			1,000	1,500
Fluorene	N/A µg/kg				1,100		890						
Indeno (1,2,3-cd) pyrene	350 µg/kg	1,700	400	740	4,700			3,100	2,300				
Naphthalene	N/A µg/kg	1,000											
Phenanthrene	280 µg/kg	410	780	1,900	11,000		5,800	6,500	5,100			770	1,200
Pyrene	660 µg/kg		1,400	2,300	15,000		6,500	10,000	6,700			1,500	1,200
Methylene Chloride	7 µg/kg			8.3	7.6				18		27		

[1] Background concentrations derived from North County Feasibility Study.

N/A= No background criterion has been established for this analyte. Results exceed established EPA or NOAA evaluation criterion for sediment.

Magnesium and manganese were exceeded only at C004 (47,800/6,150 mg/kg) during the May CY00 sampling event. Neither of these inorganics has an established EPA or NOAA evaluation criterion. Potassium was exceeded at C005 (1,270 mg/kg) during the March CY00 sampling. Sodium was greater than background at C004 and C005. The highest concentration was 410 mg/kg at C005 during March CY00. Thallium was detected only once at C004 at 0.22 mg/kg during May CY00. Vanadium levels exceeded background at stations C002, C004, C005, and C007. The greatest concentration was detected at C004 (51 mg/kg) during May CY00. None of these inorganic analytes have an established EPA or NOAA evaluation criterion.

Zinc was detected only at station C005 during the March CY00 sampling event. The concentration of 294 mg/kg was slightly over the background value of 278 mg/kg and exceeded the NOAA threshold level of 123 mg/kg.

Anthracene was detected at EMP Stations C002, C003, C004, C005, and C007 at levels above background. The highest concentration was at C003 [2,600 microgram per kilogram (µg/kg)]. All stations that had detections of anthracene exceeded the EPA evaluation secondary chronic value of 220 µg/kg. Benzo(a)anthracene was detected at every Coldwater Creek monitoring station except C006. All concentrations exceed the established EPA and NOAA investigative limits with the highest value of 6,700 µg/kg occurring at C003 in May CY00.

Benzo(b)fluoranthene was detected above background at every Coldwater Creek monitoring station except C006. The highest concentration occurred at C003 (5,300 µg/kg) during May 2000. Benzo(k)fluoranthene was detected above background at every Coldwater Creek monitoring station except C006. The highest concentration occurred at C003 (4,800 µg/kg) during May 2000. Benzo(g,h,i)perylene was detected above background at C002, C003, C004, and C005. The highest concentration was at C003 (3,800 µg/kg) during the May 2000 sampling event. None of these semi-volatile organic analytes have an established EPA or NOAA evaluation criterion.

Benzo(a)pyrene was detected above background at every Coldwater Creek monitoring station except C006. The highest concentration occurred at C003 (5,400 µg/kg) during May CY00. All stations that had detections of benzo(a)pyrene exceeded the EPA evaluation secondary chronic value and NOAA threshold and probable levels except for C007 which did not exceed NOAA probable levels.

Bis(2-ethylhexyl)phthalate concentrations were greatest at station C003 (630 µg/kg) during the May CY00 event. Background levels were also exceeded at C005 and C007 although no investigative limits were exceeded at any station.

Chrysene was detected above background at every Coldwater Creek monitoring station except C006. The highest concentration occurred at C003 (7,400 µg/kg) during May CY00. All results for chrysene exceeded the NOAA threshold level and C003, C004, C005, and C007 exceeded the NOAA probable level as well.

Dibenzo(a,h)anthracene was detected at concentrations above background at EMP Stations C002, C003, C004, and C005. The greatest concentration occurred at C002 (640 µg/kg) during the March CY00 sampling. No established EPA or NOAA evaluation criterion exists for this analyte. Dibenzofuran has no established background concentration for Coldwater Creek although detected concentrations at C002 (900 µg/kg) and at C003 (490 µg/kg) exceed the established EPA secondary chronic criterion (420 µg/kg). Fluoranthene was detected above background at every Coldwater Creek station except for C006. All fluoranthene detections were above the NOAA threshold level (111 µg/kg), with the NOAA probable level (2,360 µg/kg) exceeded at C003, C004, and C005. The EPA proposed sediment limit of 6,200 µg/kg was also exceeded at C003 (13,000 µg/kg) and C005 (9,100/12,000 µg/kg). Fluorene has no established background concentration for Coldwater Creek, although detected concentrations at C003 (1,100 µg/kg) and C004 (890 µg/kg) exceed the established EPA chronic criterion of 540 µg/kg.

Indeno(1,2,3-cd)pyrene background levels were exceeded at stations C002, C003, C004, and C005. The highest concentration occurred at C003 (4,700 µg/kg) during the May CY00 event. No established EPA or NOAA evaluation criterion exists for this analyte. Naphthalene has no established background concentration for Coldwater Creek although detected concentrations at C002 (1,000 µg/kg) exceeded the established EPA chronic criteria of 240 µg/kg.

Phenanthrene was detected at every Coldwater Creek station except for C006. The highest concentration occurred at C003 (11,000 µg/kg) during May CY00 and all stations that had detections of phenanthrene exceeded the NOAA threshold level of 410 µg/kg. Detections at C003, C004 and C005 exceeded all established EPA and NOAA investigative limit levels. Pyrene was detected at every Coldwater Creek station except for C006. The highest concentration occurred at C003 (15,000 µg/kg) during May CY00. All stations that had detections exceeded the NOAA threshold and probable levels.

The methylene chloride background level (7 µg/kg) was the only volatile organic analyte to be exceeded. Station C003 (8.3/7.6 µg/kg), C005 (18 µg/kg) and C006 (27 µg/kg) all had detections above background although no established criteria (EPA criteria 370 µg/kg) were exceeded. Methylene chloride is a multi-purpose chemical commonly used in laboratories and the positive detections may be the result of residual contamination during the analytical process.

4.0 EVALUATION OF ENVIRONMENTAL MONITORING DATA FOR GROUND WATER

The ground-water monitoring activities conducted under the EMP during CY00 are described in this section. The SLS sampled during CY00 are the SLAPS, the HISS and the SLDS. Ground water was sampled on a quarterly basis following a protocol procedure for individual wells and analytes, and analyzed for various radiological constituents, organic compounds, and inorganics. In addition, field parameters, or indicator parameters, were measured continuously during purging of the wells before sampling. The ground-water field parameter results for CY00 sampling at SLAPS, HISS and SLDS are presented in Appendix C, Table C-1. Summary tables providing the SLS ground-water analytical sampling results for CY00 are found in Appendix C, Table C-2.

Guidelines for evaluating ground-water data are derived from various environmental regulatory programs. The regulatory-based guidelines considered for evaluation of ground-water data are the MCLs and the secondary MCLs (SMCLs) of the SDWA and ground-water quality criteria promulgated by the MDNR under 10 CSR 20-7 (SAIC, 2000). In addition, ground-water background levels, where available, are compared to the sampling results to provide an indication of the nature and extent of contamination in ground water at the SLS.

4.1 SLAPS

Ground-water monitoring wells have been installed at SLAPS to characterize the site stratigraphy, ground-water chemistry, and ground-water migration pathways. In the vicinity of SLAPS, surficial deposits (Unit 1) include topsoil and anthropogenic fill (rubble, scrap metal, gravel, glass, slag, and concrete) generally less than 4 m (14 ft) thick (as seen in Figures 4-1, 4-2, and 4-3). Unit 2 corresponds to loess and has a thickness of 3 to 9 m (11 to 30 ft). Unit 3, which is subdivided into Subunits 3T, 3M, and 3B, consists primarily of clay and silt lakebed deposits. Each of these clayey subunits has a thickness of up to 9 m (30 ft). Unit 4 consists of clayey gravel with fine to very-fine sand and sandy gravel. This unit is interpreted to be approximately 2 to 5 m (5 to 15 ft) thick and thins eastward, and is absent beneath the eastern part of SLAPS, where the 3T, 3M, and 3B drape, or onlap, onto shale bedrock. Below Units 3 and 4 are Units 5 and 6, which are comprised of shale/siltstone and limestone, respectively. Depth to bedrock ranges from about 17 m (55 ft) on the east of SLAPS to a maximum of 27-m (90 ft) towards Coldwater Creek on the west.

Five hydrostratigraphic zones (HZ-A through HZ-E) are recognized beneath SLAPS. HZ-A consists of the fill (Unit 1) and the Pleistocene, glacially-related sediments of stratigraphic Unit 2 and Subunit 3T. Underlying HZ-A is HZ-B, which consists of highly impermeable clay (Subunit 3M). HZ-C consists of the stratigraphic Subunit 3B and Unit 4. The shale and limestone bedrock are recognized as HZ-D and HZ-E, respectively. HZ-E is the protected aquifer for the site.

Zone	Period	Epoch	Stratigraphy	Thickness (ft.)	Description
Hydrostratigraphic zone (HZ)-A	Quaternary	Holocene	FILL/TOPSOIL	0-14	**Unit 1** Fill - Sand, silt, clay, concrete, rubble. Topsoil - Organic silts, clayey silts, wood, fine sand.
		Pleistocene	LOESS (CLAYEY SILT)	11-32	**Unit 2** Clayey silts, fine sands, commonly mottled with iron oxide staining. Scattered roots and organic material, and a few fossils.
			GLACIO-LACUSTRINE SERIES: SILTY CLAY	19-75 (3) 9-27 (3T)	**UNIT 3** Silty clay with scattered organic blebs and peat stringers. Moderate plasticity. Moist to saturated. (3T)
Hydrostratigraphic zone (HZ)-B			VARVED CLAY	0-8	Alternating layers of dark and light clay as much as 1/16 inch thick (3M)
			CLAY	0-26	Dense, stiff, moist, highly plastic clay. (3M)
Hydrostratigraphic zone (HZ)-C			SILTY CLAY	10-29	Similar to upper silty clay. Probable unconformable contact with highly plastic clay. (3B)
			BASAL CLAYEY & SANDY GRAVEL	0-6	**UNIT 4** Glacial clayey gravels, sands, and sandy gravels. Mostly Chert.
Hydrostratigraphic zone (HZ)-D	Pennsylvanian		Cherokee (?) group (undifferentiated)	0-35	**UNIT 5** BEDROCK: Interbedded silty clay/shale, lignite/coal, sandstone, and siltstone. Erosionally truncated by glaciolacustrine sequences. (Absent at HISS).
Hydrostratigraphic zone (HZ)-E	Mississippian		STE. GENEVIEVE ST. LOUIS LIMESTONES	10+	**UNIT 6** BEDROCK: Hard, white to olive, well cemented, sandy limestone with interbedded shale laminations.

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Figure 4-1. Generalized Stratigraphic Column for SLAPS and HISS

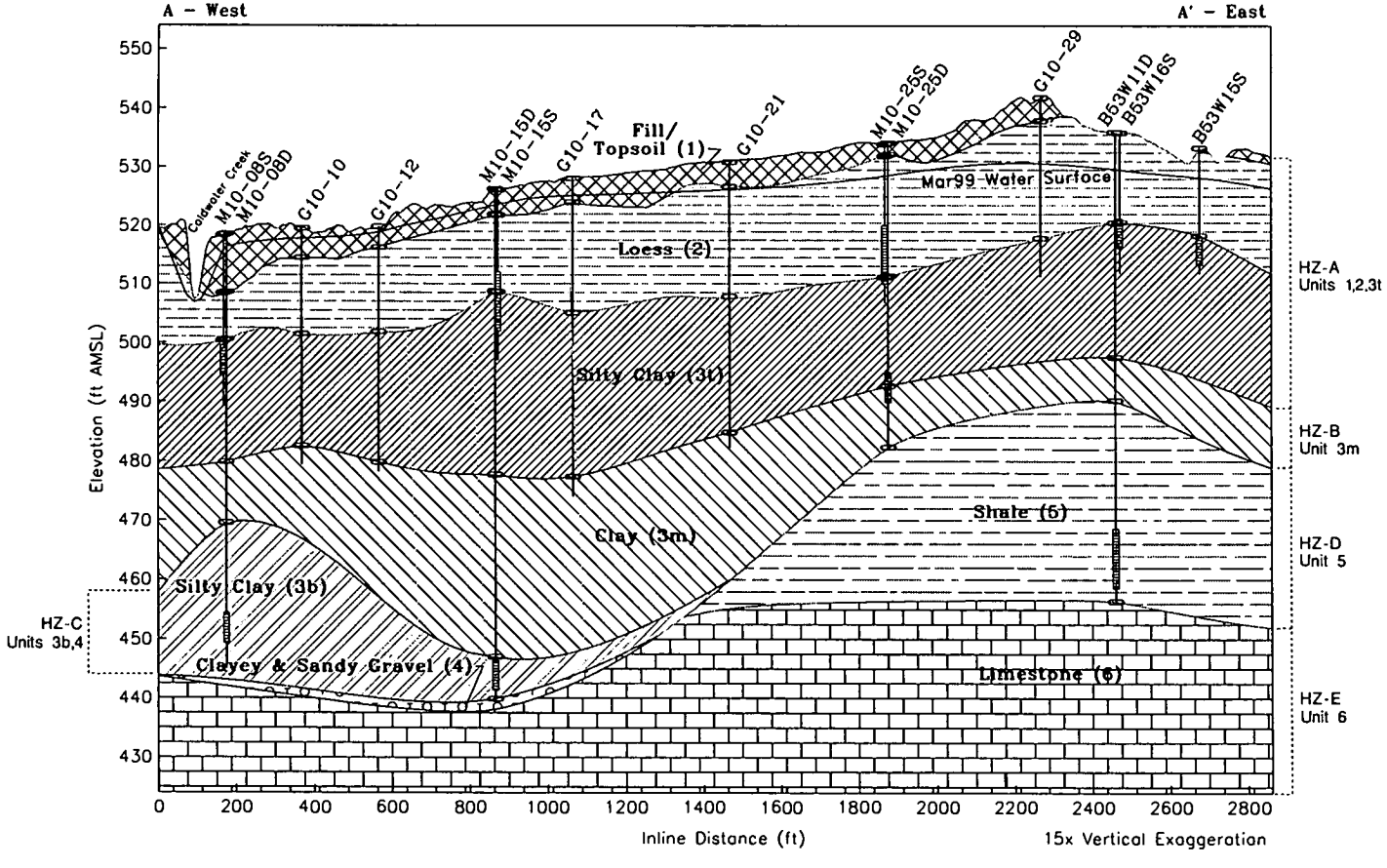


Figure 4–2.
SLAPS Geologic
Cross–Section A–A'

Notes

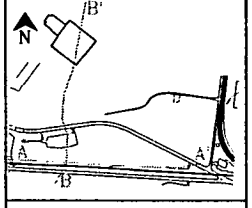
Geologic data used in the cross section collected through 2000.

Legend

Borehole pick

Well screen

Cross Section Location Map



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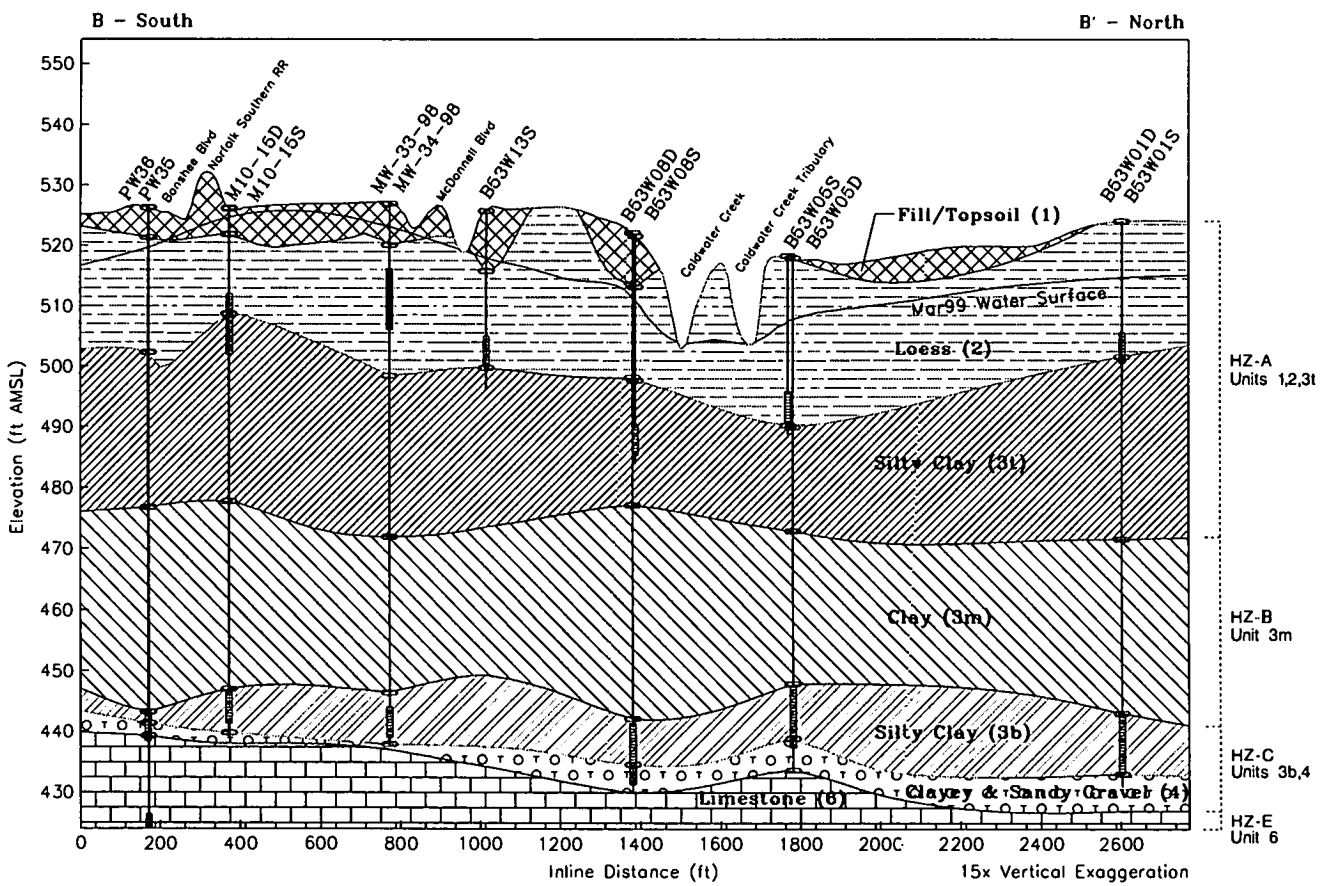


Figure 4–3.
SLAPS Geologic
Cross–Section B–B'

Notes

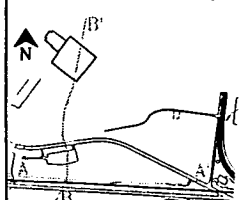
Geologic data used in the cross section collected through 2000.

Legend

Borehole pick

Well screen

Cross Section Location Map



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The HZ-A or shallow ground-water flow is toward Coldwater Creek under normal flow conditions. Average depths to the water table at the site range from near the ground surface during the winter months to about 3 m (10 ft) below ground surface during the summer months. The dominant flow in HZ-A is through the more permeable Unit 2. Each of the subunits in Unit 3 has lower hydraulic conductivities than Units 1, 2 and 4 (USACE, 2000a). HZ-B and the Pennsylvanian shale, HZ-D, limit the passage of ground water vertically beneath the entire SLAPS. Subunit 3M of HZ-B acts as a vertical barrier to ground-water movement under the western portion of the site. It is a highly impermeable clay aquitard that effectively separates the HZ-A ground-water system from the underlying HZ-C and HZ-E (USACE, 2000a). The dominant unit to obtain water in the lower horizon is Unit 4. Unit 4 of HZ-C is taken as a surrogate for HZ-E, as water movement within the limestone is dependent upon the limestone's joint and solutioned system.

Many of the monitoring wells are screened across more than one HZ; therefore, for discussion purposes, HZ-A is considered the upper (or shallow) zone, while HZ-C, HZ-D, and HZ-E are considered the lower (or deep) zone. Twenty-nine wells are screened exclusively across the shallow HZ-A. Ten wells are screened in the lower HZ-C, HZ-D, and/or HZ-E. The remaining seven wells (B53W01D, B53W05D, B53W08D, B53W12D, M10-8D, M10-15D, and M10-25D) are screened across multiple zones. Table 4-1 provides a summary of the HZ information for SLAPS ground-water monitoring wells. This designation of upper and lower HZs is separated at Subunit 3M. The current SLAPS ground-water monitoring well network is shown in Figure 4-4.

Table 4-1. Screened Hydrostratigraphic Zones for SLAPS Ground-water Monitoring Wells

Well ID	Screened Hydrostratigraphic Zone(s)
B53W01D	HZ-C
B53W01S	HZ-A
B53W02D	HZ-C
B53W02S	HZ-A
B53W03D	HZ-C
B53W03S	HZ-A
B53W04D	HZ-C, HZ-B
B53W04S	HZ-A, HZ-B
B53W05D	HZ-C
B53W05S	HZ-A
B53W06D	HZ-C, HZ-B
B53W06S	HZ-A
B53W07D	HZ-C
B53W07S	HZ-A
B53W08D	HZ-C
B53W08S	HZ-A
B53W09D	HZ-D
B53W09S	HZ-A
B53W10S	HZ-A, HZ-B
B53W11S	HZ-A

Table 4-1. Screened Hydrostratigraphic Zones for SLAPS Ground-water Monitoring Wells (Cont'd)

Well ID	Screened Hydrostratigraphic Zone(s)
B53W12D	HZ-B, HZ-D
B53W13S	HZ-A
B53W14S	HZ-A
B53W17S	HZ-A
B53W18S	HZ-A
B53W19S	HZ-A
B53W20S	HZ-A
M10-08D	HZ-B
M10-08S	HZ-A
M10-15D	HZ-B
M10-15S	HZ-A
M10-25D	HZ-A, HZ-B
M10-25S	HZ-A
MW-31-98	HZ-A
MW-32-98	HZ-A
MW-33-98	HZ-A
MW-34-98	HZ-B, HZ-C
PW35	HZ-E
PW36	HZ-B, HZ-C
PW37	HZ-A
PW38	HZ-A
PW39*	HZ-A
PW40*	HZ-A
PW41*	HZ-A
PW42*	HZ-C
PW43*	HZ-A

* Indicates a well installed during CY00.

4.1.1 Evaluation of the CY00 EMP Ground-water Sampling at SLAPS

A total of forty-six ground-water wells were sampled for various parameters in CY00 at SLAPS. [Five of these wells (PW39 through PW43) were installed during CY00 with sampling initiated in the third quarter of CY00. See Section 4.5 for more information concerning the installation of these wells.] Ground-water samples collected from the existing wells have been analyzed for both radiological and nonradiological constituents. However, historically, the main focus of ground-water sampling has been radiological parameters. Ground-water samples were analyzed for total uranium (metals analysis), individual radioisotopes of uranium (U-234, U-235, and U-238), Ra-226, Th-228, Th-230, and Th-232.

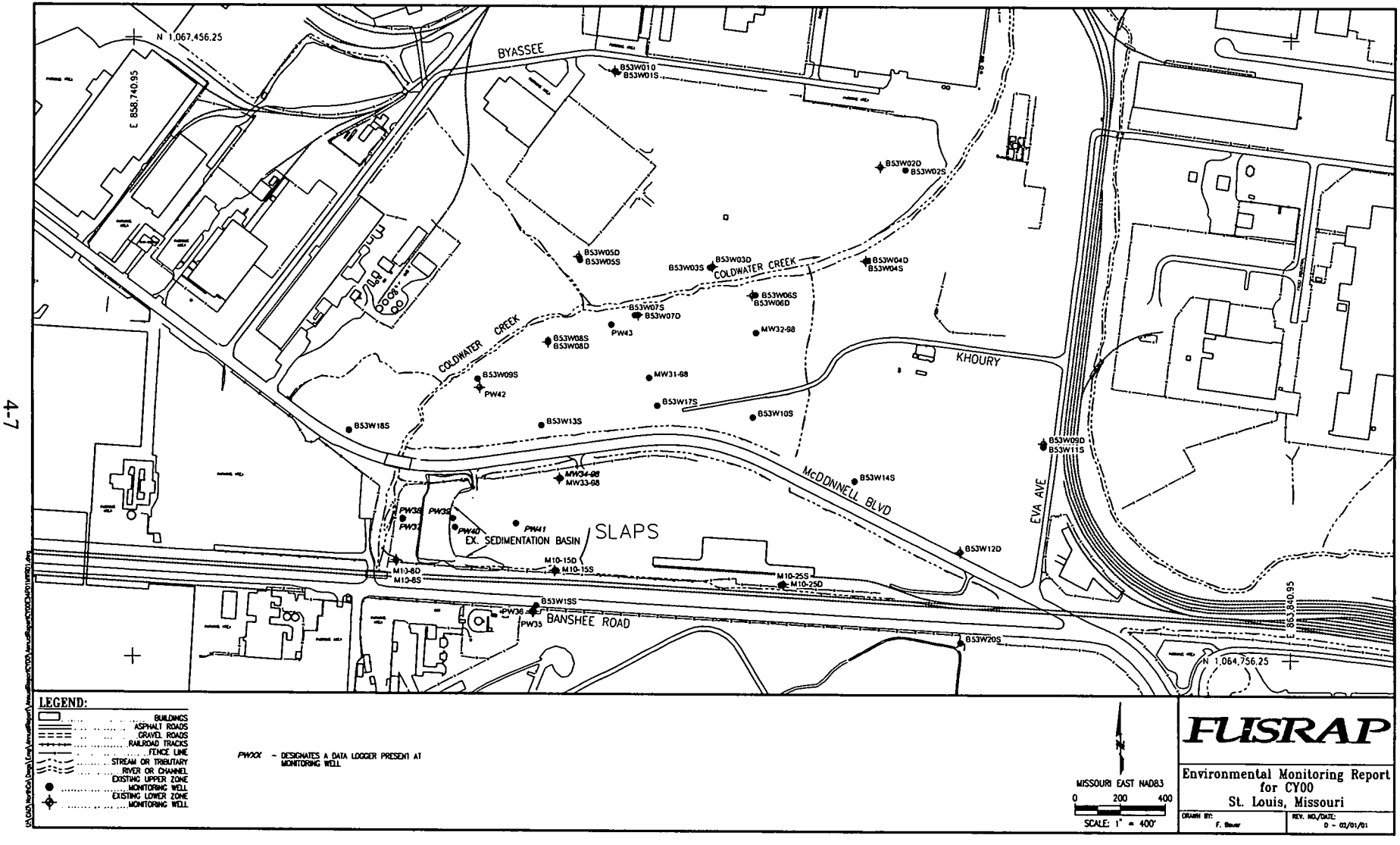


Figure 4-4. Ground-water Monitoring Well Locations at the SLAPS

In CY00, ground-water sampling at SLAPS was conducted between February 22 and March 28 (first quarter); May 1 to June 15 (second quarter); August 8 to September 26 (third quarter); and November 14 to Nov 29 (fourth quarter). The results of the ground-water sampling are summarized in Tables 4-2 and 4-3. For discussion purposes, the ground-water analytical data acquired in the CY00 sampling events at SLAPS are presented separately for the upper and lower ground-water zones. The sampling results are compared to EPA-designated MCLs and SMCLs. The results are also compared to the ground-water background concentrations identified in the North County Feasibility Study (USACE, 2000a).

Upper, HZ-A Ground Water

Results of ground-water sampling conducted during CY00 indicate that various metals, radionuclides, and organic compounds are present above MCLs or SMCLs in HZ-A ground water at SLAPS. The contaminants include the inorganics arsenic, chromium, iron, manganese, nitrate, selenium, and thallium; the organic compounds 1,2-DCE and TCE; and the radionuclides Ra-226 and uranium. Table 4-2 provides a summary of the results. Additional contaminants, in particular Th-230, U-234, U-235, and U-238, were detected in HZ- A ground water but have no designated MCLs or SMCLs.

The metals detected above MCLs or SMCLs include arsenic, chromium, iron, manganese, selenium, and thallium. Arsenic was detected in five wells at concentrations above the proposed MCL (10 µg/L). The maximum concentration detected was 215 µg/L in the second quarter sample from MW-33-98. Chromium (129 µg/L) was detected above the MCL of 100 µg/L in a single sample from well B53W19S, located south of Banshee Road. Iron was detected at concentrations exceeding the SMCL of 300 µg/L in twelve wells, with the maximum concentration of 26,200 µg/L detected in M10-8S. Manganese was detected in numerous HZ-A wells at levels exceeding both the MCL (50 µg/L) and the established HZ-A background level (1,580 µg/L). The maximum manganese concentration detected was 9,070 µg/L in the third quarter sample from PW40. Selenium was detected in twelve HZ-A wells at levels exceeding the MCL of 50 µg/L. The maximum detected concentration was 1,390 µg/L, detected in the fourth quarter sample from PW41. Thallium exceeded its MCL of 2 µg/L in two HZ-A wells. The maximum concentration of 4.9 µg/L was detected in MW-32-98, located in the ballfields.

The CY00 ground-water sampling results indicate that the principal radiological contaminants present in the HZ-A ground water are Ra-226, Th-230, U-238, U-234, and U-235. Ra-226 was detected at levels above the combined Ra-226/Ra-228 MCL of 5 pCi/L in six wells, with concentrations ranging from below the detection limit to 10.3 pCi/L. The HZ-A wells B53W02S, located north of Coldwater Creek, and PW38, located at the western edge of SLAPS, reported the highest values of Ra-226 (10.3 pCi/L and 10.1 pCi/L, respectively). Th-230 was detected above its background concentration of 1.18 pCi/L in twenty-two wells, with the maximum concentration (59.2 pCi/L) detected in PW38 at the western edge of SLAPS. U-238 has been detected at varying levels in HZ-A wells. The U-238 results exceeded the established HZ-A ground-water background concentration of 2.3 pCi/L in sixteen wells.

Table 4-2. Analytes Detected above MCLs in HZ-A[1] Ground Water at SLAPS

Event	Filtering	Chemical	Units	Detects			Mean Concentration[2]	MCL	Detection Frequency	Number >MCL
				Minimum	Maximum	Mean				
First Quarter CY00	Unfiltered	1,2-Dichloroethene	µg/L	1.9	78	40	13	1	2 / 7	2
		Arsenic	µg/L	3.2	26.6	18.4	4.2	10	5 / 25	4
		Chloride	mg/L	1.3	1630	161.4	161.4	250	25 / 25	3
		Iron	µg/L	307	24300	9099	3279	300	9 / 25	9
		Manganese	µg/L	12.4	2310	954.7	763.8	50	20 / 25	16
		Nitrate/Nitrite	mg/L	0.026	723	149.8	131.8	10	22 / 25	11
		Radium-226	pCi/L	2.12	5.2	3.7	1.1	5	2 / 23	1
		Selenium	µg/L	26.3	792	348.5	111.9	50	8 / 25	7
		Sulfate	mg/L	6.9	513	131.7	126.4	250	24 / 25	4
		Total Dissolved Solids	mg/L	491	5460	1582	1582.4	500	25 / 25	22
		Trichloroethene	µg/L	2.3	370	69.4	59.9	5	6 / 7	5
		Uranium[3]	µg/L	2.9	9168.0	673.8	377.9	30	14 / 25	4
	Filtered	Arsenic	µg/L	23.1	23.1	23.1	11.8	10	1 / 2	1
		Iron	µg/L	16600	16600	16600	8303	300	1 / 2	1
		Manganese	µg/L	21.8	1740	880.9	880.9	50	2 / 2	1
		Radium-226	pCi/L	5.2	5.2	5.2	3.0	5	1 / 2	1
		Selenium	µg/L	429	429	429	214.8	50	1 / 2	1
		Uranium[3]	µg/L	51.7	51.7	51.7	26.5	30	1 / 2	1
Second Quarter CY00	Unfiltered	1,2-Dichloroethene	µg/L	1.2	80	21.2	13.2	1	4 / 7	4
		Arsenic	µg/L	3.4	215	33.7	11.5	10	8 / 25	3
		Chloride	mg/L	1.2	1620	154.8	154.8	250	25 / 25	4
		Iron	µg/L	27.4	16100	5142	3042	300	13 / 22	8
		Manganese	µg/L	37.7	2020	728.3	553.6	50	19 / 25	16
		Nitrate/Nitrite	mg/L	0.075	670	108.4	95.4	10	22 / 25	10
		Radium-226	pCi/L	2.67	9.9	6.3	2.0	5	2 / 25	1
		Selenium	µg/L	2.7	712	273.7	88.2	50	8 / 25	6
		Sulfate	mg/L	7.2	635	152.2	146.2	250	24 / 25	4
		Total Dissolved Solids	mg/L	444	4900	1530	1530	500	25 / 25	23
		Trichloroethene	µg/L	2.5	340	64.4	55.6	5	6 / 7	5
		Uranium[3]	µg/L	3.30	6494	482	271	30	14 / 25	4
	Filtered	Arsenic	µg/L	3.7	10.4	7.1	7.1	10	2 / 2	1
		Iron	µg/L	171	16100	8135.5	8135.5	300	2 / 2	1
		Manganese	µg/L	49.1	1770	909.6	909.6	50	2 / 2	1

[1] Results include those wells screened in the HZ-A and/or HZ-B ground-water units

[2] Mean Concentration was calculated using value equal to 1/2 detection limit when result was qualified as undetected.

[3] Uranium Values were calculated from isotopic results and specific activities.

Table 4-2. Analytes Detected above MCLs in HZ-A[1] Ground Water at SLAPS (Cont'd)

Event	Filtering	Chemical	Units	Detects			Mean Concentration[2]	MCL	Detection Frequency	Number >MCL
				Minimum	Maximum	Mean				
Third Quarter CY00	Unfiltered	1,2-Dichloroethene	µg/L	1.6	94.0	35.5	17.5	1	5 / 11	5
		Arsenic	µg/L	1.8	25.6	8.7	2.6	10	7 / 29	2
		Chloride	mg/L	1.2	2050	171.4	165.5	250	28 / 29	3
		Chromium	µg/L	9.1	129	42.9	7.94	100	4 / 29	1
		Iron	µg/L	57.4	26200	4492.4	2334.6	300	15 / 29	9
		Manganese	µg/L	28	9070	1138	1059.5	50	27 / 29	23
		Nitrate/Nitrite	mg/L	0.023	783	181.1	155.2	10	24 / 28	14
		Radium-226	pCi/L	2.32	10.3	5.2	1.9	5	4 / 28	2
		Selenium	µg/L	3.3	1340	415.5	158.4	50	11 / 29	9
		Sulfate	mg/L	3.4	669	182.7	170.4	250	27 / 29	7
		Thallium	µg/L	4.9	4.9	4.9	1.8	2	1 / 29	1
		Total Dissolved Solids	mg/L	525	6450	1977	1842	500	27 / 29	27
		Trichloroethene	µg/L	7.2	350	102.6	66.2	5	7 / 11	7
		Uranium[3]	µg/L	1.2	7091	249.3	400.7	30	18 / 29	1
	Filtered	Arsenic	µg/L	22.9	22.9	22.9	11.8	10	1 / 2	1
		Iron	µg/L	58.3	18600	9329.2	9329.2	300	2 / 2	1
		Manganese	µg/L	53.2	1640	846.6	846.6	50	2 / 2	2
		Selenium	µg/L	738	738	738	370	50	1 / 2	1
Fourth Quarter CY00	Unfiltered	1,2-Dichloroethene	µg/L	2.9	60	32	17.2	1	3 / 6	3
		Iron	µg/L	22.9	10400	3315.2	1511.9	300	5 / 11	2
		Manganese	µg/L	17.2	8250	1488.4	1353.1	50	10 / 11	8
		Nitrate/Nitrite	mg/L	2.3	808	449.5	367.8	10	9 / 11	8
		Radium-226	pCi/L	2.89	10.1	6.4	3.5	5	3 / 7	2
		Selenium	µg/L	4.6	1390	410.2	298.6	50	8 / 11	7
		Sulfate	mg/L	62.4	407	217.6	217.6	250	11 / 11	5
		Thallium	µg/L	3.8	3.8	3.8	1.7	2	1 / 11	1
		Total Dissolved Solids	mg/L	489	6390	3231	3231	500	11 / 11	10
		Trichloroethene	µg/L	21	360	131.6	110.1	5	5 / 6	5
		Uranium[3]	µg/L	3.3	7874	1352	1352	30	7 / 7	4

[1] Results include those wells screened in the HZ-A and/or HZ-B) ground-water units

[2] Mean Concentration was calculated using value equal to 1/2 detection limit when result was qualified as undetected.

[3] Uranium Values were calculated from isotopic results and specific activities.

The highest levels of U-238 (up to a maximum of 3,046 pCi/L), U-234 (2,955 pCi/L) and U-235 (166.1 pCi/L), were detected in PW38. Two other radionuclides, Th-228 (maximum of 1.7 pCi/L in M10-8S) and Th-232 (maximum 7.5 pCi/L in PW38), were detected at slightly elevated levels in HZ-A ground-water wells, primarily in the western portion of SLAPS.

Total uranium concentrations were calculated using the isotopic uranium results. These results indicate total uranium concentrations above the MCL of 30 µg/L were present in seven HZ-A wells sampled at SLAPS in CY00. The highest concentration (9,168 µg/L) was detected in the first quarter unfiltered sample from PW38, located near Coldwater Creek at the western edge of SLAPS. Concentrations in this well were elevated well above the MCL in all CY00 samples, decreasing to a minimum of 6,494 µg/L in the second quarter sample but increasing to 7,874 µg/L in the fourth quarter sample. The remaining six wells with total uranium concentrations above the MCL (M10-25S, B53W06S, MW3398, PW39, PW40, and PW41) had maximum concentrations ranging from 32 to 928 µg/L. The highest concentrations were found in the southwestern portion of SLAPS.

The principal organic contaminant detected in the HZ-A ground water is TCE, which was detected in the HZ-A ground water at concentrations exceeding the MCL of 5 µg/L in eight wells. The sampling results indicate that TCE is distributed in two distinct areas, one centered around B53W17S west of the end of Khoury Road and the other at the western half of SLAPS centered around PW37, PW38, PW39, PW40, and PW41. The highest TCE concentration detected during CY00 (370 µg/L) was from B53W17S, located in the ballfields near the end of Khoury Road. Concentrations in the area at the western edge of SLAPS ranged from non-detect levels in PW37 to a maximum concentration of 130 µg/L in PW39. The TCE degradation product cis-1,2-DCE has also been detected in a similar distribution pattern to that of TCE. The distribution of 1,2-DCE indicates that degradation of TCE to 1,2-DCE is occurring primarily in the west portion of SLAPS. The maximum concentration was 94 µg/L, detected in PW38. Vinyl chloride (VC) was not detected in any ground-water samples. This suggests that insufficient time has passed since the TCE releases took place for complete degradation to VC to occur.

Elevated concentrations of TDS were found in several wells, including the upgradient well B53W20S, an indication that these concentrations may be due to natural conditions or the industrial activities in the surrounding region. Concentrations of nitrates above the MCL of 10 mg/L were detected in fifteen SLAPS wells sampled in CY00. The nitrate values at SLAPS ranged from 0.02 mg/L at PW37 to 808 mg/L at PW40, with a mean of 161 mg/L. Sulfates and chlorides did not exceed their established HZ-A background levels.

Lower, HZ-C through HZ-E Ground Water

Seven wells are screened across both the HZ-B and deeper horizons. An additional ten wells are screened exclusively in HZ-C, HZ-D, and/or HZ-E at SLAPS and the adjacent ballfields. The CY00 sampling data indicate that arsenic, iron, manganese, and TDS were present above MCLs or SMCLs in the ground-water samples from these wells. In addition, Ra-226 was detected at levels slightly exceeding the MCL in samples from one well screened across both HZ-C and HZ-E and one well screened across both HZ-B and HZ-C. Table 4-3 provides a summary of the lower ground-water sampling results for CY00.

Arsenic was detected at levels exceeding the proposed MCL of 10 µg/L and the background concentration for HZ-C groundwater, 82.7 µg/L. The maximum concentration in unfiltered samples, 233 µg/L, was detected in the first quarter sample from MW-34-98, which is screened across the lower ground-water unit HZ-C. MW-34-98 is adjacent to MW-33-98, which had the maximum detected concentration in the HZ-A ground-water unit. Iron and manganese were detected above their SMCLs (200 µg/L and 50 µg/L, respectively) and background concentrations (15,200 µg/L and 231 µg/L, respectively). The maximum concentrations detected were 24,500 µg/L iron in M10-15D and 5020 µg/L manganese in M10-25D. Both M10-15D and M10-25D were screened across both HZ-B and lower ground-water zones (HZ-C and HZ-C/HZ-D, respectively). Elevated concentrations of iron (up to 19,400 µg/L) and manganese (up to 1,800 µg/L) were also detected in wells screened exclusively across the deep (HZ-C, HZ-D, and/or HZ-E) zones. Total dissolved solids exceeded the SMCL of 500 mg/L, ranging from 433 mg/L to 1,010 mg/L in the deep ground-water samples.

Radium-226 was detected above the combined Ra-226/Ra-228 MCL of 5 pCi/L in two HZ-C wells. The maximum Ra-226 concentration (8.62 pCi/L) was detected in the third quarter sample from B53W06D, a well screened across the lower, HZ-C and HZ-E ground-water zones. A second exceedance (7.84 pCi/L Ra-226 in B53W08D) was detected from a well screened across both the HZ-B and HZ-C ground-water zones. The radionuclides U-234 and U-238 were detected at maximum concentrations of 93.4 pCi/L and 94.2 pCi/L, respectively, in a deep (HZ-C) well, MW-34-98. The maximum total uranium concentration calculated for this well, based on the isotope concentrations, was 283 µg/L, which exceeds the MCL of 30 µg/L. The only other significant concentrations of U-234 and U-238 detected in HZ-C ground water were from well B53W09D, screened within the shale (HZ-D). The maximum detected concentrations of U-234 and U-238 in this well were 25.9 pCi/L and 23.2 pCi/L, respectively. The maximum total uranium concentration calculated for B53W09D was 69.4 µg/L. The elevated concentrations of uranium in this well may be a result of high natural uranium concentrations in the shale. [Shales typically have higher concentrations of most trace elements, including uranium, than other sedimentary rocks (Brownlow, 1996).] Additional radionuclides (Th-228 and Th-230) were detected in wells screened in the HZ-C through HZ-E ground water, but their maximum concentrations were only slightly above background levels.

The only organic compounds detected in the deep ground-water samples were the common laboratory contaminants methylene chloride (9.2 µg/L in the third quarter sample from PW35) and acetone (27 µg/L and 11 µg/L from PW35 and PW36, respectively). Nitrate did not exceed its MCL of 10 mg/L in any of the deep ground-water wells sampled in CY00.

Table 4-3. Analytes Detected above MCLs in HZ-C[1] Ground Water at SLAPS

Event	Filtering	Chemical	Units	Detects			Mean Concentration[2]	MCL	Detection Frequency	Number >MCL
				Minimum	Maximum	Mean				
First Quarter CY00	Unfiltered	Arsenic	µg/L	17.9	233	75.7	65.7	10	13 / 15	13
		Iron	µg/L	2430	22100	13015	11281	300	13 / 15	13
		Manganese	µg/L	157	4900	883	883	50	15 / 15	15
		Total Dissolved Solids	mg/L	449	723	553	553	500	15 / 15	12
	Filtered	Arsenic	µg/L	82.4	235	158.7	158.7	10	2 / 2	2
		Iron	µg/L	7710	11800	9755	9755	300	2 / 2	2
		Manganese	µg/L	156	212	184	184	50	2 / 2	2
Second Quarter CY00	Unfiltered	Arsenic	µg/L	19.4	122	72.1	48.4	10	10 / 15	10
		Iron	µg/L	1500	22600	13369	10697	300	12 / 15	12
		Manganese	µg/L	27	5020	877	877	50	15 / 15	14
		Selenium	µg/L	385	385	385	27	50	1 / 15	1
		Total Dissolved Solids	mg/L	433	753	547	547	500	15 / 15	12
	Filtered	Arsenic	µg/L	30.6	30.6	30.6	30.6	10	1 / 1	1
		Iron	µg/L	6030	6030	6030	6030	300	1 / 1	1
		Manganese	µg/L	375	375	375	375	50	1 / 1	1
Third Quarter CY00	Unfiltered	Arsenic	µg/L	1.4	213	72.8	60.1	10	14 / 17	13
		Iron	µg/L	4.6	24500	12275.3	10113.0	300	14 / 17	13
		Manganese	µg/L	126	4750	781	781	50	17 / 17	17
		Radium-226	pCi/L	4.18	8.62	6.30	2.38	5	4 / 18	2
		Total Dissolved Solids	mg/L	499	1010	612	577	500	16 / 17	15
		Uranium[3]	µg/L	1.5	282	60	22.2	30	6 / 17	2
	Filtered	Arsenic	µg/L	20.6	94.2	59.24	59.24	10	5 / 5	5
		Iron	µg/L	0.6	12600	5630.1	5630.1	300	5 / 5	4
		Manganese	µg/L	7.4	334	154.0	154.0	50	5 5	4
Fourth Quarter CY00	Unfiltered	Arsenic	µg/L	45.5	227	107.7	107.7	10	4 / 4	4
		Iron	µg/L	5940	13800	8915	8915	300	4 / 4	4
		Manganese	µg/L	55.1	275	172.5	172.5	50	4 / 4	4
		Total Dissolved Solids	mg/L	593	806	710	710	500	4 4	4
	Filtered	Arsenic	µg/L	59.3	59.3	59.3	59.3	10	1 1	1
		Iron	µg/L	5230	5230	5230	5230	300	1 1	1
		Manganese	µg/L	53.4	53.4	53.4	53.4	50	1 1	1

[1] Results include those wells screened in HZ-C through HZ-E ground-water units and wells screened across HZ-B and lover ground-water units

[2] Mean Concentration was calculated using value equal to 1/2 detection limit when result was qualified as undetected.

[3] Uranium Values were calculated from isotopic results and specific activities.

4.1.2 Comparison of Historical Ground-water Data at SLAPS

The evaluation of historical trends for ground water focuses on those contaminants identified as soil COCs that exceeded ground-water reference levels (MCLs, SMCLs, and/or background levels) in a significant number of samples collected during CY00. [The COCs identified for SLAPS soils include antimony, arsenic, barium, cadmium, chromium, molybdenum, nickel, selenium, thallium, uranium, vanadium, and various radionuclides (USACE, 2000a).] Based on the CY00 data, arsenic and selenium are the principal inorganic COCs present in ground water at the site. The radionuclides Ra-226, Th-230, U-234, and U-238 were also identified as present at elevated levels in ground-water samples during CY00. Where sufficient data was available, statistical trend analysis was conducted to evaluate whether concentrations of the principal contaminants are increasing or decreasing over time.

4.1.2.1 Statistical Method

There are several statistical methods available to evaluate contaminant trends in ground water. These include the Mann-Kendall test, the Wilcoxon rank sum test, and the Seasonal Kendall test (EPA, 2000). The last two tests are applicable to data that may or may not exhibit seasonal behavior, but generally require larger sample sizes than the Mann-Kendall test. The Mann-Kendall test was selected for the purposes of this study because it can be used with small sample sizes and because a seasonal variation in concentrations was not indicated by the time plots for these contaminants at SLAPS. The Mann-Kendall test is a non-parametric test and, as such, it is not dependent upon assumptions of distribution, missing data, or irregularly-spaced monitoring periods. In addition, data reported as less than the detection limit can be used (Gibbons, 1994). The test can assess whether a time-ordered data set exhibits an increasing or decreasing trend, within a predetermined level of significance. While the Mann-Kendall test can use as few as four data points, often this is not enough data to detect a trend. Therefore, the test was performed only at those monitoring stations where at least six or more rounds of data have been collected.

The Mann-Kendall test involves listing the sampling results in chronological order and computing all differences that may be formed between measurements and earlier measurements. The test statistic, S, is the difference between the number of strictly positive differences and the number of strictly negative differences. If S is a large positive value, then there is evidence of an increasing trend in the data. If S is a large negative value, then there is evidence of a decreasing trend in the data. If there is no trend and all observations are independent, then all rank orderings of the annual statistics are equally likely; this result is used to compute the statistical significance of the test statistic (EPA, 2000).

To avoid biasing the Mann-Kendall test, all non-detect (ND) data values for a given compound were assigned a single value that was less than the detection limit, even when the detection limit varied over time. This was to make sure that any identified trends are data trends and not trends of laboratory detection limits. The value that was entered for ND results is one half of the detection limit from the round with the lowest detection limit for that compound. For data sets where more than 20 percent of the time-series data is ND, results from the Mann-

Kendall trend test were not reported. Where more than one sample was collected on the same sampling date, the average detected value was used for that sampling date.

The Mann-Kendall test was performed using the Wisconsin Department of Natural Resources (WDNR) Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends. Because the Mann-Kendall test does not take into account the magnitude of scatter in the data, the spreadsheet provides an additional test if the Mann-Kendall test indicates no-trend is present. If no trend is identified, the coefficient of variation (CV) is used to determine if there is a lot of scatter in the data (non-stable condition) or if the amount of scatter is small (stable condition). The CV is equal to the standard deviation divided by the average. If the CV is less than or equal to one, the data is considered stable. If the CV is greater than one, the data is considered non-stable.

4.1.2.2 Results of Trend Analysis at SLAPS

Time versus concentration plots were prepared for each of the principal contaminants to look for changes in concentration at each monitoring location. Only unfiltered data was used and, where more than one sample was available for a given sampling date, the mean value was used. For those stations where sufficient data was available to evaluate trend, statistical trend analysis was conducted to assess whether concentrations of the principal contaminants (selenium, arsenic, and total uranium) are increasing (upward trending) or decreasing (downward trending) over time. Although no organics were identified as COCs for SLAPS, statistical analysis was conducted for TCE because elevated concentrations have been detected in several HZ-A wells. For the purposes of this report, a statistically significant trend in concentration is defined as a trend with a confidence level greater than 90 percent. The confidence level indicates the probability that the trend indicated is an actual trend in the data, rather than a result of the random nature of environmental data.

Inorganics

Selenium, IIZ-A ground-water data for SLAPS is available for the period from July CY97 to November CY00. As shown in the time versus concentration plots for selenium presented in Figure 4-5, there are several wells that have consistently shown selenium levels above its MCL of 50 µg/L during this period. All wells with selenium exceedances were screened in the HZ-A ground-water zones. Mann-Kendall tests were performed on six wells having concentrations exceeding the selenium MCL: B53W09S, B53W13S, B53W17S, M10-15S, MW-31-98, and MW-33-98. Although additional wells (PW37, PW38, PW39, PW40, and PW41) had concentrations above the MCL during this period, insufficient data was available to perform the test. A significant trend in selenium concentrations (i.e., trends with a confidence level greater than 90 percent) was observed for five wells. Four wells (B53W09S, B53W13S, B53W17S, and MW-33-98) had concentrations that were decreasing and one well (M10-15S) had concentrations that were increasing during this period. The test indicated no trend for the remaining well (MW-31-98). The well with increasing trend, M10-15S, had the highest selenium concentrations at the site, with a maximum detected concentration of 792 µg/L. It is suspected that the upward trend in M10-15S reflects a temporary increase due to remedial activities being conducted in the vicinity of the well, but continued monitoring will be necessary to determine the cause. Results of the Mann-Kendall test are presented in Table 4-4.

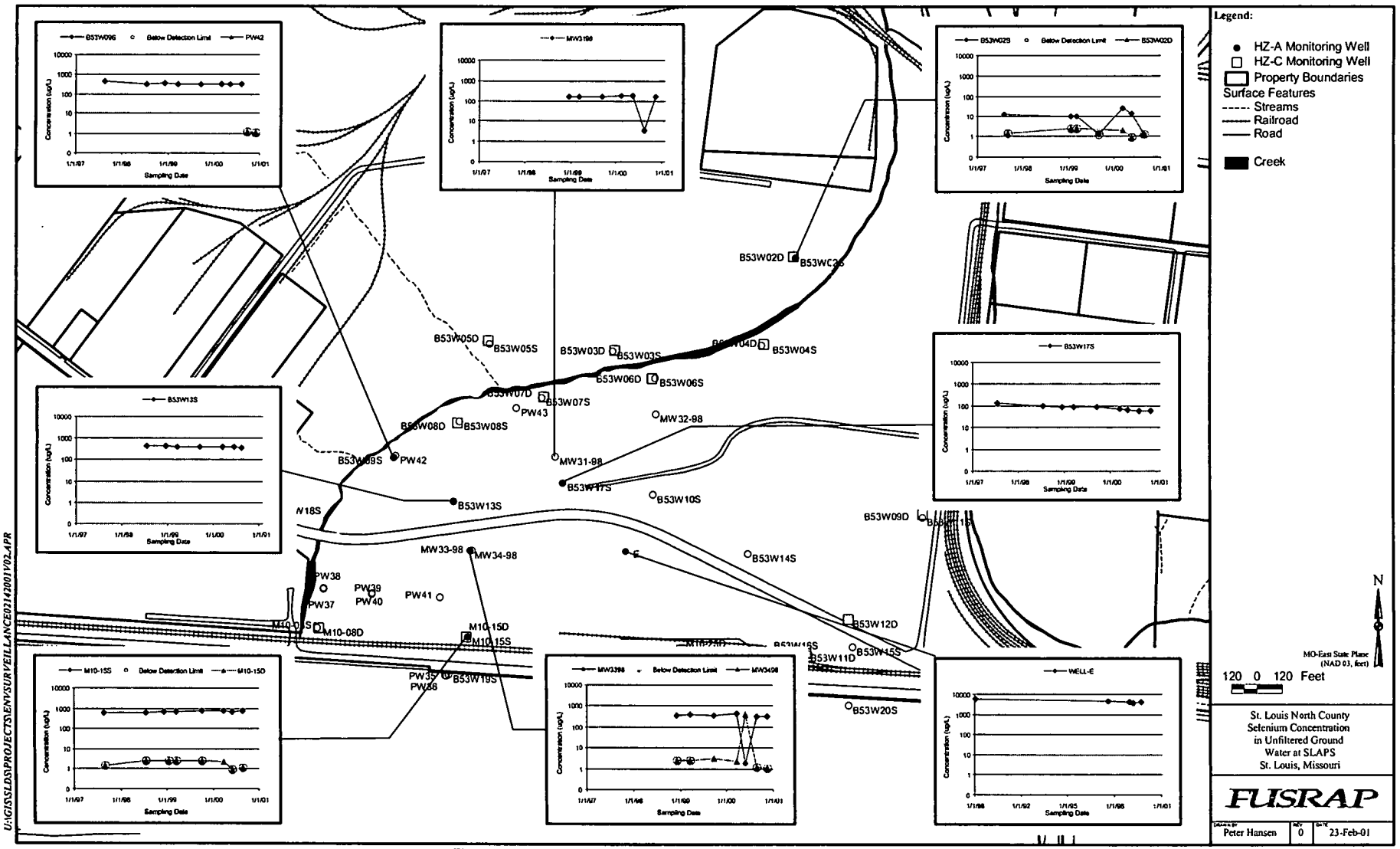


Figure 4-5 Selenium Concentration in Unfiltered HZ-A Ground Water at SLAPS

Table 4-4. Results of Mann-Kendall Trend Test for HZ-A Selenium at SLAPS

Event Number	Sampling Date	Station					
		B53W09S (Unit 2 and 3T)	B53W13S (Unit 2)	B53W17S (Unit 2 and 3T)	MW-31-98 (Unit 2)	MW-33-98 (Unit 2)	M10-15S (Unit 2 and 3T)
1	Baseline Event (Third Quarter 1997)	456		129			623.5
2	Third Quarter 1998	344	438	101			634
3	Fourth Quarter 1998	368	435	86.4	178	370	657
4	First Quarter 1999	353	409	86.8	181	387	683
5	Third Quarter 1999	326	401	84.2	181	368	729
6	First Quarter 2000	338	407	71.4	195	429	792
7	Second Quarter 2000	353	392	66.8	185	0.9	712
8	Third Quarter 2000	324	379	58.9	3.3	332	751
9	Fourth Quarter 2000			59.6	171	333	
Mann Kendall Statistic (S) =		-15	-19	-32	-2	-7	22
Number of Rounds (n) =		8	7	9	7	7	8
Average =		357	408.71	82.70	156.32	316.71	697.70
Standard Deviation =		40.32	21.50	22.33	67.90	143.30	59.98
Coefficient of Variation(CV)=		0.12	0.05	0.27	0.43	0.45	0.08
Trend ≥80% Confidence Level		Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Increasing
Trend ≥90% Confidence Level		Decreasing	Decreasing	Decreasing	No Trend	No Trend	Increasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	CV <= 1 STABLE	NA	NA

The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

Arsenic data is available for numerous SLAPS wells for the period since the Summer CY97 baseline ground-water characterization effort. Eleven HZ-C wells have consistently shown arsenic levels above its MCL (10 µg/L) during this period. In contrast, with the exception of one well (B53W14S), the concentrations in the HZ-A wells were generally below the MCL; although arsenic was detected in five HZ-A wells at concentrations above the MCL during CY00, four of these wells exceeded the MCL only once. The Mann-Kendall test was conducted for the single HZ-A well (B53W14S) and for the eleven HZ-C wells showing arsenic concentrations consistently exceeding the MCL. The results, presented in Table 4-5, indicate that half of the wells tested (five HZ-C wells and the single HZ-A well) have statistically significant increasing trends. The Mann-Kendall test does not provide an indication of the magnitude of the increasing trend. Based on the slopes observed in the time plots, the increasing trends are of low magnitude. For the remaining six HZ-C wells, no trend in concentration was observed. The lack of a correlation between the arsenic concentrations in the HZ-C ground water and the arsenic concentrations reported for nearby HZ-A wells indicate that the increasing trend in HZ-C ground water is not due to FUSRAP-related activities at the site.

Radionuclides

Historical results of radiological analysis for uranium indicate that numerous HZ-A wells have elevated concentrations of uranium isotopes, particularly U-234 and U-238. An evaluation of historical uranium concentrations has been conducted using total uranium concentrations based on radiological analysis. The Mann-Kendall test was performed on twelve HZ-A wells using the quarterly data collected from Spring CY88 through Winter CY00. Additional wells (PW38, PW39, and PW40) had significantly elevated levels of total uranium. In particular, PW38 had the highest levels at the site, with a maximum level of 9,160 µg/L reported for the first quarter of CY00 (Figure 4-6). Less than six rounds of data are available for PW38, PW39, and PW40, so a Mann-Kendall test could not be performed for these wells. Total uranium concentrations (in µg/L) were calculated for the twelve wells listed in Table 4-6. A value equal to one half of the detection limit was substituted for non-detect isotopic values prior to calculating the total uranium concentration used in the time plots and Mann-Kendall test. A significant trend in total uranium concentrations (i.e., a trend with a confidence level greater than 90 percent) was identified for only three of the twelve wells (two decreasing and one increasing trend). The increasing trend was observed in a well with relatively low total uranium concentrations, B53W18S. However, most of the isotopic uranium values in this well were close to the detection limit or non-detect; this may have been a factor in the test detecting a trend. Decreasing trends were identified for M10-25S and M10-08S located near the southern edge of SLAPS. The remaining nine wells displayed no trend. On a broad scale, there does not appear to be any change in uranium concentrations in HZ-A ground water at SLAPS since the Fall of CY98.

Table 4-5. Results of Mann-Kendall Trend Test for Arsenic at SLAPS

Event Number	Sampling Date	Stations					
		B53W01D (Units 3B and 4)	B53W02D (Unit 4)	B53W03D (Unit 4)	B53W04D (Units 3M and 3B)	B53W05D (Units 3B and 4)	B53W06D (Units 3B and 3M)
1	Baseline Event (Third Quarter 1997)	81.2	41.7	69.95		114	28.95
2	Third Quarter 1998	72					24.5
3	Fourth Quarter 1998	70.4	31.4	67.2	21.5	111	28
4	First Quarter 1999	78.2	29.8	65.6	18.6	99.9	27
5	Third Quarter 1999	73.6		68	16.4	104.3	29.2
6	First Quarter 2000	82.2	28	70.2	17.9	95.5	30.3
7	Second Quarter 2000	83.1	1.1	70.6	19.4	112.7	31.1
8	Third Quarter 2000	83.9	32.7	71.2	20.5	107	27.9
Mann Kendall Statistic (S) =		16	-7	13	1	-5	10
Number of Rounds (n) =		8	6	7	6	7	8
Average =		78.08	27.5	69.0	19.1	106.3	28.4
Standard Deviation =		5.37	13.8	2.07	1.83	6.9	2.05
Coefficient of Variation(CV)=		0.07	0.50	0.03	0.10	0.07	0.07
Trend ≥80% Confidence Level		INCREASING	DECREASING	INCREASING	No Trend	No Trend	INCREASING
Trend ≥90% Confidence Level		INCREASING	No Trend	INCREASING	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	CV <= 1 STABLE	CV <= 1 STABLE	NA

Event Number	Sampling Date	Station					
		B53W07D (Unit 4)	B53W08D (Units 3B and 4)	M10-08D (Unit 3B)	M10-15D (Unit 3B)	MW-34-98 (Unit 3B)	B53W14S (Unit 3T)
1	Baseline Event (Third Quarter 1997)	67.15	56.4	73.05	53.55		20.1
2	Third Quarter 1998	64		64.2	59	216	
3	Fourth Quarter 1998	5	70.7	71	71.2	236	20.9
4	First Quarter 1999	65.2	70.4	66.2	75	217	21.7
5	Third Quarter 1999	66.2	73.15	69.3	85.4	233	22
6	First Quarter 2000	68.2	74.14	66.1	103	1.1	25.3
7	Second Quarter 2000	70.3	78.1	71.3	95.6	213	21.9
8	Third Quarter 2000	69.1	79.8	66	101	227	25.6
Mann Kendall Statistic (S) =		16	19	-6	24	-3	17
Number of Rounds (n) =		8	7	8	8	7	7
Average =		59.39	71.81	68.39	80.47	191.87	22.5
Standard Deviation =		22.07	7.65	3.18	18.83	84.58	2.12
Coefficient of Variation(CV)=		0.37	0.10	0.05	0.23	0.44	0.09
Trend ≥80% Confidence Level		Increasing	Increasing	No Trend	Increasing	No Trend	Increasing
Trend ≥90% Confidence Level		Increasing	Increasing	No Trend	Increasing	No Trend	Increasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	CV <= 1 STABLE	NA	CV <= 1 STABLE	NA

The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

Table 4-6. Results of Mann-Kendall Trend Test for HZ-A Total Uranium at SLAPS

Event Number	Sampling Date	Station					
		B53W06S (Units 2 and 3T)	B53W07S (Unit 2)	B53W09S (Units 2 and 3T)	B53W10S (Units 3M and 3T)	B53W13S (Units 3T and 3M)	B53W17S (Units 2 and 3T)
1	Third Quarter 1998	32.59	11.22	7.45	4.46	13.62	6.63
2	Fourth Quarter 1998	64.93	2.17	19.82	0.30	16.77	0.32
3	First Quarter 1999	68.69	12.88	8.62	10.12	11.50	6.39
4	Third Quarter 1999	66.24	7.62	11.16	4.73	14.68	5.39
5	First Quarter 2000	83.50	9.29	10.98	7.89	12.99	4.02
6	Second Quarter 2000	75.58	13.23	13.98	3.64	13.99	1.09
7	Third Quarter 2000	14.21	9.30	11.21	6.92	13.17	3.02
8	Fourth Quarter 2000						8.13
Mann Kendall Statistic (S) =		5	5	7	3	-3	-2
Number of Rounds (n) =		7	7	7	7	7	8
Average =		57.96	9.39	11.89	5.44	13.82	4.37
Standard Deviation =		25.01	3.78	4.07	3.19	1.63	2.76
Coefficient of Variation(CV)=		0.43	0.40	0.34	0.59	0.12	0.63
Trend ≥80% Confidence Level		No Trend	No Trend	Increasing	No Trend	No Trend	No Trend
Trend ≥90% Confidence Level		No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		CV <= 1 STABLE	CV <= 1 STABLE	NA	CV <= 1 STABLE	CV <= 1 STABLE	CV <= 1 STABLE

Event Number	Sampling Date	Station					
		B53W18S (Unit 2 and 3T)	M10-08S (Unit 3T)	M10-15S (Unit 2 and 3T)	M10-25S (Unit 2 and 3T)	MW-32-98 (Unit 2)	MW-33-98 (Unit 2)
1	Third Quarter 1998	5.42	65.97	7.90	114.28	0.65	68.84
2	Fourth Quarter 1998	2.43	98.25	3.14	120.75	6.54	75.22
3	First Quarter 1999	2.36	64.05	8.91	74.69	1.41	132.85
4	Third Quarter 1999	2.85	5.36	8.71	46.62	6.50	46.17
5	First Quarter 2000	2.94	13.73	6.19	51.73	6.70	65.71
6	Second Quarter 2000	6.10	7.90	5.02	40.81	6.02	2.51
7	Third Quarter 2000	6.12	9.71	5.77	65.62		
Mann Kendall Statistic (S) =		11	-11	-5	-11	5	-7
Number of Rounds (n) =		7	7	7	7	6	6
Average =		4.03	37.86	5.52	73.50	4.64	65.22
Standard Deviation =		1.76	37.53	2.11	32.21	2.81	42.38
Coefficient of Variation(CV)=		0.44	0.99	0.32	0.44	0.61	0.65
Trend ≥80% Confidence Level	Increasing		Decreasing	No Trend	Decreasing	No Trend	Decreasing
Trend ≥90% Confidence Level	Increasing		Decreasing	No Trend	Decreasing	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level	NA		NA	CV <= 1 STABLE	NA	CV <= 1 STABLE	NA

The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

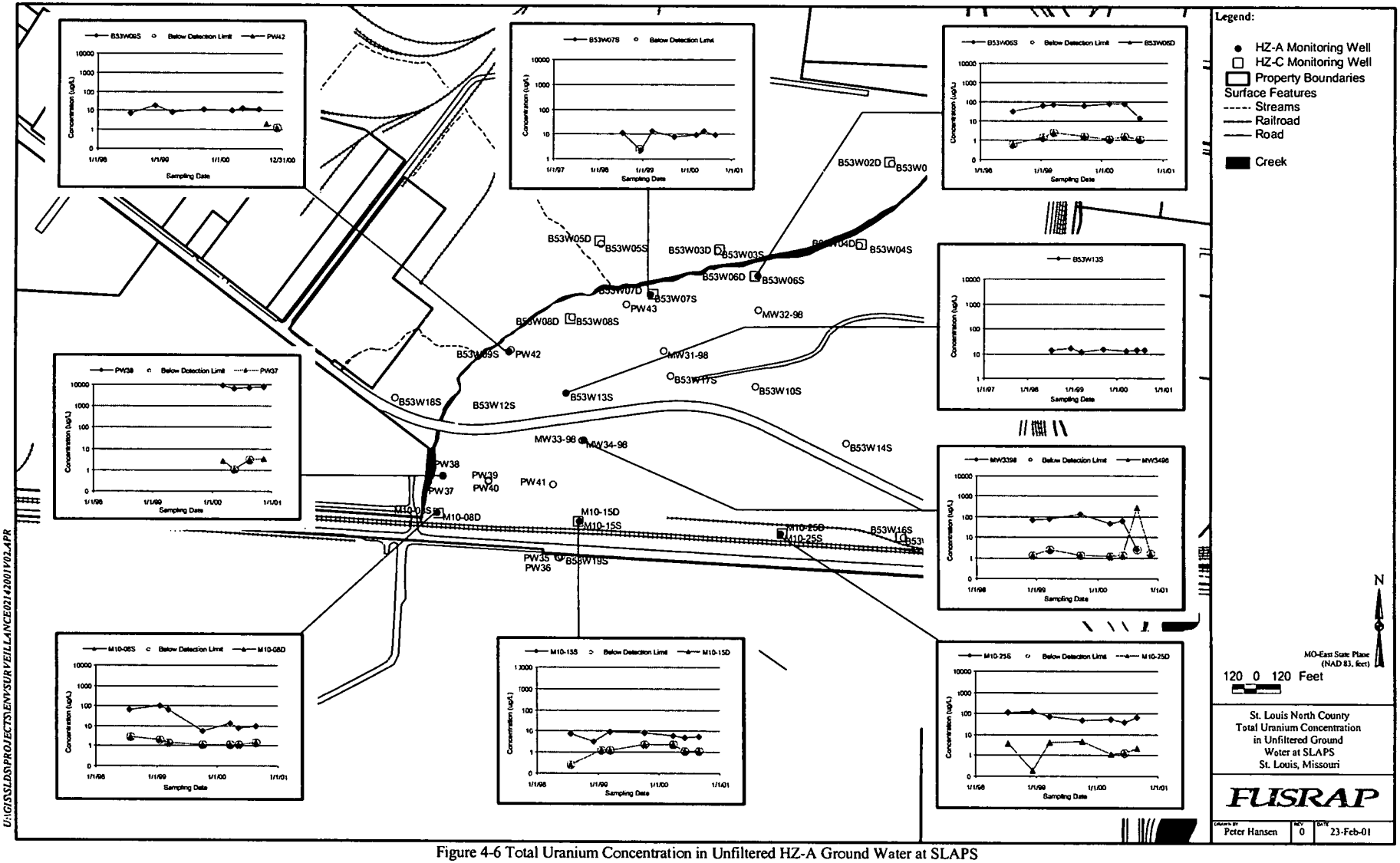


Figure 4-6 Total Uranium Concentration in Unfiltered HZ-A Ground Water at SLAPS

During CY00, Ra-226 was detected at levels above the MCL of 5 pCi/L in six HZ-A wells, one HZ-C well, and a well screened across both HZ-B and HZ-C. No wells had more than a single exceedance of the MCL. Because the concentrations were consistently low and the incidence of non-detection was high, a trend analysis was not performed for Ra-226. Th-230 levels were also consistently low for most wells at the site. Wells PW38, PW39, PW40, and PW41 had multiple detections above Th-230 IIZ-A background levels, but insufficient data was available to conduct trend analysis. Future trend analysis is planned, after additional data is collected.

Trichloroethene

Because significant levels of TCE were detected in several HZ-A wells, a trend analysis was also performed for that compound. The historical data indicates that four wells (B53W13S, B53W17S, MW-31-98, and MW-33-98) have consistently elevated levels of TCE (Figure 4-7). Trend analysis was performed on these four monitoring points using the Mann-Kendall test. Additional wells (in particular, PW38, PW39, PW40, and PW41) have concentrations exceeding the MCL of 5 µg/L but insufficient data was available to conduct the test. A significant trend in TCE concentrations was indicated for all four wells. Two wells (MW-31-98 and B53W13S) had concentrations that were increasing and two wells (MW-33-98 and B53W17S) had concentrations that were decreasing. Results of the Mann-Kendall test are presented in Table 4-7. The results may indicate that TCE is present due to a discrete release of TCE in the past, in the vicinity of B53W17S. Decreasing concentrations near the source area would indicate there is not a continuing source of TCE contamination in the area. The TCE concentrations in the source area are declining due to advection, dispersion, and natural attenuation. The gradually increasing concentrations in downgradient wells MW-31-98 and B53W13S indicate that the dissolved TCE "plume" is continuing to migrate slowly northward and, to a lesser extent westward, from the source area.

Table 4-7. Results of Mann-Kendall Trend Test for TCE at SLAPS

Event Number	Sampling Date	Station			
		B53W17S (Units 2 and 3T)	MW-31-98 (Unit 2)	B53W13S (Unit 2)	MW-33-98 (Unit 2)
1	Baseline Event (Third Quarter 1997)	600		4	
2	Third Quarter 1998	840		6	
3	Fourth Quarter 1998	970	3	5	24
4	First Quarter 1999	690	2.5	6	14
5	Third Quarter 1999		5	4	13
6	First Quarter 2000	370	7.9	6.4	18
7	Second Quarter 2000	340	14	7.1	14
8	Third Quarter 2000	350	13	7.2	2.5
9	Fourth Quarter 2000	360	21		
Mann-Kendall Statistic (S) =		-14	17	18	-8
Number of Rounds (n) =		8	7	8	6
Average =		565	9.486	5.713	14.25
Standard Deviation =		248.826	6.817	1.262	7.055
Coefficient of Variation(CV)=		0.440	0.719	0.221	0.495
Trend ≥80% Confidence Level		Decreasing	Increasing	Increasing	Decreasing
Trend ≥90% Confidence Level		Decreasing	Increasing	Increasing	Decreasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	NA	NA

The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

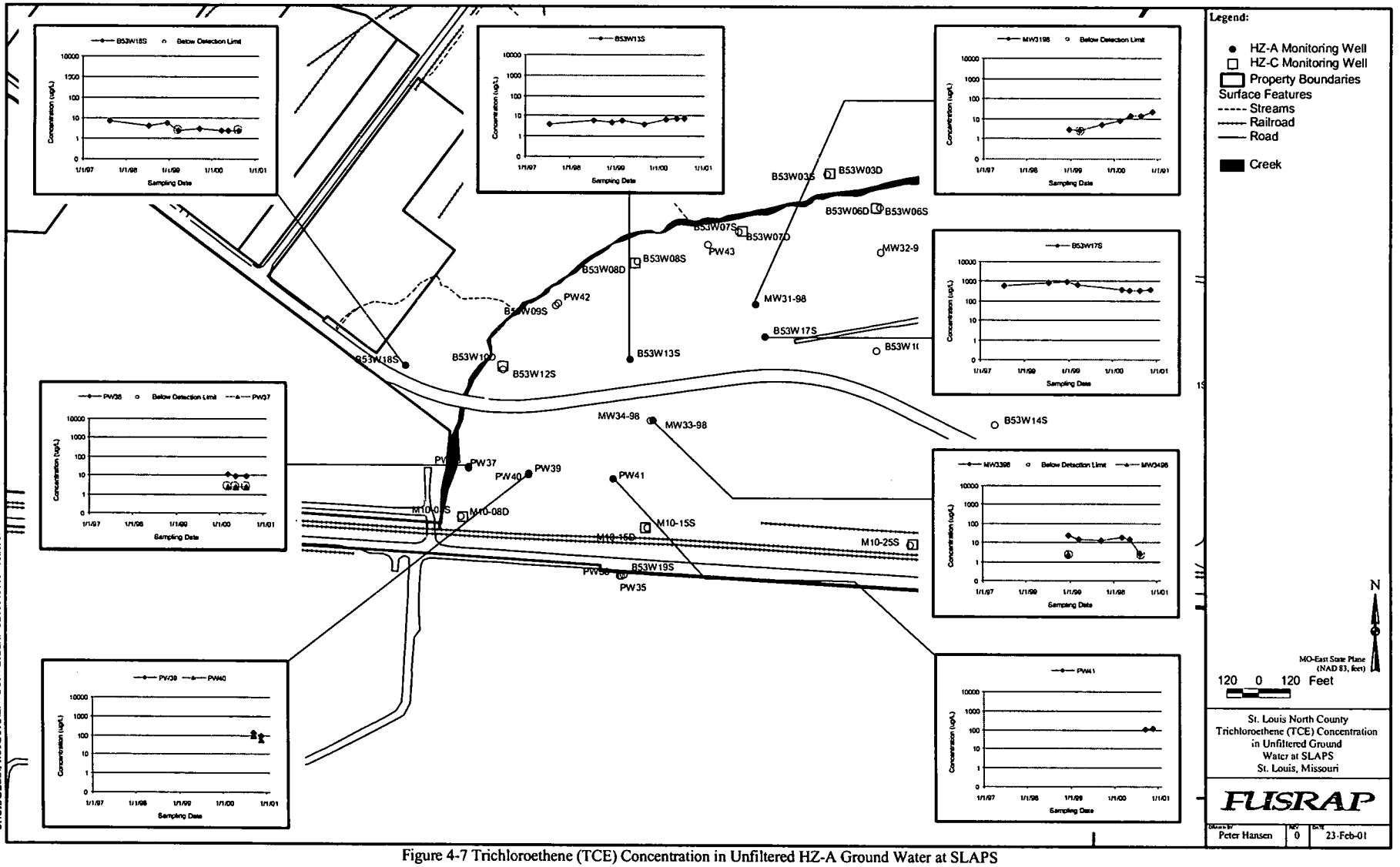


Figure 4-7 Trichloroethene (TCE) Concentration in Unfiltered HZ-A Ground Water at SLAPS

4.1.3 Evaluation of the CY00 Potentiometric Surfaces at SLAPS

Ground-water surface elevations were measured from wells at SLAPS in February, April, August, and November of CY00. Ground-water surface elevation contours were drawn using the April 28th and November 10th measurements to provide a comparison of the ground-water flow conditions in periods of high and low precipitation, respectively. The potentiometric surface maps, shown in Figures 4-8 through 4-11, were developed for both HZ-A and HZ-C ground-water zones. The ground-water flow direction is interpreted to be perpendicular to the ground-water equipotential contours.

The ground-water flow direction at SLAPS in April and November CY00 in the HZ-A ground water is westerly to northwesterly towards Coldwater Creek (Figures 4-8 and 4-10). HZ-A ground water beneath properties located north of the creek also converges to the creek as shown. The hydraulic gradient increased near the southern side of Coldwater Creek. The unconfined HZ-A ground water is interpreted to discharge into Coldwater Creek, which divides the HZ-A ground-water system south and east of the creek from areas north and west of Coldwater Creek. Recharge to the ground water occurs from precipitation, off-site inflow of ground water, and creek bed infiltration during high creek stage. Discharge may occur by seepage into Coldwater Creek during low creek stage (BNI, 1994). The vertical gradient varies beneath the site and is influenced by stratigraphic heterogeneity and seasonal fluctuations in recharge and evapotranspiration. The position of the HZ-A ground-water surface tends to be lower in the summer and higher in the winter, ranging from 1 m to more than 5 m below existing grade.

A review of the screened intervals in the deep wells indicates many screened intervals crossed several lithologic units and HZs. It was determined that the HZ-C (Unit 4) potentiometric surface was a proper representation of the lower ground water system. While this reduces the number of data points, it provides a higher confidence in the potentiometric surfaces.

Figures 4-9 and 4-11 illustrate the potentiometric surface contours for the HZ-C ground water in CY00. The flow in HZ-C is generally east to northeast at a gradient of approximately 0.002 feet per foot (ft/ft). A comparison of the ground-water elevation measurements from monitoring well pairs indicates that the wells completed in the upper groundwater zones (HZ-A and HZ-B) exhibit different hydraulic heads from the wells completed in lower zones (HZ-C, HZ-D, and/or HZ-E). Near Coldwater Creek, the potentiometric surface of the "confined" aquifer HZ-C [ranging in elevation between 510 and 518 ft above mean sea level (amsl)] is higher than the potentiometric surface of the unconfined HZ-A zone, indicating an upward vertical gradient. In other areas beneath SLAPS, the potentiometric measurements indicate a downward hydraulic gradient. The large difference in hydraulic head demonstrates that the HZ-A and HZ-C ground-water zones are distinct and independent ground-water systems with limited hydraulic connection. This is supported by the lithologic data, which indicates that a highly impermeable clay (Subunit 3M) and silty clay (Subunit 3B) separates the HZ-A ground-water system from the underlying ground-water zones. The HZ-C potentiometric do not appear to be influenced by Coldwater Creek (the creek's thalweg is about 500 ft amsl) or by seasonal changes. These features are likely a result of the overlying clay layers limiting vertical ground-water movement.

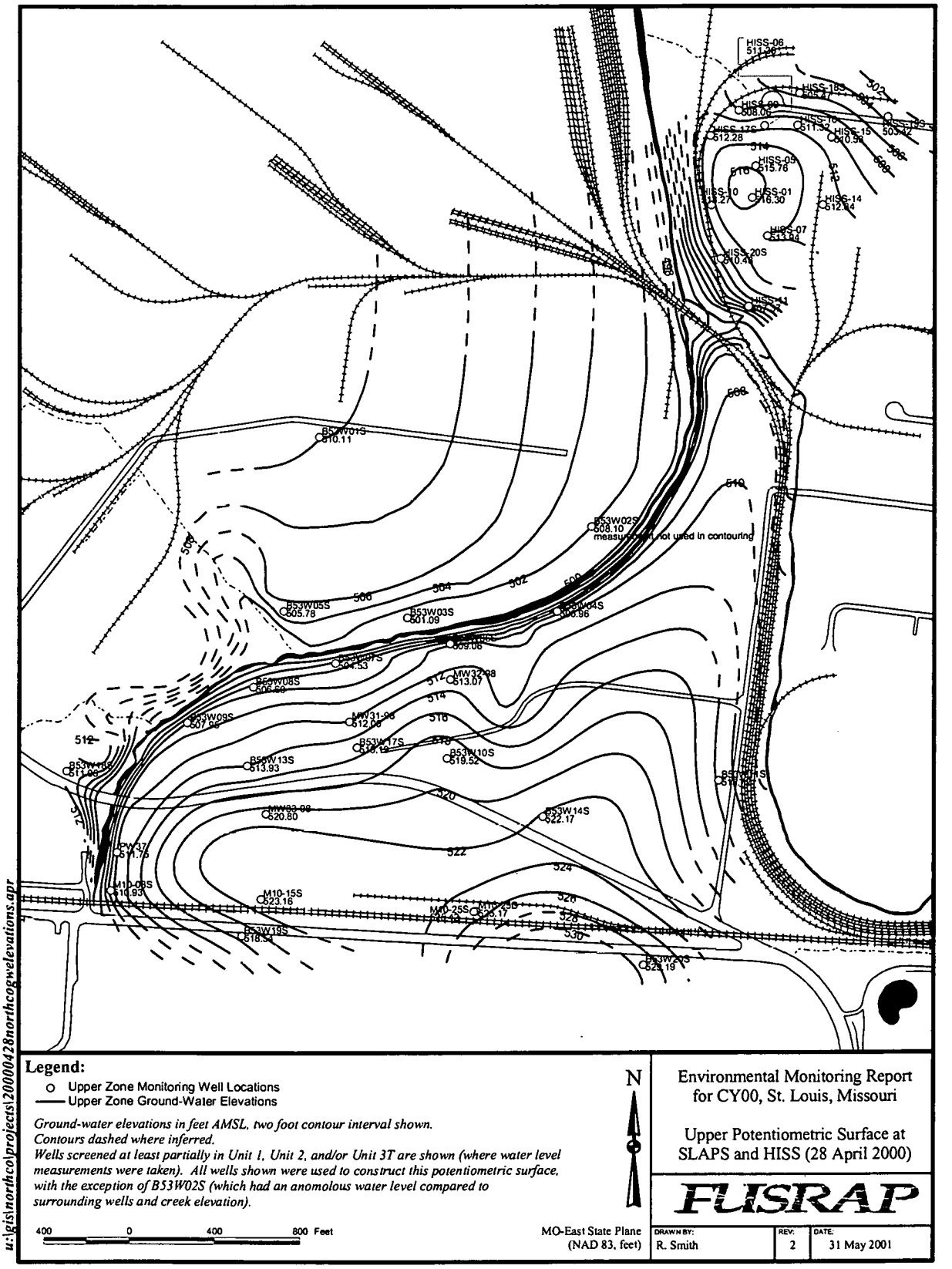


Figure: 4-8. Upper HZ-A Potentiometric Surface at SLAPS and HISS (28 April 2000)

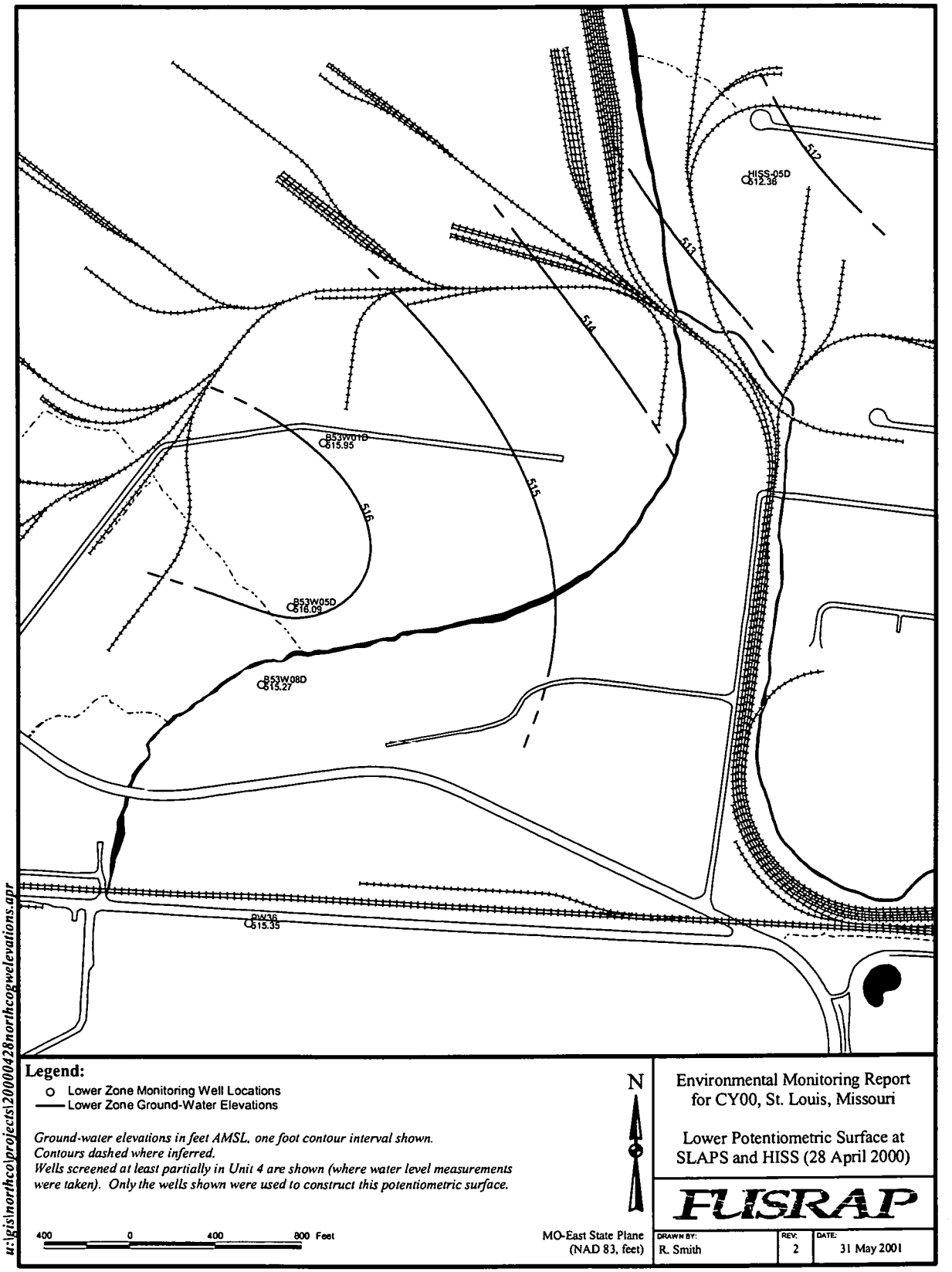


Figure: 4-9. Lower HZ-C Potentiometric Surface at SLAPS and HISS (28 April 2000)

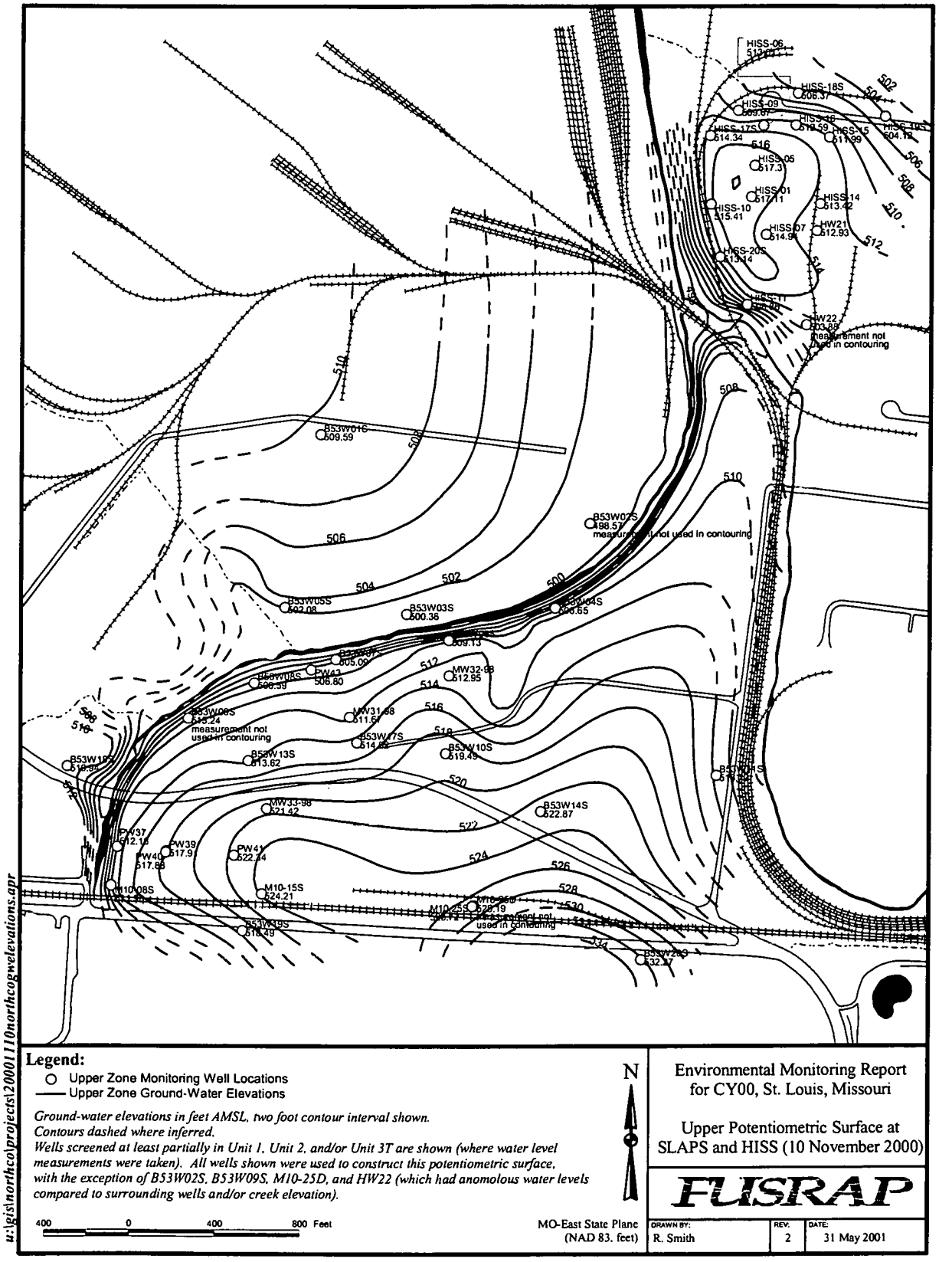


Figure: 4-10. Upper HZ-A Potentiometric Surface at SLAPS and HISS (10 November 2000)

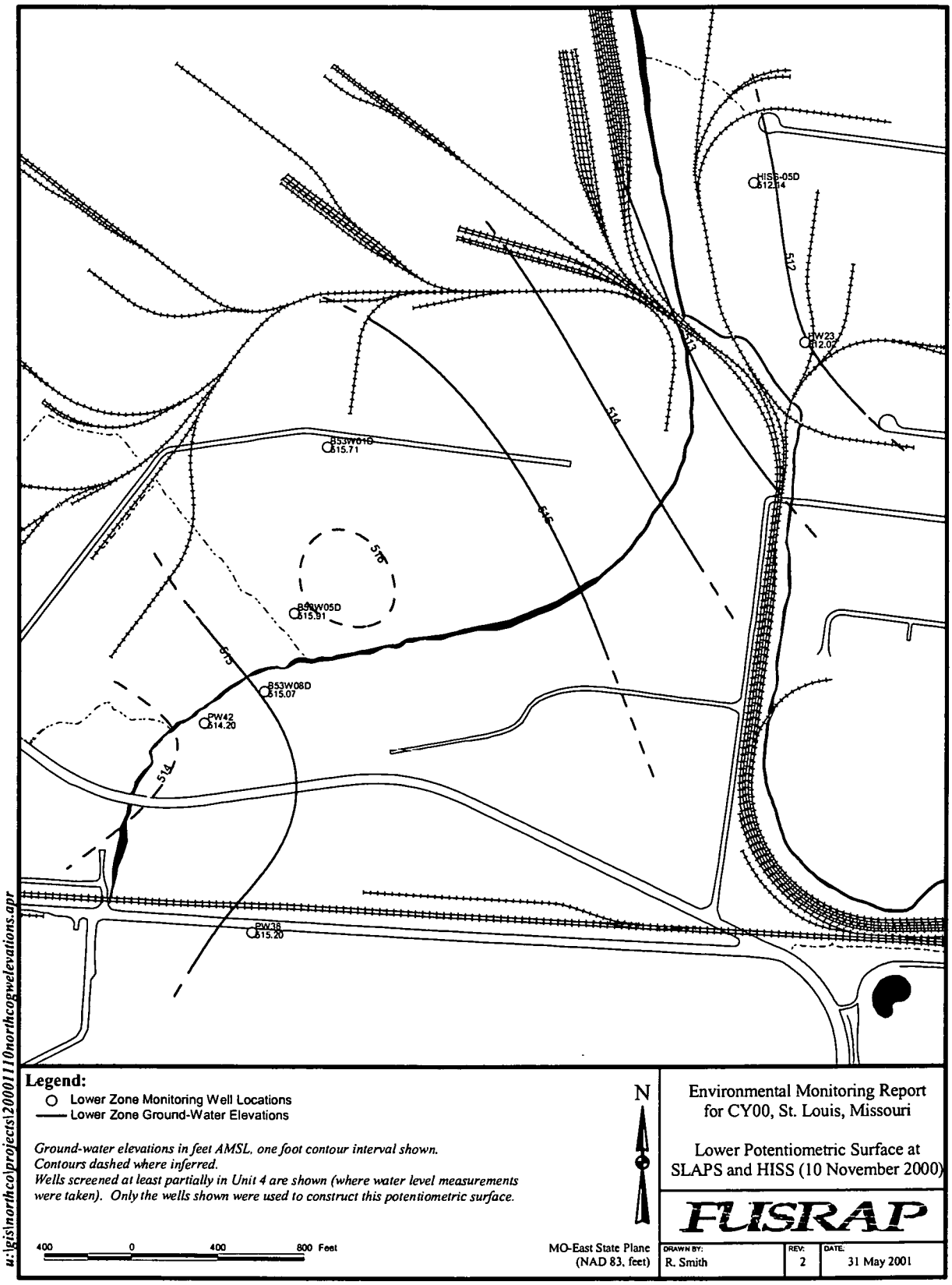


Figure: 4-11. Lower HZ-C Potentiometric Surface at SLAPS and HISS (10 November 2000)

4.2 HISS

The hydrogeologic and geologic setting at HISS is similar to that at SLAPS, with one exception. The Pennsylvanian shale bedrock unit (Unit 5), present at SLAPS, is absent at HISS. As previously discussed, the 3M Unit of HZ-B acts as a barrier to vertical ground-water movement in part based on the differences in ground-water chemistry and potentiometric differences between the HZ-A and HZ-C.

A total of twenty-four ground-water monitoring wells have been installed at HISS from CY79 to CY00. The EMP well network for HISS is identified in Figure 4-12. With the exception of monitoring wells HISS-05D and HW23, which are screened in HZ-C, all of the monitoring wells at HISS are screened in HZ-A. Table 4-8 provides a summary of the HZ information for HISS ground-water monitoring wells.

Table 4-8. Screened HZs for HISS Ground-water Monitoring Wells

Well ID	Screened Hydrostratigraphic Zone(s)
HISS-01	HZ-A
HISS-02	HZ-A
HISS-03	HZ-A
HISS-04	HZ-A
HISS-05	HZ-A
HISS-05D	HZ-C
HISS-06	HZ-A
HISS-07	HZ-A
HISS-08	HZ-A
HISS-09	HZ-A
HISS-10	HZ-A
HISS-11	HZ-A
HISS-12	HZ-A
HISS-13	HZ-A
HISS-14	HZ-A
HISS-15	HZ-A
HISS-16	HZ-A
HISS-17S	HZ-A
HISS-18S	HZ-A
HISS-19S	HZ-A
HISS-20S	HZ-A
HW21*	HZ-A
HW22*	HZ-A
HW23*	HZ-C

* Indicates a well installed in CY00

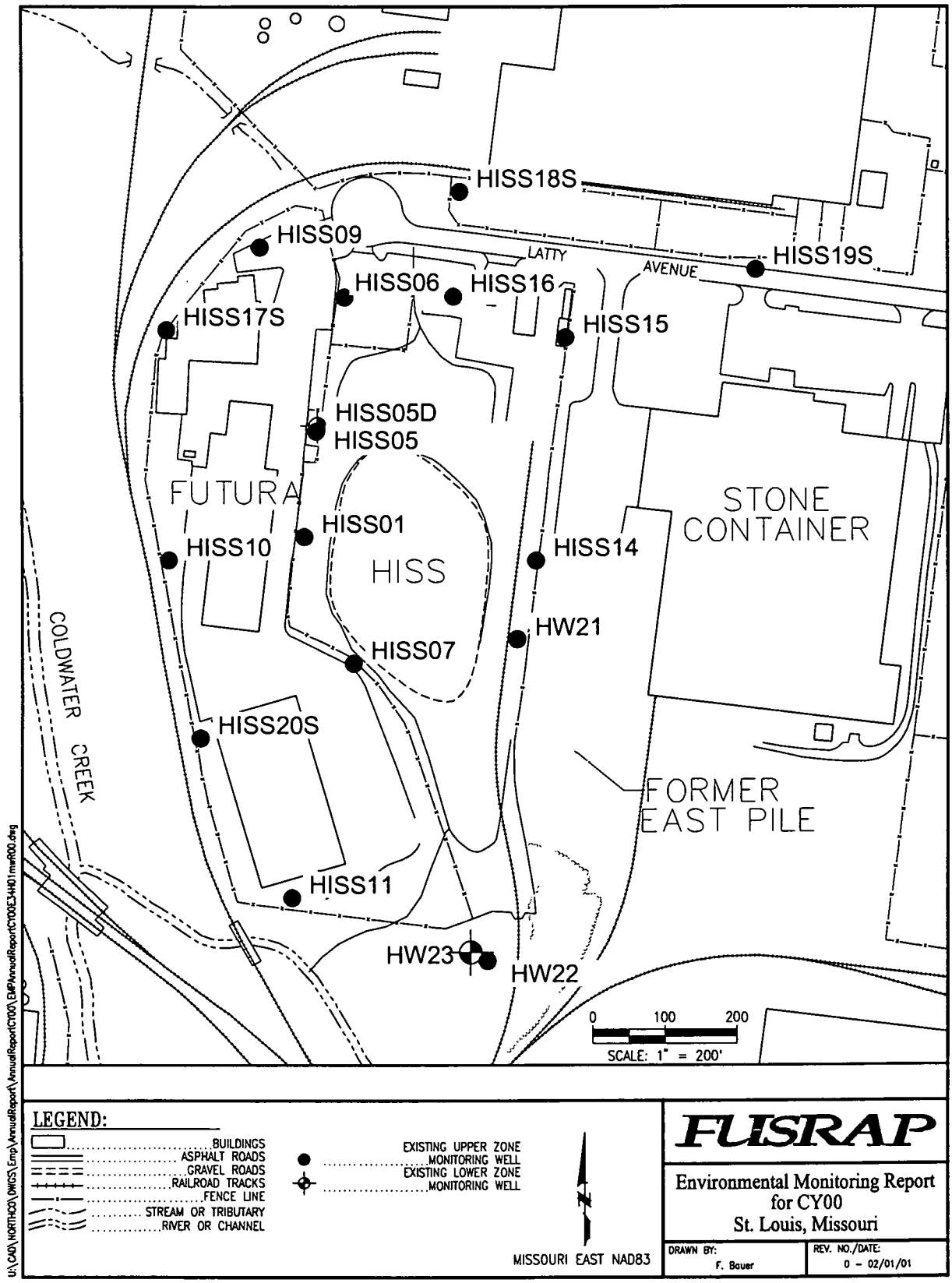


Figure 4-12. Ground-water Monitoring Well Locations at the HISS

4.2.1 Evaluation of the CY00 EMP Ground-Water Sampling at HISS

Ground water sampling was conducted at eighteen ground-water monitoring wells at HISS during CY00. First quarter sampling was conducted from March 20 to April 26; second quarter sampling from May 15 to June 14; third quarter sampling from August 17 to September 29; and fourth quarter sampling from November 29 through December 4. The analytical results were compared to regulatory limits (MCLs or SMCLs) and to background concentrations. For discussion purposes, the ground-water analytical data acquired in the CY00 sampling events at HISS are presented separately for the upper (HZ-A) and lower (HZ-C) ground-water zones.

HZ-A Ground Water

Table 4-9 summarizes the results of the CY00 ground-water sampling for contaminants exceeding MCLs or SMCLs in upper, HZ-A ground-water at HISS. Eight inorganics (antimony, arsenic, barium, iron, manganese, nitrate, selenium, and sulfate) were detected at concentrations exceeding MCLs or SMCLs in HZ-A ground water. Based on the number of exceedances, the most widely occurring of these inorganics were iron, manganese, nitrate, and selenium. Iron was detected above the MCL of 300 µg/L in four HZ-A wells (HISS-16, HISS-18S, HISS-19S, and HW21). The maximum detected concentration was 12,700 µg/L, detected in the second quarter sample from HISS-19S. Manganese exceeded its SMCL of 50 µg/L in ten HZ-A HISS wells during CY00, but with the exception of HISS-19S, the concentrations in these wells did not exceed the established HZ-A background concentration of 1,580 µg/L. The maximum concentration of 4,240 µg/L was detected in the second quarter sample from HISS-19S. Nitrates were detected above the MCL of 10 mg/L in 11 of the 16 HZ-A wells monitored during CY00. The maximum nitrate concentration detected was 2,270 mg/L in the third quarter sample from HW21. Selenium was detected above its MCL of 50 µg/L in seven HZ-A wells, with the maximum concentration (465 µg/L) detected in the second quarter sample from HISS-7, located near the southwest edge of the main storage pile at HISS.

The remaining inorganics (antimony, arsenic, barium, and sulfate) were found to exceed MCLs in only a limited number of well samples. Antimony only slightly exceeded its MCL of 6 µg/L in one sample (6.2 µg/L), the fourth quarter sample from monitoring well HISS-1. Arsenic concentrations were detected above the MCL (10 µg/L) in one HZ-A well, HISS-19S, during the first, second, and third quarters. The maximum arsenic concentration was 161 µg/L, detected in the third quarter sample from this well. Arsenic was also detected in two other HZ-A wells, HISS-16 and HISS-18S, but the concentrations in these wells did not exceed the MCL. Barium was detected above its MCL of 2,000 µg/L in the third and fourth quarter samples from monitoring well HW21. The maximum concentration detected was 2,370 µg/L. This concentration is also well above the barium background concentration of 198 µg/L. Concentrations of sulfate exccced the MCL of 250 mg/L in samples from one well, HISS-20. The maximum detected concentration, 329 mg/L, was below the established HZ-A background concentration of 376 mg/L.

Table 4-9. Analytes Exceeding MCLs or SMCLs in HZ-A Ground Water at HISS (Unfiltered Data)

Chemical	Station[1]	MCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects> MCL	Frequency of Detection
1,2-Dichloroethene	HISS-9	1	µg/L	2.9	2.9	2.9	1	1/3
Antimony	HISS-1	6	µg/L	6.2	6.2	6.2	1	1/4
Arsenic	HISS-19S	10	µg/L	125	161	148	3	3/3
Barium	HW21	2000	µg/L	2370	2370	2370	2	2/2
Manganese	HISS-11	50	µg/L	199	1340	601	3	3/3
	HISS-14	50	µg/L	199	231	211	3	3/3
	HISS-15	50	µg/L	74.5	74.5	74.5	1	1/2
	HISS-16	50	µg/L	22.6	77.2	41.8	1	3/3
	HISS-17S	50	µg/L	23.6	462	238.2	3	4/5
	HISS-18S	50	µg/L	11.4	563	208.4	3	3/3
	HISS-19S	50	µg/L	4030	4240	4160	3	3/3
	HISS-20	50	µg/L	43.7	143	76.4	2	4/4
	HISS-9	50	µg/L	39.5	118	78.5	2	3/3
	HW21	50	µg/L	810	1090	950	2	2/2
Radium-226	HISS-11	5	pCi/L	8.04	8.04	8.04	1	1/3
	HISS-16	5	pCi/L	5.21	5.21	5.21	1	1/3
	HISS-7	5	pCi/L	4.78	7.79	6.3	1	2/3
	HW21	5	pCi/L	8.94	8.94	8.94	1	1/2
Selenium	HISS-1	50	µg/L	215	239	231	3	3/4
	HISS-14	50	µg/L	264	273	268.5	2	2/2
	HISS-17S	50	µg/L	15.4	65.5	47.4	3	5/5
	HISS-20	50	µg/L	124	142	131	5	4/4
	HISS-5	50	µg/L	25.4	161	84.7	2	3/3
	HISS-6	50	µg/L	2.2	96.2	49.2	1	2/2
	HISS-7	50	µg/L	397	465	431	2	2/3
Trichloroethene	HISS-17S	5	µg/L	77	150	104	3	3/4
	HISS-9	5	µg/L	640	670	655	2	2/3
Iron	HISS-16	300	µg/L	248	628	438	1	2/3
	HISS-18S	300	µg/L	208	1980	909	3	3/3
	HISS-19S	300	µg/L	10300	12700	11700	3	3/3
	HW21	300	µg/L	320	320	320	1	1/2

Table 4-9. Analytes Exceeding MCLs or SMCLs in HZ-A Ground Water at HISS (Unfiltered Data) (Cont'd)

Chemical	Station[1]	MCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects> MCL	Frequency of Detection
Nitrate/Nitrite	HISS-1	10	mg/L	218	284	258	4	4/4
	HISS-10	10	mg/L	43.1	66	54.9	3	3/3
	HISS-11	10	mg/L	32	67.9	53.8	3	3/3
	HISS-14	10	mg/L	1480	1660	1600	3	3/3
	HISS-17S	10	mg/L	3.3	56.2	39.5	4	5/5
	HISS-20	10	mg/L	317	386	350	4	4/4
	HISS-5	10	mg/L	5.8	15.9	11.3	2	3/3
	HISS-6	10	mg/L	15.3	181	98.15	2	2/2
	HISS-7	10	mg/L	190	244	215	3	3/3
	HW21	10	mg/L	2200	2270	2235	2	2/2
	HW22	10	mg/L	63.2	69.7	66.45	2	2/2
Chloride	HISS-16	250	mg/L	36.3	2360	830	2	3/3
Sulfate	HISS-20	250	mg/L	255	329	297.5	5	4/4
Uranium[2]	HISS-5	30	µg/L	71.5	137.3	112.3	3	3/3
	HISS-06	30	µg/L	33.4	58.9	46.1	2	2/2

[1] Table lists only those stations at which the analyte exceeds the MCL or SMCL.
[2] Uranium values were collected from isotopic results specific activities.

Two organic compounds, TCE and 1,2-DCE, were detected at concentrations exceeding their MCLs (5 µg/L and 1 µg/L, respectively) in HZ-A ground water at HISS. TCE was detected in two wells, HISS-17S and HISS-9. Ground-water data for HISS has historically shown elevated levels of TCE in these two wells. During CY00, the maximum concentration of 670 µg/L was detected in the fourth quarter sample from HISS-9; this concentration is approximately half the maximum level detected in CY99 (1300 µg/L). Concentrations in HISS-17S reached a maximum concentration of 150 µg/L in the second quarter (June CY00) sampling event, but concentrations dropped to non-detectable levels in the fourth quarter sample from this well. 1,2-DCE, a TCE degradation product, was detected once at levels above its MCL (1 µg/L). The concentration detected was 2.9 µg/L in HISS-9. The source of TCE and 1,2-DCE is not known. These contaminants are not related to MED/AEC stockpiled materials and so are not designated as COCs at HISS.

The organic compounds toluene (maximum concentration 5.9 µg/L) and dimethylbenzene (maximum concentration 170 µg/L) were detected in ground-water samples from HISS-11, located at the northwestern edge of the Futura property. Underground storage tanks (USTs) at Futura may be potential sources of these organic compounds. The organic compounds stored in these USTs included xylol (also known as dimethylbenzene) and toluene. There were no detected concentrations of the other organics (xylene, m-butyl acetate, and methyl isobutyl ketone) reportedly stored in USTs at Futura.

Total uranium (based on isotopic results) and Ra-226 were detected at levels above their MCLs. Uranium exceeded the MCL of 30 µg/L in two HISS wells, HISS-05 and HISS-06, with the maximum concentration of 137.3 µg/L detected in the third quarter sample from HISS-05. The radionuclide Ra-226 exceeded the combined Ra-226/Ra-228 MCL of 5 pCi/L as well as the established HZ-A ground-water background concentration (0.91 pCi/L) in monitoring wells HW21, HISS-16, HISS-7, and HISS-11. However, it was detected only once above the MCL in these wells during CY00. The maximum activity concentration dctected was 8.94 pCi/L, reported for the fourth quarter sample from well HW21. Th-230 was detected in HZ-A ground water above its background level of 1.18 pCi/L in 14 wells. The maximum activity concentration, 5.85 pCi/L, was detected in a first quarter sample from HISS-20 near the eastern edge of the Futura Site.

In summary, the data indicate there are significant localized impacts to the HZ-A ground water from source-related contaminants. The most significant levels of inorganic and radiological contamination were reported for monitoring wells HW21 (for barium, manganese, nitrates, and Ra-226) and HISS-19S (for arsenic, iron, and manganese). HW21 and HISS-19S are located east and northeast of the Main Storage Pile at HISS, respectively. In addition, two organic solvents, TCE and 1,2-DCE, were detected at significant levels in two HZ-A ground-water wells located northeast of the Futura building. The source of this contamination is not known but is likely associated with non-FUSRAP-related activities.

HZ-C Ground Water

Ground-water samples were collected from two deep (HZ-C) wells, HISS-5D and HW23, during CY00. Concentrations of the analytes were compared to MCLs, SMCLs, and established ground-water background concentrations. Table 4-10 presents a list of those contaminants detected above MCLs or SMCLs in HZ-C ground-water samples collected at HISS during CY00. Table 4-11 presents a list of the contaminants detected above the background concentrations identified for HZ-C ground water at HISS (USACE, 2000a).

Table 4-10. Analytes Exceeding MCLs or SMCLs in HZ-C Ground Water at HISS in CY00 (Unfiltered Data)

Chemical	Station	MCL	Units	Minimum Detected	Maximum Detected	Mean Detected	# Detects> MCL	Frequency of Detection
Arsenic	HISS-5D	10	µg/L	6.9	25	16	1	2/3
	HW23	10	µg/L	1.5	205	103	1	2/2
Manganese	HISS-5D	50	µg/L	157	417	287	2	2/3
	HW23	50	µg/L	192	209	201	2	2/2
Iron	HISS-5D	300	µg/L	2,400	18,000	10,200	2	2/3
	HW23	300	µg/L	8,410	10,800	9,605	2	2/2

Table 4-11. Analytes Exceeding Background Concentrations in HZ-C Ground Water at HISS (Unfiltered Data)

Chemical	Background (HZ-C)	Station[1]	Units	Minimum Detect	Maximum Detect	Mean	# Detects > Background	Frequency of Detection
Arsenic	82.7	HW23	µg/L	1.5	205	205	1	2/2
Barium	424	HISS-5D	µg/L	412	716	551	2	3/3
Boron	214	HISS-5D	µg/L	202	226	214	1	2/3
		HW23	µg/L	260	284	272	2	2/2
Chloride	1.21	HISS-5D	mg/L	1.4	1.7	1.5	3	3/3
		HW23	mg/L	1.8	2.3	2.05	2	2/2
Iron	15,200	HISS-5D	µg/L	2,400	18,000	10,200	1	2/3
Magnesium	42,600	HISS-5D	µg/L	34,000	48,500	42,433	2	3/3
Manganese	231	HISS-5D	µg/L	157	417	287	1	2/3
Molybdenum	0	HW23	µg/L	10.5	10.5	10.5	1	1/2
Nickel	1.1	HISS-5D	µg/L	4.2	4.2	4.2	1	1/3
		HW23	µg/L	6.4	6.4	6.4	1	1/2
Strontium	742	HISS-5D	µg/L	864	1,200	1,041.3	3	3/3
		HW23	µg/L	730	791	760	1	2/2
Thorium-230	0.63	HISS-5D	pCi/L	1.42	1.45	1.435	2	2/3

[1] Table lists only those stations at which the analyte exceeds the background concentration for HZ-C ground water.

Analytes exceeding MCLs or SMCLs in samples from both HZ-C wells include arsenic, manganese, and iron. The maximum concentrations of arsenic, manganese, and iron also exceeded their background levels (82.7 µg/L, 231 µg/L, and 15,200 µg/L, respectively). Arsenic was detected above its proposed MCL of 10 µg/L at a maximum concentration of 205 µg/L in the fourth quarter sample from HW23. Concentrations of arsenic in the other HZ-C well, HISS-05D, did not exceed background levels. Manganese was detected above the SMCL (50 µg/L) at a maximum concentration of 417 µg/L in the first quarter sample from HISS-5D, but its concentrations decreased to below background levels in subsequent samples. Iron was detected above the SMCL level of 300 µg/L in both wells, with the maximum concentration (18,000 µg/L) detected in the first quarter sample from HISS-5D. Iron decreased to levels below background concentrations in subsequent samples from both wells.

Additional contaminants (barium, boron, magnesium, nickel, silver, strontium and Th-230) were identified as present in HZ-C ground water at levels above the background levels presented in the North County Feasibility Study (USACE, 2000a). The range of detected concentrations above background are listed in Table 4-11. Although barium exceeded background, it was detected at levels well below the MCL of 2,000 µg/L. Boron, iron, magnesium, and silver were detected at levels only slightly exceeding their background levels. Nickel was detected at a maximum concentration of 6.4 µg/L in the unfiltered third quarter sample from upgradient well HW23, exceeding the background concentration of 1.1 µg/L. Strontium was detected at a maximum concentration of 1,200 µg/L in the first quarter unfiltered sample from HISS-5D. Its concentration decreased to 791 µg/L in the fourth quarter unfiltered sample, which is only slightly above the background level of 742 µg/L. Nickel and strontium are not present at elevated levels in HZ-A ground water and so are unlikely to be MED/AEC-related contaminants. Th-230 was detected above the background level of 0.63 pCi/L in HISS-5D at a maximum concentration of 1.45 pCi/L. It was not detected in the other HZ-C well.

In summary, the data concerning HZ-C ground-water at HISS indicates that some metals are present at elevated concentrations. In particular, arsenic and manganese had average concentrations that exceeded MCLs as well as the established background concentrations for the HZ-C ground-water zone. The source of manganese and arsenic in the HZ-C ground water is not known but is likely the result of natural conditions. The HZ-A ground-water contaminants Ra-226, nitrates, uranium, and selenium were not detected above their background levels or MCLs/SMCLs in HZ-C ground water. Additional sampling data will be collected for future evaluations to determine if site contaminants are significantly impacting HZ-C ground water at HISS.

4.2.2 Comparison of Historical Ground-Water Data at HISS

Ground-water sampling has been conducted at HISS from CY84 to the present. The most comprehensive ground-water monitoring program, involving sampling from eighteen monitoring wells, was conducted at the site in the Summer of CY97. The results for this baseline ground-water sampling event and results from subsequent sampling events were used to evaluate contaminant trends at HISS during the period from Summer CY97 to Winter CY00. Time versus concentration plots were used to help identify temporal patterns that required further evaluation using statistical analysis.

HZ-A Ground-Water

The evaluation of historical trends for the HZ-A ground-water unit focuses on those contaminants identified as COCs in the North County Feasibility Study that exceeded reference levels (MCLs, SMCLs, and/or background levels) in ground-water samples collected during CY00. The soil COCs identified at HISS include antimony, arsenic, barium, cadmium, molybdenum, nickel, selenium, thallium, vanadium, and radionuclides in the uranium, thorium, and actinium series (USACE, 2000a). The COCs identified at significant levels in HISS HZ-A ground water during CY00 include selenium, Ra-226, Th-230, and total uranium. The time versus concentration plots shown in Figures 4-13 and 4-14 provide an overview of the temporal and spatial variability in the concentrations of two of the principal contaminants, selenium and total uranium. Statistical analysis was used to assist in identifying trends for those contaminants for which a temporal pattern was suggested by the time plots.

Inorganics

Statistical trend analysis using the Mann-Kendall test was conducted to evaluate whether concentrations of selenium are increasing or decreasing over time. The test was performed on seven HZ-A wells (HISS-01, HISS-05, HISS-06, HISS-07, HISS-14, HISS-17S, and HISS-20S) that have exceeded the MCL (50 µg/L) more than once in the period from Summer CY97 through Winter CY00. As shown in Table 4-12, a significant trend in selenium concentrations (i.e., a trend with a confidence level greater than 90 percent) was observed for four of these wells. Three wells (HISS-01, HISS-17S, and HISS-20S) had concentrations that were decreasing and one well (HISS-14) had concentrations that were increasing. The remaining three wells exhibited no trend in concentrations.

Arsenic has been detected at consistently elevated levels in only a single well, HISS-19S. The arsenic data for Summer CY97 through Winter CY00 indicate that, with the exception of well HISS-19S, arsenic was generally at non-detectable levels in HZ-A ground water. The concentrations in HISS-19S are significantly elevated above the proposed MCL of 10 µg/L, with the maximum concentration (161 µg/L) detected in the second quarter CY00 sample. Based on the trend analysis, the concentrations are increasing over time in this well (Table 4-13).

Radionuclides

An evaluation of historical uranium concentrations was conducted using total uranium concentrations calculated using the radiological analysis (isotopic uranium results). A value equal to one half of the detection limit was substituted for non-detected isotopic values prior to calculating the total uranium concentration used in the time plots and Mann-Kendall trend test. Three wells (HISS-01, HISS-05, and HISS-06) exceeded the uranium MCL of 30 µg/L during the period from January CY99 through December CY00. HISS-05 had the highest levels at the site, with a maximum level of 368 µg/L (Figure 4-14). The Mann-Kendall test was conducted for HISS-01, HISS-05, and HISS-06 (Table 4-14). HISS-05 and HISS-06 had only 5 rounds of data. The Mann-Kendall test can be performed with as few as four data points, but the trends may not be confirmed by future trend analyses performed on data sets covering a longer time period.

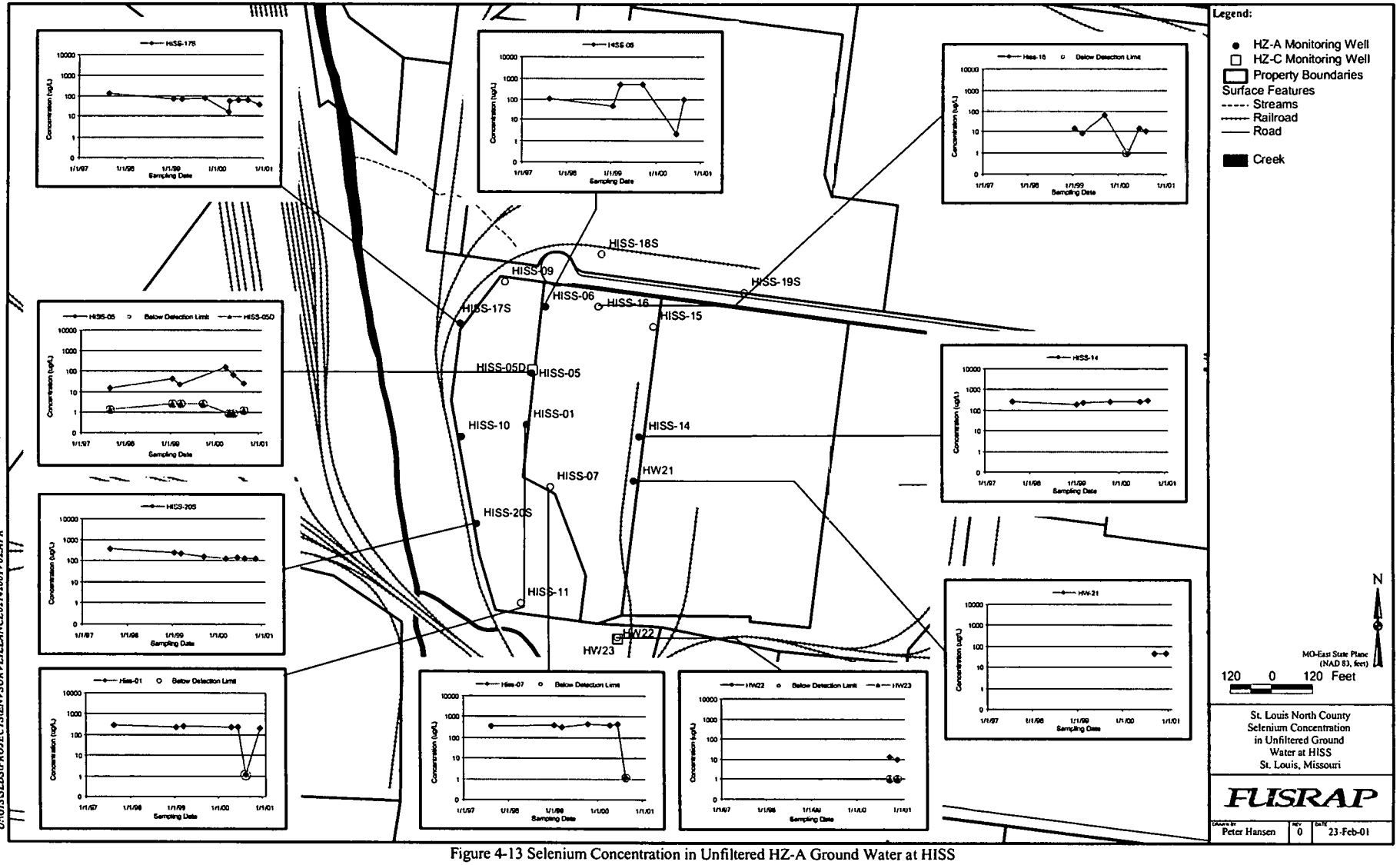


Figure 4-13 Selenium Concentration in Unfiltered HZ-A Ground Water at HISS

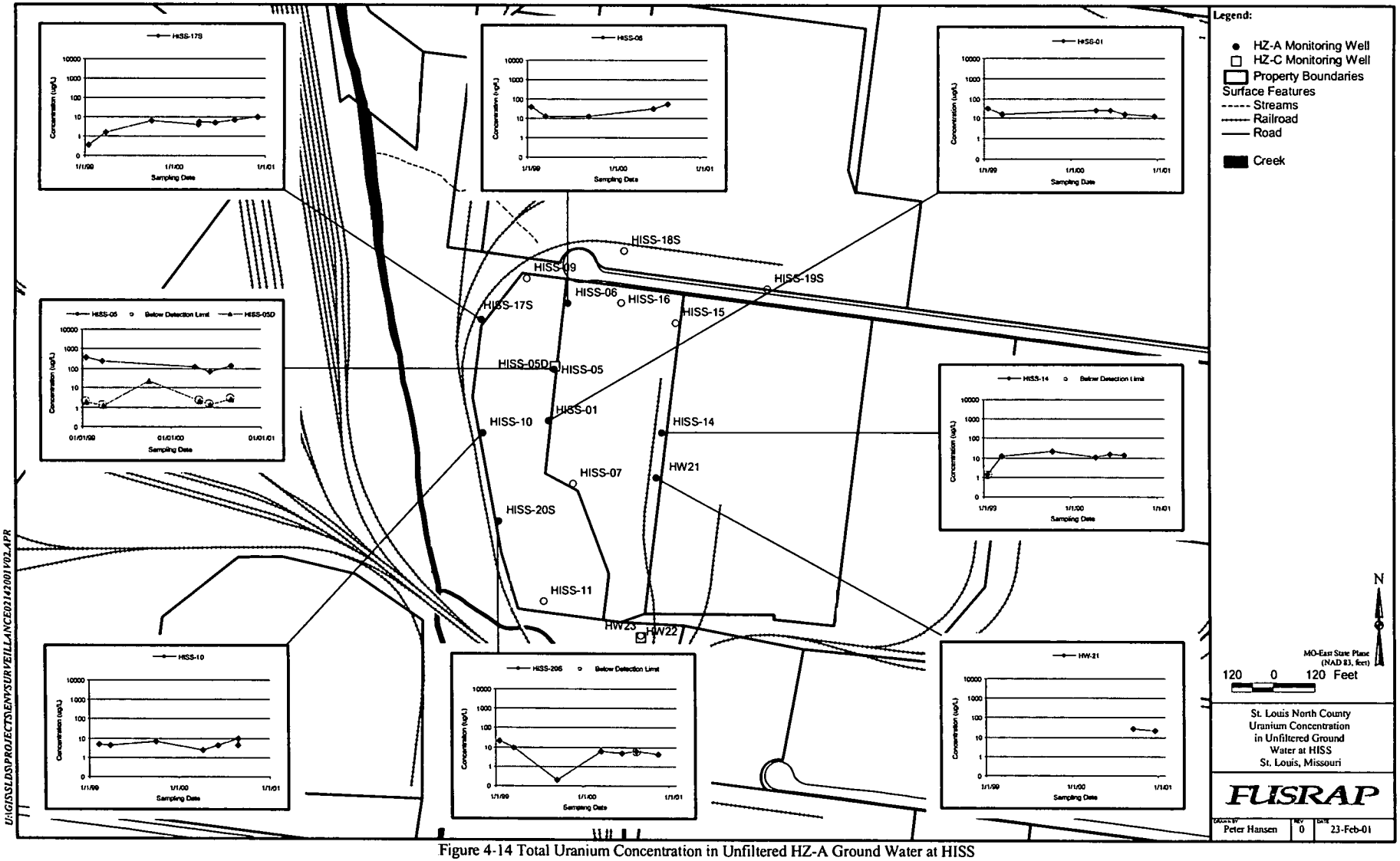


Figure 4-14 Total Uranium Concentration in Unfiltered HZ-A Ground Water at HISS

Table 4-12. Results of Mann-Kendall Trend Test for HZ-A Selenium at HISS

Event Number	Sampling Date (Approximate)	Station[a]							
		HISS-01	HISS-05	HISS-06	HISS-07	HISS-14	HISS-16	HISS-17S	HISS-20S
1	Baseline Event (Third Quarter 1997)	279	15.5	107	342	249	13.8	132	386
2	First Quarter 1999	241	43.5	45.2	415	194	8.1	70.6	240
3	Second Quarter 1999	267	21.8	513	333	236	60.75	72.7	226
4	Third Quarter 1999						0.9	75.4	151
5	First Quarter 2000	239	161	520	422	260	14.95	35.5	133
6	Second Quarter 2000	238	67.7	2.2	397	264	10.2	65.5	142
7	Third Quarter 2000	1.2	25.4	96.2	465	273		62.5	126
8	Fourth Quarter 2000	215			1.2			38.1	124.5
Mann Kendall Statistic (S) =		-17	5	-1	1	11	-1	-16	-26
Number of Rounds (n) =		7	6	6	7	6	6	8	8
Average =		211.46	55.82	213.93	339.31	246	18.12	69.04	191.06
Standard Deviation =		95.05	54.89	237.37	156.02	28.50	21.47	29.66	90.76
Coefficient of Variation(CV) =		0.45	0.98	1.11	0.46	0.12	1.19	0.43	0.48
Trend ≥80% Confidence Level		Decreasing	No Trend	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing
Trend ≥90% Confidence Level		Decreasing	No Trend	No Trend	No Trend	Increasing	No Trend	Decreasing	Decreasing
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV <= 1 Stable	CV > 1 Non-stable	CV <= 1 Stable	NA	CV > 1 Non-stable	NA	NA

[a] Monitoring wells are screened in Units 2 and 3B.

The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

Table 4-13. Results of Mann-Kendall Trend Test for HZ-A Arsenic, Uranium, and Th-230 at HISS

Event Number	Contaminant and Station[a]			
	Sampling Date	Arsenic HISS-19S	Th-230 HISS-10	Th-230 HISS-11
1	Baseline Event (Third Quarter 1997)	31.8	0.05	0.0244
2	First Quarter 1999	94.7	1.05	1.99
3	Second Quarter 1999	136	4.55	1.3
4	Third Quarter 1999	157	2.76	2.13
5	First Quarter 2000	125	4.01	44.29
6	Second Quarter 2000	161	2.32	2.17
7	Third Quarter 2000	158	0.52	1.76
Mann Kendall Statistic (S) =		15	1	9
Number of Rounds (n) =		7	7	7
Average =		123.36	2.18	7.67
Standard Deviation =		46.75	1.73	16.17
Coefficient of Variation(CV) =		0.38	0.79	2.11
Trend ≥80% Confidence Level		Increasing	No Trend	Increasing
Trend ≥90% Confidence Level		Increasing	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	CV <= 1 Stable	NA

[a] Monitoring wells are screened in Units 2 and 3T.
The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

The Mann-Kendall test was performed on two additional wells (HISS-14 and HISS-20S) that did not exceed MCLs but had elevated concentrations (greater than 10 µg/L) as well as at least six rounds of data. As shown in Table 4-14, a significant trend in total uranium concentrations (i.e., a trend with a confidence level greater than 90 percent) was not identified for any of the wells.

During CY00, Ra-226 was detected at levels above the MCL of 5 pCi/L in four HZ-A wells (HISS-07, HISS-11, HISS-16, and HW21). No wells had more than a single sample exceeding the MCL. Because the concentrations were generally low and the incidence of non-detection was high, a trend analysis was not performed for Ra-226. Th-230 was detected in HZ-A ground water above its background level of 1.18 pCi/L in fifteen wells during the period from Summer CY97 through Winter CY00. Th-230 levels generally ranged from non-detect to just over background in these wells. Due to the high percentage of non-detect values (> 20% ND) in some of these wells, the Mann-Kendall test could only be performed for HISS-10 and HISS-11. The results of the test, provided in Table 4-13, indicate that neither well has statistically significant trends in Th-230 concentrations.

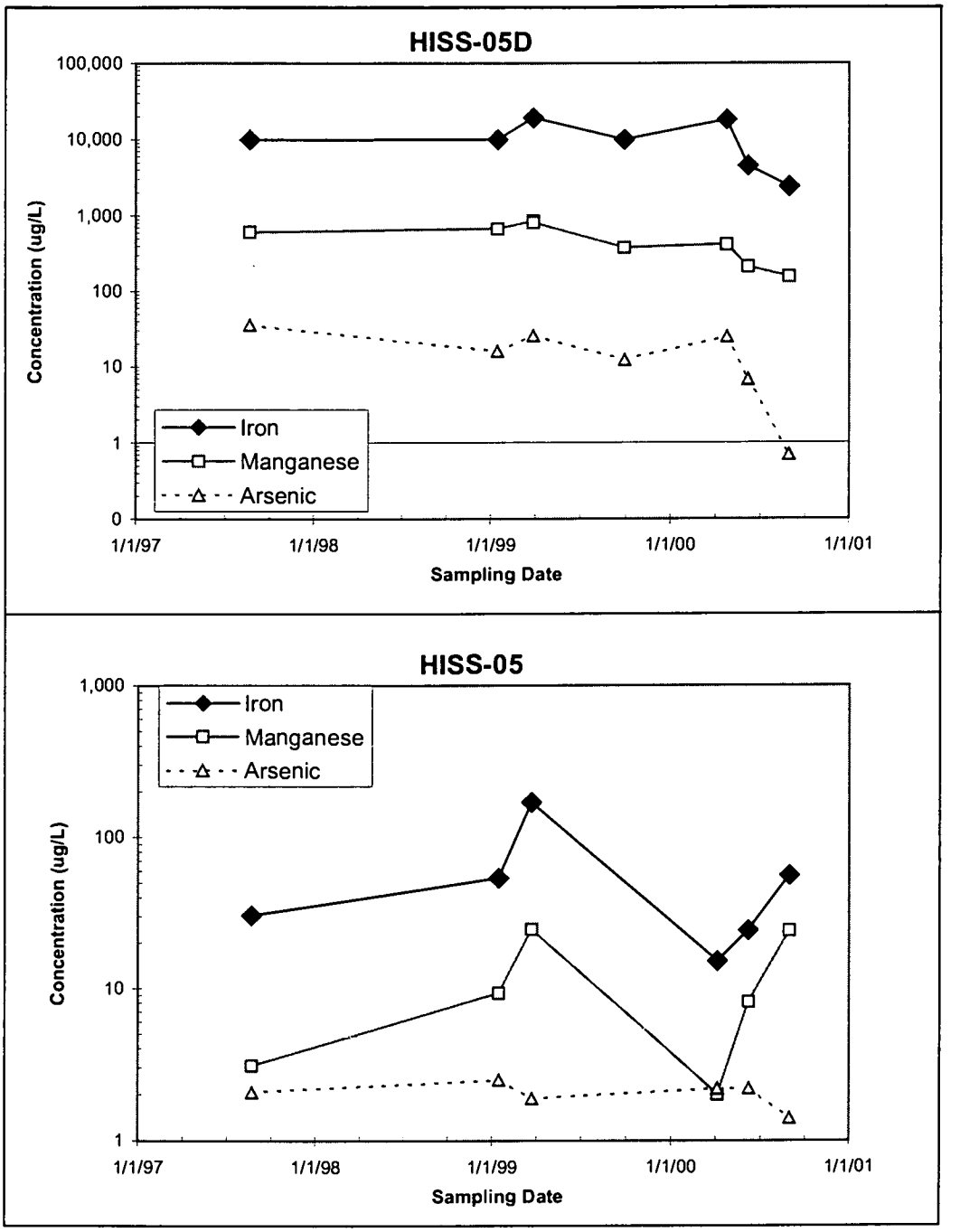
Table 4-14. Results of Mann-Kendall Trend Test for HZ-A Total Uranium at HISS

Event Number	Sampling Date	Station[a]				
		HISS-01	HISS-05	HISS-06	HISS-14	HISS-20S
1	First Quarter 1999	32.90	368.44	41.96	1.37	20.54
2	Second Quarter 1999	16.72	242.28	12.76	12.62	9.87
3	Third Quarter 1999			12.60	21.94	0.20
4	First Quarter 2000	24.71	128.17		10.23	5.73
5	Second Quarter 2000	25.14	71.50	33.37	15.61	4.68
6	Third Quarter 2000	17.16	137.31	58.85	13.75	5.91
7	Fourth Quarter 2000	13.23				4.46
Mann Kendall Statistic (S) =		-7	-6	2	5	-9
Number of Rounds (n) =		6	5	5	6	7
Average =		21.64	189.54	31.91	12.59	7.34
Standard Deviation =		7.26	117.49	19.80	6.77	6.48
Coefficient of Variation(CV) =		0.34	0.62	0.62	0.54	0.88
Trend ≥80% Confidence Level		Decreasing	Decreasing	No Trend	No Trend	Decreasing
Trend ≥90% Confidence Level		No Trend	No Trend	No Trend	No Trend	No Trend
Stability Test, If No Trend Exists at 80% Confidence Level		NA	NA	CV <= 1 Stable	CV <= 1 Stable	NA

[a] Monitoring wells are screened in Units 2 and 3T.
The Mann-Kendall test was performed using the Wisconsin DNR Mann Kendall Excel Spreadsheet for Statistical Analysis of Contaminant Trends.

HZ-C Ground-Water

Limited data is available to evaluate contaminant trends in the HZ-C ground-water unit at HISS. Although two HZ-C wells (HISS-05D and HW23) are currently sampled at HISS, historical data is available only for HISS-05D. Plots of concentration versus time were constructed for HISS-05D for the contaminants arsenic, iron, and manganese, the primary contaminants exceeding reference levels based on the CY00 ground-water sampling data (Figure 4-15). Concentrations of these three contaminants in the well pair HISS-05 and HISS-05D were plotted for comparison purposes. The data indicate that concentrations in the HZ-A ground water samples from HISS-05S are generally over an order of magnitude lower than in the HZ-C ground-water samples from HISS-05D. In addition, the concentration trends in the HZ-A well do not parallel trends in the HZ-C ground water well. This suggests that the elevated concentrations of arsenic, iron, and manganese in HZ-C ground water are not the result of contaminant migration from the HZ-A ground water and supports the view that the source of these three contaminants is unrelated to FUSRAP-related activities at the site. Additional sampling data will be collected from HZ-C ground water for future evaluations to determine if MED/AEC contaminants are significantly impacting HZ-C ground water at HISS.



FUSRAP

Environmental Monitoring
Report for CY00
St. Louis, Missouri

NOT TO SCALE

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Figure 4-15 Time Versus Concentration Plots for Arsenic, Iron, and Manganese in Wells HISS-5D and HISS-5

4.2.3 Evaluation of the CY00 Potentiometric Surfaces at HISS

Ground-water surface elevations were measured at HISS in February, April, August, and November of CY00. The potentiometric surface maps created from the April 28 and November 10 ground-water elevation measurements are illustrated in Figures 4-8, 4-9, 4-10, and 4-11.

The top of the saturated zone occurs in the low conductivity silts and clays of stratigraphic Units 2 and 3T at HISS. The potentiometric data indicate a near-radial potentiometric surface contour pattern for the HZ-A ground water at HISS. Wells HISS-01 and HISS-05 near the center of the site have the highest potentiometric surface elevations, with decreased ground-water elevations measured in the surrounding wells. The central ground-water mound corresponds to a low wet area on the ground surface, which collected some surface-water run-off from the main covered soil pile. At the western edge of the site, ground-water in the HZ-A zone flows toward Coldwater Creek. The potentiometric surface of the HZ-C ground water at HISS is not well defined due to the limited data available for the deeper HZs. The flow direction in the HZ-C ground water is generally toward the northeast in the vicinity of the site.

4.3 SLDS

Ground water at SLDS is found within three HUs. These units are the upper, HU-A unit, which consists of fill overlying clay and silt; the lower, HU-B alluvial unit, referred to as the Mississippi Alluvial Aquifer; and the limestone bedrock, referred to as HU-C (Figure 4-16). HU-A is not an aquifer and is not considered a potential source of drinking water because it has insufficient yield and poor natural water quality. The HU-B, Mississippi Alluvial Aquifer, is one of the principal aquifers in the St. Louis area, but expected future use as drinking water at SLDS is minimal, since the Mississippi and Missouri Rivers provide a readily available source. As shown in Figure 4-17, the erosional surface of the bedrock dips eastward toward the river. HU-A overlies HU-B on the east and overlies bedrock on the western side of SLDS. HU-B thins westerly along the rock surface until it becomes absent beneath the SLDS, being truncated by the rising bedrock and HU-A.

4.3.1 Evaluation of the CY00 EMP Ground-water Sampling at SLDS

The EMP monitoring well network for SLDS is shown on Figure 4-18. Table 4-17 identifies the screened HUs for the SLDS ground-water monitoring wells. Prior to the long-term monitoring requirements for the HU-B aquifer specified in the SLDS ROD (USACE, 1998d), there was no EMP sampling performed at SLDS. In CY00, a total of twenty-two wells (11 HZ-A and 11 HU-B) were sampled for radionuclides and inorganic constituents at SLDS. Ground-water wells at SLDS were not sampled for organics in the CY00 sampling events. The ground-water data for the SLDS COCs are compared to investigative limits as identified in the SLDS ROD and to SDWA MCLs, or SMCLS. The COCs for SLDS as identified in the SLDS ROD are radionuclides, arsenic, and cadmium (USACE, 1998d).

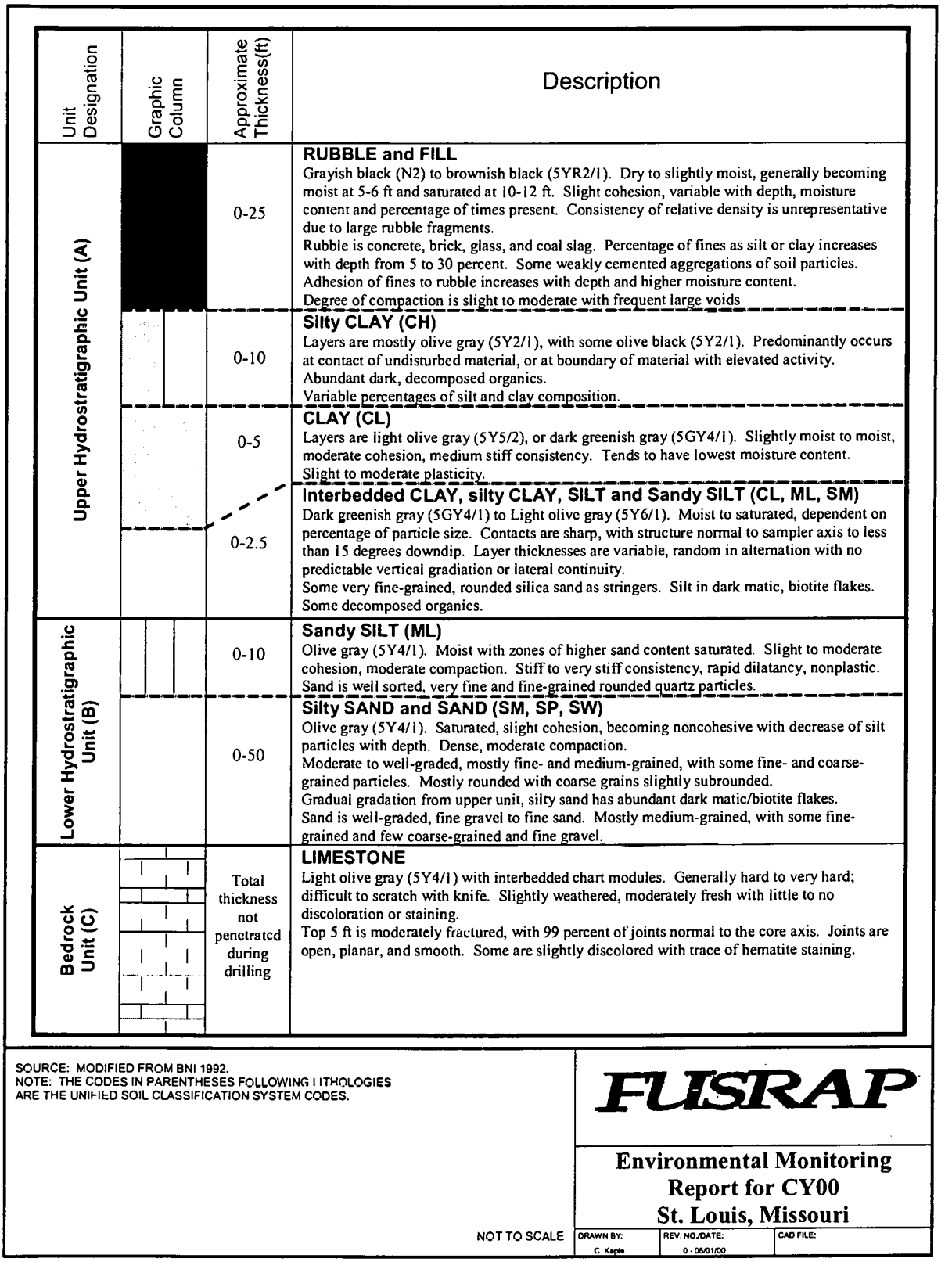
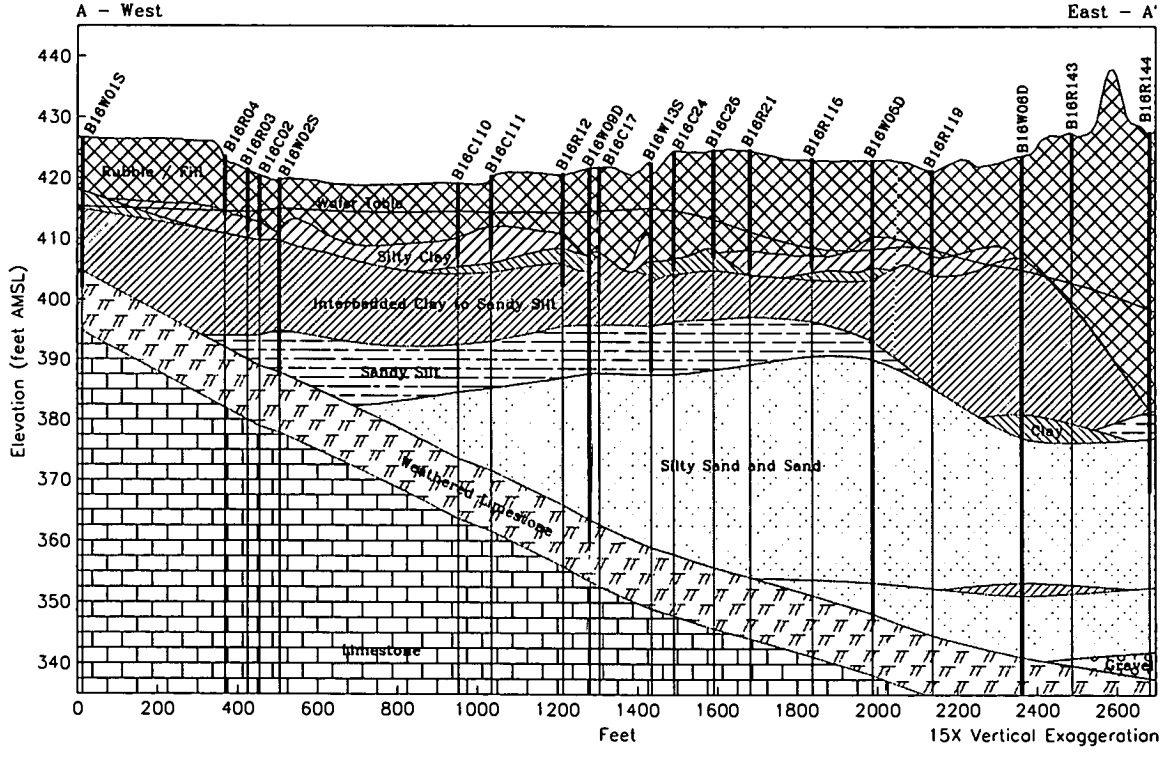


Figure 4-16 Generalized Stratigraphic Column for SLDS



Geologic Cross Section A – A' at SLDS

Geologic data used in the cross section collected prior to 1998.

Cross Section Location Map

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St. Louis Downtown Site
St. Louis, Missouri

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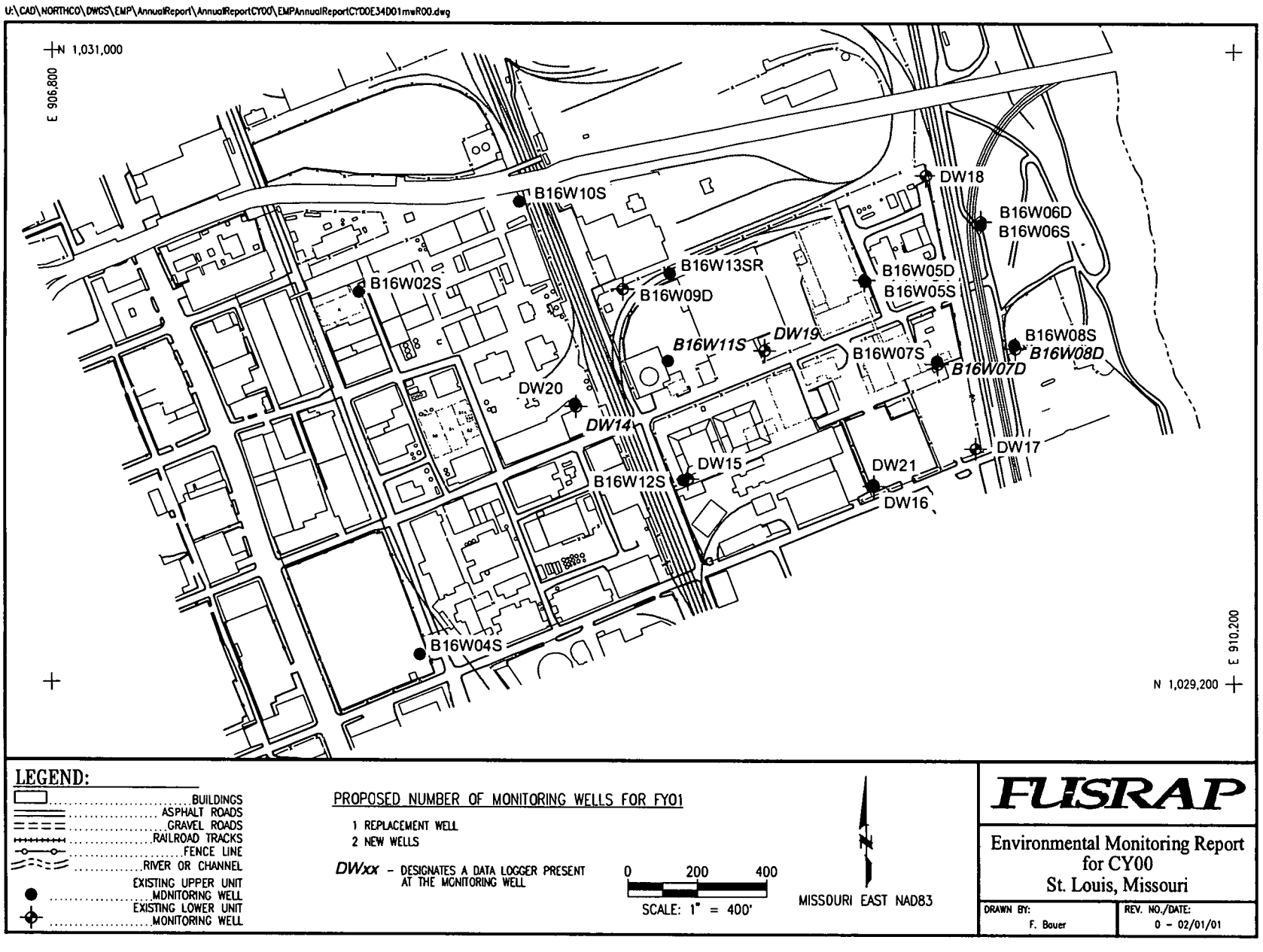

Figure 4-18. Gound-water Monitoring Well Locations at the SLDS

Table 4-15. Screened Hydrostratigraphic Units for SLDS Ground-water Monitoring Wells

Well ID	Screened Hydrostratigraphic Unit
B16W02S	HU-A
B16W04S	HU-A
B16W05D	HU-B
B16W05S	HU-A
B16W06D	HU-B
B16W06S	HU-A
B16W07D	HU-B
B16W07S	HU-A
B16W08D	HU-B
B16W08S	HU-A
B16W09D	HU-B
B16W10S	HU-A
B16W11S[1]	HU-A
B16W12S	HU-A
B16W13SR	HU-A
DW14	HU-B
DW15	HU-B
DW16	HU-B
DW17	HU-B
DW18	HU-B
DW19	HU-B
DW20	HU-A
DW21	HU-A

[1] Well believed to be communicating with HU-B.

The results of the CY00 ground-water sampling for SLDS COCs are provided in Tables 4-16 through 4-19. The summary statistics for all analytes in ground water are presented in Table C-2 in Appendix C. The SLDS wells were sampled following a protocol that did not require every analyte to be sampled every quarter for each well.

HU-A Ground Water

HU-A is not considered a potential source of drinking water. For that reason, the federal and state laws and regulations related to drinking water are not considered to be applicable or relevant and appropriate to currently impacted shallow, HU-A ground water beneath the SLDS. Instead of MCLs, the investigative limits specified in the SLDS ROD are provided in Tables 4-16 through 4-19 for comparison purposes to assist in identifying the COCs present at significant concentrations in SLDS ground water (USACE, 1998d). Well B16W11S is listed as a HU-A well, but it seems potentiometrically related to HU-B.

Table 4-16. Results for First Quarter CY00 SLDS Ground-Water Sampling (Unfiltered)

HU	Well ID	Arsenic (µg/L)	Cadmium (µg/L)	Radium-226 (pCi/L)	Thorium-230 (pCi/L)	Total Uranium[1] (µg/L)
HU-A	DW21	173	<0.8	<2.1	2.2	<4.5
	B16W02S	<2.2	<0.8	<2.3	2.5	204.1
	B16W04S	15.3	<0.8	<1.1	<0.7	<5.7
	B16W05S	20	<0.8	<2.5	<0.7	<2.3
	B16W06S	155	<0.8	<2.3	<1.3	<2.2
	B16W07S	13.4	<2.0	<2.2	<1.5	<2.2
	B16W08S	30.6	<0.8	<2.6	<0.8	<5.4
	B16W10S	12.9	1.0	<5.8	<0.6	<2.4
	B16W11S[1,2]	5.3	<0.8	<2.7	<0.7	59.7
	B16W12S	<2.2	<0.8	<2.2	<1.5	9.2
	B16W13SR	<2.2	<0.8	<2.3	<0.7	134.4
HU-B	DW14	176	<2.0	6.11	<0.7	<2.8
	DW15	57.1	<0.8	<1.3	<1.2	<2.3
	DW16	3.4	<0.8	<2.4	<0.6	2.5
	DW17	8.4	<2.0	3.9	1.8	2.2
	DW18	32.9	<0.8	<2.9	1.2	<2.2
	DW19	20.9	<0.8	3.9	2.3	101.4
	B16W05D	13.8	<0.8	<2.3	<1.2	<4.1
	B16W06D	<2.2	<0.8	<2.3	<0.6	<4.4
	B16W07D	24.2	<0.8	<2.4	<0.6	<2.5
	B16W08D	27.5	<0.8	<1.3	<1.7	<2.3
	B16W09D	<2.2	<0.8	<2.7	<0.6	<1.9
IL		*50*	*5*	---	---	*20*

< Reported concentration below sample quantitation limit based on "Laboratory" or "Review Qualifier".
--- Not Available
[1] Total Uranium Values were calculated from isotopic concentrations and specific activities.
[2] Well believed to be communicating with HU-B.
IL = Investigative Limit

Table 4-17. Results for Second Quarter CY00 SLDS Ground-Water Sampling (Unfiltered)

HU	Well ID	Arsenic (µg/L)	Cadmium (µg/L)	Radium-226 (pCi/L)	Thorium-230 (pCi/L)	Total Uranium[1] (µg/L)
HU-A	DW21	125	<0.3	<2.0	1.13	<2.8
	B16W02S	<1.4	<2.8	<3.5	2.0	115, 178[2]
	B16W04S	12.2	<0.8	<4.0	1.2	<2.2
	B16W05S	52.3	<2.8	<6.2	2.0	2.5, <151.2[2]
	B16W06S	258	<0.8	<3.9	1.7	<2.4
	B16W07S	13.6	<0.3	<5.8	<0.7	<2.6
	B16W08S	24.2	<0.8	<4.6	<1.5	<2.6
	B16W10S	20.3	<0.3	<4.1	1.5	<2.9
	B16W11S[3]	6.3	<2.8	<3.9	1.8	41.0, <151.2[2]
	B16W12S	<1.4	<0.3	<2.5	<1.9	4.1
	B16W13SR	<1.4	<0.3	<4.5	2.4	62.8

Table 4-17. Results for Second Quarter CY00 SLDS Ground-Water Sampling (Unfiltered) (Cont'd)

HU	Well ID	Arsenic (µg/L)	Cadmium (µg/L)	Radium-226 (pCi/L)	Thorium-230 (pCi/L)	Total Uranium[1] (µg/L)
HU-B	DW14	181	<2.8	5.4	<1.18	<2.4
	DW15	59.5	<0.3	<2.6	2.0	16.6
	DW16	9.9	<0.3	2.2	<0.7	19.3
	DW17	6.1	<0.3	<3.0	<1.3	7.8
	DW18	31.3	<0.3	<2.1	1.5	<4.7
	DW19	20.2	<0.3	<2.5	<1.5	61.9
	B16W05D	12.6	<0.3	<4.2	<1.1	<3.7
	B16W06D	<2.2	<0.8	<6.1	1.5	<4.1
	B16W07D	22	<2.8	<9.1	<1.2	<2.3
	B16W08D	21.4	<0.3	<2.5	<1.2	<2.5
	B16W09D	7.1	<0.3	<1.1	2.5	<2.3
IL		*50*	*5*	---	---	*20*

< Reported concentration below sample quantitation limit based on "laboratory" or "review qualifier".
--- Not Available
[1] Total Uranium Values were calculated from isotopic concentrations and specific activities.
[2] Second Total Uranium Value is a measured, not calculated, value
[3] Well believed to be communicating with HU-B.
IL = investigative limit

Table 4-18. Results for Third Quarter CY00 SLDS Ground-Water Sampling (Unfiltered)

HU	Well ID	Arsenic (µg/L)	Cadmium (µg/L)	Radium-226 (pCi/L)	Thorium-230 (pCi/L)	Total Uranium[1] (µg/L)
HU-A	DW21	131	<0.3	<1.1	<1.4	<3.7
	B16W02S	<1.4	<0.3	<1.9	1.3	117.8
	B16W04S	<1.4	<0.3	<2.0	---	<4.6
	B16W05S	39.7	<0.3	<2.7	<0.6	<2.3
	B16W06S	208	<0.3	<2.2	1.3	<2.3
	B16W07S	<1.4	<0.3	<2.4	<1.2	<2.3
	B16W08S	<1.4	<0.3	<2.8	1.9	<5.4
	B16W10S	<1.4	<0.3	5.7	<0.7	<3.8
	B16W11S	71	5	<1.1	<1.2	53.3
	B16W12S	<1.4	<0.3	<2.8	1.4	6.4
	B16W13SR	<1.4	<0.3	2.32	1.87	77.6
HU-B	DW14	160	<0.3	3.8	2.3	<2.6
	DW15	55.7	<0.3	<2.9	---	<2.5
	DW16	<1.4	<0.3	2.2	---	11.4
	DW17	15.1	<0.3	<1.1	<1.6	10.0
	DW18	34.4	<0.3	<3.7	<0.7	3.0
	DW19	19.4	<0.3	23.0	<1.6	91.1
	B16W05D	11.3	<0.3	<3.7	2	<2.2
	B16W06D	<1.4	<0.3	<2.5	1.4	<1.9
	B16W07D	27	<0.3	<2.6	2.5	<2.7
	B16W08D	26.6	<0.3	<3.1	<0.7	<2.5
	B16W09D	<1.4	<0.3	2.6	---	<2.0
IL		*50*	*5*	---	---	*20*

< Reported concentration below sample quantitation limit based on "Laboratory" HZ-A HU wells or "Review Qualifier". Value shown is detection limit
--- Data not available
[1] Total Uranium Values were calculated from isotopic concentrations and specific activities.
[2] Well believed to be communicating with HU-B.
IL = investigative limit

Table 4-19. Results for Fourth Quarter CY00 SLDS Ground-water Sampling (Unfiltered)

HU	Well ID	Arsenic (µg/L)	Cadmium (µg/L)	Radium-226 (pCi/L)	Thorium-230 (pCi/L)	Total Uranium[1] (µg/L)
HU-A	DW21	134	0.4	< 2.2	<1.3	<2.4
HU-B	DW15	58.4	1.6	<4.7	<1.3	<5.3
	DW18	28.9	0.4	<2.7	<1.6	<4.1
	DW19	19.4	< 5.0	< 2.8	<0.7	97.2
IL		*50*	*5*	---	---	*20*

< Reported concentration below sample quantitation limit based on "laboratory" or "review qualifier".
---Not Available
[1] Total Uranium Values were calculated from isotopic concentrations and specific activities
IL = investigative limit

The two principal COCs that exceed MCLs and investigative limits in HU-A ground water are arsenic and total uranium. Arsenic concentrations exceeding the proposed MCL of 10 µg/L were detected in eight HU-A wells at SLDS during CY00. The most significant concentrations (ranging from 125 to 258 µg/L) were found in two wells located in the eastern portion of SLDS, DW21 and B16W06S. Total uranium concentrations, calculated from the isotopic uranium results, were detected above the investigative limit and the MCL in two wells screened exclusively in HU-A, B16W02S and B16W13SR. Well B16W02S had a maximum total uranium concentrations of 204.1 µg/L. B16W13SR had a maximum detected concentration of total uranium of 134.4 µg/L. (B16W11S is above the limit however, it is not considered indicative of HU-A.). All three wells reported their maximum uranium concentration in the first quarter sample. An evaluation of the concentration trends over time for arsenic and total uranium in ground water is presented in Section 4.3.2

Other COCs identified in the SLDS ROD include Ra-226, Th-230, and cadmium. Radium-226 was detected only once above its MCL of 5 pCi/L (combined Ra-226/Ra-228) in the CY00 HU-A ground-water samples. The maximum level detected was an estimated (J qualified) value of 5.74 pCi/L in a third quarter sample from B16W10S. The only other detection of Ra-226 in HU-A ground water was from B16W13SR. A concentration of 2.32 pCi/L Ra-226, which is below the MCL of 5 pCi/L, was detected in the third quarter sample from this well. Cadmium was not detected above its investigative limit at any wells at SLDS during CY00, but it was detected once at the investigative limit of 5 µg/L in HU-A well B16W11S.

The concentrations of chloride, nitrate, sulfate, and TDS in HU-A groundwater samples were compared to the SMCLs for these analytes. Chloride and nitrate were not detected at levels exceeding their SMCLs in HU-A ground water. Sulfate and TDS were detected in one HU-A well, DW21, at concentrations exceeding their SMCLs (250 and 500 mg/L, respectively). Sulfate was detected at a maximum concentration of 276 mg/L. Total dissolved solids were detected at levels up to 1,180 mg/L in DW21.

HU-B Ground Water

During CY00, eleven SLDS wells completed in the Mississippi Alluvial Aquifer (HU-B) were monitored for various parameters, including the COCs arsenic, cadmium, Th-228, Th-230, Th-232, Ra-226, Ra-228, U-234, U-235, and U-238. The concentrations of the COCs were

compared to the following investigative levels specified in the ROD: 50 µg/L for arsenic, 5 µg/L for cadmium, and 20 µg/L for total uranium (USACE, 1998d). The investigative limits for arsenic and total uranium differ from the current SDWA MCLs. In December CY00, EPA updated its standards for radionuclides in drinking water, increasing the uranium MCL from 20 µg/L to 30 µg/L. In January CY01, EPA proposed a new standard for arsenic in drinking water that reduced the MCL from 50 µg/L to 10 µg/L. The EPA is delaying the effective date for this rule until February 22, 2002 to allow time to review the proposed standard and to provide the public with an opportunity for further input. Although use of the Mississippi River Alluvial Aquifer (Unit B) as a drinking water source is not likely at SLDS, SDWA MCLs and SMCLs are used here for comparison purposes to determine if significant concentrations of site contaminants occur in HU-B ground water.

As specified in the SLDS ROD, initiation of a Ground-Water Remedial Action Alternative Assessment (GRAAA) would be undertaken, if significant exceedances of the investigative limits for arsenic, cadmium, and total uranium are observed in the Mississippi Alluvial Aquifer (HU-B) (USACE, 1998d).

The CY00 sampling results indicate cadmium was not present above the investigative level (5 µg/L) in samples collected from HU-B ground-water wells. Arsenic was detected above the investigative limit of 50 µg/L in two wells: DW14, and DW15. The arsenic levels ranged from only slightly exceeding the limit in DW15 (maximum 59.5 µg/L) to over 3 times the limit in DW14 (maximum 182 µg/L). The maximum concentrations in these two wells were reported for the second quarter samples. The lowest concentrations reported in these two wells (160 µg/L in DW14 and 55.7 µg/L in DW15) were reported in the third quarter samples.

The total uranium concentrations were calculated for each sample from the isotopic uranium results and specific activities. Total uranium was present above the investigative level of 30 µg/L in all four quarterly samples collected from DW19, located at Plant 6. The total uranium concentrations ranged from 61.9 µg/L (second quarter) to 101.4 µg/L (first quarter) in this well. Total uranium concentrations detected in the third quarter and fourth quarter samples from DW19 were similar in value (91.1 µg/L and 97.2 µg/L, respectively). Well B16W11S had a maximum total uranium concentrations of 59.7 µg/L but may be a poor representation of HU-B. Continued ground-water sampling is necessary to determine if the source removal actions being conducted at SLDS will result in a reduction of uranium concentrations in ground-water samples from these wells. Four other HU-B wells (DW15, DW16, DW17, and DW18) reported detectable levels of total uranium, but their maximum concentrations (16.6 µg/L-second quarter; 19.3 µg/L-second quarter; 10.0 µg/L-third quarter; an 3 µg/L-third quarter, respectively) are below the investigative levels.

Two other COCs detected in HU-B ground-water at SLDS, Th-230 and Ra-226, do not have established investigative levels. The MCL for combined Ra-226/Ra-228, 5 pCi/L, was compared to the concentration activities of Ra-226 detected in the HU-B wells during CY00. The maximum Ra-226 concentration, 23.0 pCi/L, was reported for ground-water sample (third quarter) from DW19. Concentrations returned to nondetectable levels in the fourth quarter sample from this well. In addition, Ra-226 was detected at levels slightly exceeding the MCL in two other HU-B wells at SLDS: DW14 (maximum 7.46 pCi/L – second quarter) and DW16

(maximum 8.13 pCi/L – third quarter). There are no established MCLs or SMCLs for Th-230. The maximum concentration of Th-230 detected in HU-B ground water was 3.28 pCi/L, detected in DW14 (fourth quarter).

The concentrations of TDS, chloride, nitrate, and sulfate were compared to the SMCLs for these analytes. The results indicate that these constituents are present in HU-B ground water at levels exceeding their SMCLs. TDS were present above the SMCL of 500 mg/L in six HU-B wells (DW14 through DW19), with the highest levels detected in DW14. The maximum TDS concentration was 7,400 mg/L (second quarter). The high TDS concentrations are believed to be naturally occurring. Chloride was detected above its SMCL of 250 mg/L in two HU-B wells, DW15 and DW14, up to a maximum concentration of 3,920 mg/L in DW14. Nitrate was detected at elevated concentrations (461 mg/L) in one sample for (third quarter) DW17. Sulfate was detected in three HU-B wells at concentrations exceeding its SMCL of 250 mg/L. The maximum concentration detected was 1,270 mg/L in DW15 (second quarter). The elevated TDS, chloride, and sulfate levels may be due to leakage of highly-mineralized ground water from the underlying bedrock (Miller and Vandike, 1997).

4.3.2 Comparison of Historical Ground-Water Data at SLDS

A qualitative evaluation of COC concentration trends in both HU-A and HU-B was conducted based on available sampling data for the period from January CY99 through December CY00. Table 4-20 summarizes the historical HU-A ground-water sampling data for the principal COCs at SLDS. The results indicate that shallow, HU-A ground water has been impacted by arsenic and uranium. However, the COC concentrations observed in HU-A ground water did not increase in CY00 over the levels observed in CY99. Figures 4-19 and 4-20 provide time versus concentration plots for selected SLDS wells for arsenic and uranium, respectively. As shown in Figure 4-19, arsenic concentrations have remained relatively stable, but with some seasonal variation, since January CY99. Decreasing trends in uranium concentrations can be seen in B16W02S located in the western portion of the Mallinckrodt plant (Figure 4-20). Concentrations of total uranium in the remaining HU-A wells have generally remained stable. Historical data indicate that activity concentrations of the radionuclides Ra-226, Th-228, Th-230, and Th-232 have also remained relatively stable at low or nondetectable levels in HU-A ground-water samples.

Ground-water sampling results for SLDS indicate that no significant changes from CY00 COC levels have occurred in HU-B ground water during CY00. As shown in the time versus concentration plots in Figures 4-19 and 4-20, concentrations of arsenic and uranium in the HU-B wells have not shown significant increases since January CY99. Total uranium was observed above the investigative level of 20 µg/L in DW19 (maximum concentration 101.4 µg/L) in CY00, but the concentrations observed were not greater than those observed in CY99. The concentration of total uranium in monitoring well B16W11S has exceeded the investigative level, but seems to be declining over time. As with the HU-A ground water samples, arsenic concentrations in HU-B ground-water samples were relatively constant over both CYs. Continued sampling will be necessary to determine if the first quarter sample result was anomalous.

Table 4-20. Historical HU-A Ground-Water Sampling Data for the Principal Contaminants at SLDS

Chemical	Units	MCL	Station	Fourth Quarter 1998 1/19 - 2/5/99	First Quarter 1999 3/3 - 3/25/99	Second Quarter 1999 5/17 - 5/28/99	Third Quarter 1999 9/23/99	First Quarter 2000 4/11-4/27/00	Second Quarter 2000 5/17-6/29/00	Third Quarter 2000 9/5 - 9/8/00	Fourth Quarter 2000 12/5/00
Arsenic	µg/L	10	B16W02S	2.5 U	2.5 U	2.1		2.5 U	3.2 U	3.6 U	
			B16W04S	24.2	17.1	14.2		15.3	12.2	5.7 U	
			B16W05S	27.3	25.6	40.8		20	52.3	39.7	
			B16W06S	242	266	223		155	258	208	
			B16W07S	15 U	9.7 J	11.5		13.4	13.6	13.7 U	
			B16W08S	5.5 J	9.1 J	13		30.6	24.2	8.9 U	
			B16W10S	3.5 J	6.5 J	8.5 U		12.9	20.3	2.3 U	
			B16W11S	2.5 U	9.7 U	5.6 U		5.3	6.3	71	
			B16W12S	2.5 U	2.5 U	1.9 U		2.2 U	1.4 U	1.4 U	
			B16W13SR	2.5 U	2.5 U	1.9 U		2.2 U	1.4 U	1.4 U	
			DW20		116	129					
			DW21		125	114	130	173	125	131	134
Cadmium	µg/L	5	B16W02S	0.59 U	0.5 U	0.3 U		0.8 U	2.8 U	0.3 U	
			B16W04S	4.2 U	4.3 J	0.4 U		0.8 U	0.8 U	7.8 U	
			B16W05S	4.2 U	0.5 U	0.3 U		0.8 U	2.8 U	0.3 U	
			B16W06S	0.5 U	0.5 U	0.3 U		0.8 U	0.8 U	0.64 U	
			B16W07S	0.5 U	0.5 U	0.3 U		2 U	0.3 U	1 U	
			B16W08S	1.9 J	0.8 U	0.77 U		0.8 U	0.8 U	0.71 U	
			B16W10S	0.76 J	1.9 U	8.8		1	0.3 U	0.3 U	
			B16W11S	2 U	0.5 U	0.3 U		0.8 U	2.8 U	5	
			B16W12S	4.2 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U	
			B16W13SR	4.2 U	0.5 U	0.3 U		0.8 U	0.3 U	0.3 U	
			DW20		0.2 U	0.3 U					
			DW21		0.5 U	0.3 U	3 U	0.8 U	0.3 U	0.3 U	0.43 J
Radium-226	pCi/L	5	B16W02S	0.28 U	0 U	1.39 U		2.13 U	0.53 U	-0.1 U	
			B16W04S	0.3 U	1.06 U	-0.35 U		0.4 U	1.4 U	0.7 U	
			B16W05S	0 U	0.85 U	1.71 U		-0.21 U	0.93 U	0.62 U	
			B16W06S	0 U	0.58 U	-0.14 U		0.81 U	1.34 U	0.32 U	
			B16W07S	-0.09 U	0 U	-0.06 U		-0.11 U	-0.48 U	0.61 U	
			B16W08S	0 U	-0.1 U	0.17 U		-0.21 U	-0.62 U	-0.23 U	
			B16W10S	0.31 U	0.41 U	0.43 U		0.49 U	-0.2 U	5.74 J	
			B16W11S	-0.28 U	0 U	1.02 U		1.14 U	1.45 U	0.4 U	
			B16W12S	-0.3 U	1.46 U	0.78 U		0.32 U	0.21 U	1.1 U	
			B16W13SR	0.78 U	0.5 U	0.86 U		0.78 U	0.17 U	2.32 J	
			DW20		85.81 J	13.36					
			DW21		0.8 UJ	0.54 U	0 U	-0.1 U	-0.1 U	0 U	-0.11 U

Table 4-20. Historical HU-A Ground-Water Sampling Data for the Principal Contaminants at SLDS (Cont'd)

Chemical	Units	MCL	Station	Fourth Quarter 1998 1/19 - 2/5/99	First Quarter 1999 3/3 - 3/25/99	Second Quarter 1999 5/17 - 5/28/99	Third Quarter 1999 9/23/99	First Quarter 2000 4/11-4/27/00	Second Quarter 2000 5/17-6/29/00	Third Quarter 2000 9/5 - 9/8/00	Fourth Quarter 2000 12/5/00
Thorium-228	pCi/L	NA	B16W02S	0.58 U	0.51 UJ	0.16 U		0.27 U	0.06 U	0.17 U	
			B16W04S	0.26 U		0.16 U		1.43 U	0.37 U	0.81 U	
			B16W05S	0.72 U	0.51 U	2.43 J		0.45 U	0.13 U	0.3 U	
			B16W06S	0.6 U	4.28 J	0.39 U		0.47 U	0 U	0.46 U	
			B16W07S	0.91 U	0.11 U	0.4 U		0.4 U	-0.18 U	1.08 U	
			B16W08S	0.25 U	1.13 U	0.33 U		0.68 U	-0.12 U	0 U	
			B16W10S	0.39 U	0.34 U	2.96 J		0.91 U	-0.06 U		
			B16W11S	0.37 U	0.1 U	0.83 U		1.9 J	0.67 U	0.24 U	
			B16W12S	0.78 U	0.42 U	1.53 J		0.26 U	0.95 U	1.3 U	
			B16W13SR	0.07 U	0.22 U	1.14 J		1.05 U	0.41 U	0.5 U	
			DW20		3.08 J	1.39 J					
			DW21		1.32 UJ	1.02 U	0 U	2.32 J	0.87 J	0.56 U	0.4 U
Thorium-230	pCi/L	NA	B16W02S	2.63 J	4.78 J	1.81 J		2.52 J	2.02 J	1.31 J	
			B16W04S	2.06 J	1.53 J			0.99 U	1.22 J		
			B16W05S	0.51 U	2.17 J	5.12 J		0.48 U	2.02 J	0.47 U	
			B16W06S	1.74 J	11.96 J	0.83 U		0.7 U	1.68 J	1.29 J	
			B16W07S	2.86 J	1.62 J	0.95 U		0.63 U	0.72 U	0.65 U	
			B16W08S	2.27 J	0.12 U	1.55 J		0.57 U	-0.12 U	1.87 J	
			B16W10S	3.05 J	2.53 J	5.06 J		0.61 U	1.52 J	0.48 U	
			B16W11S	1.46 J	1.24 J	1.01 U		0.48 U	1.78 J	-0.06 U	
			B16W12S	1.07 U	0.96 J	6.6 J		0.87 U	0.64 U	1.43 J	
			B16W13SR	2.79 J	1.53 J			1.75 J	2.36 J	1.87 J	
			DW20			0.58 U					
			DW21		0.39 UJ	1.47 J		2.22 J	1.13 J	0.77 U	0.46 U
Thorium-232	pCi/L	NA	B16W02S	0 U	0 UJ	0 U		0.26 U	0.24 U	0 U	
			B16W04S	-0.09 U	0.19 U	0.3 U		0 U	0 U	0 U	
			B16W05S	0.25 U	0.2 U	0 J		0.18 U	-0.06 U	0 U	
			B16W06S	0 U	0.036 U	-0.08 U		0 U	0.24 U	0 U	
			B16W07S	0 U	0.18 U	0 U		0 U	0 U	0.24 U	
			B16W08S	0.32 U	0.5 U	0.15 U		0 U	0.24 U	0 U	
			B16W10S	0 U	0 U	0 U		0 U	0.25 U	-0.06 U	
			B16W11S	0 U	0.35 U	-0.07 U		0 U	0.24 U	0.24 U	
			B16W12S	0 U	0.16 U	0.22 J		-0.12 U	0 U	-0.07 U	
			B16W13SR	0 U	0.19 U	0.14 J		0.25 U	0.21 U	-0.05 U	
			DW20			0 U			U		
			DW21		-0.06 UJ	0 U	0 U	0.47 U	0 U	0.21 U	0 U

Table 4-20. Historical HU-A Ground-Water Sampling Data for the Principal Contaminants at SLDS (Cont'd)

Chemical	Units	MCL	Station	Fourth Quarter 1998 1/19 - 2/5/99	First Quarter 1999 3/3 - 3/25/99	Second Quarter 1999 5/17 - 5/28/99	Third Quarter 1999 9/23/99	First Quarter 2000 4/11-4/27/00	Second Quarter 2000 5/17-6/29/00	Third Quarter 2000 9/5 - 9/8/00	Fourth Quarter 2000 12/5/00
Uranium*	µg/L	30	B16W02S	600.9	305.3	359.3		204.1	115	117.8	
									178*		
			B16W04S	2.6 U	0.4 U	2.7 U		5.7 U	2.2 U	4.6 U	
			B16W05S	2.1 U	2.5 U	2.4 U		2.3 U	2.5 U	2.3 U	
				71.3* U					151.2 U		
			B16W06S	2.7 U	2.7 U	4.6 U		2.2 U	2.3 U	2.3 U	
			B16W07S	2.3 U	2.2 U	5 U		2.2 U	2.6 U	2.4 U	
			B16W08S	2.7 U	0.4 U	3.9		5.4 U	2.6 U	5.4 U	
			B16W10S	0.4 U	5.6	5.4 U		2.4 U	2.9 U	3.8 U	
			B16W11S	106.3	69.5	72.6		59.7	41	53.3	
									151.2* U		
			B16W12S	11.8	7.2	8.1		9.2	4.1	6.4	
				71.3* U							
			B16W13SR	60.3	61.4	61.7		134.4	62.8	77.6	
				71.3* U							
			DW20		4.6 U				4 U		
			DW21		6.5 U	5.4 U	6 U		2.8 U	3.7 U	2.4 U
Uranium-234	pCi/L	NA	B16W02S	189.1	100.1	111.4		76.89	38.84	42.09	
			B16W04S	0.18 U		-0.06 U		0.52 U	-0.06 U	0 U	
			B16W05S	0 U	0.26 U	0.25 U		0.21 U	2.35 J	0.24 U	
			B16W06S	0 U	0 U	0.45 U		0.23 U	0.25 U	-0.06 U	
			B16W07S	0.42 U	-0.06 U	0.07 U		0.4 U	0.81 U	-0.06 U	
			B16W08S		0 U	1.12 U		0.26 U	-0.07 U	0 U	
			B16W10S	0.57 U	1.35 J			0.5 U	0.23 U	0 U	
			B16W11S	32.25	22.25	23.7		19.4	16.41	18.56 J	
			B16W12S		3.53 J	1.72 J		2.75 J	0.94 U	2.02 J	
			B16W13SR	21.19	17.72	18.63		37.45	19.04	21.87	
			DW20		0.94 UJ	-0.06 U					
			DW21		0.78 UJ	-0.07 U	0.47 U	0 U	-0.074 U	0 U	-0.06 U
Uranium-235	pCi/L	NA	B16W02S	8.33	3.65 J	8.16		2.29 J	0.79 U		
			B16W04S	-0.07 U	0 U	0.54 U		-0.16 U	0 U	0 U	
			B16W05S	0 U	0 U	0 U		-0.06 U	0.32 U	0 U	
			B16W06S	0 U	0 U	-0.08 U		0 U	0 U	0 U	
			B16W07S	0 U	0 U	-0.25 U		0 U	0 U	0 U	
			B16W08S	0 U	0.31 U	0.29 U		-0.08 U	0.33 U	0 U	
			B16W10S	0 U	-0.08 U	0 U		0 U	0 U	0 U	
			B16W11S	1.58 J		0.98 U		0.66 U	1.4 U	0.28 U	
			B16W12S	0 U	0.4 U	0 U		0 U	0 U	0.28 U	
			B16W13SR		0.42 U	1.71 U		2.04 J	0.76 U	0.39 U	
			DW20		-0.15 UJ	0 U					
			DW21		-0.08 UJ	-0.08 U	0 U	0 U	0 U	0 U	0 U

Table 4-20. Historical HU-A Ground-Water Sampling Data for the Principal Contaminants at SLDS (Cont'd)

Chemical	Units	MCL	Station	Fourth Quarter 1998 1/19 - 2/5/99	First Quarter 1999 3/3 - 3/25/99	Second Quarter 1999 5/17 - 5/28/99	Third Quarter 1999 9/23/99	First Quarter 2000 4/11-4/27/00	Second Quarter 2000 5/17-6/29/00	Third Quarter 2000 9/5 - 9/8/00	Fourth Quarter 2000 12/5/00
Uranium-238	pCi/L	NA	B16W02S	200	101.7	119.1		68.03	38.44	39.46	
			B16W04S	0.48 U		0.5 U		0 U	0.22 U	0.21 U	
			B16W05S	0 U	0 U	0 U		0 U	0.78 U	0 U	
			B16W06S	0.17 U	0.55 U	-0.06 U		0 U	0 U	0 U	
			B16W07S	0.24 U	0 U	0.2 U		0.23 U	0.54 U	0 U	
			B16W08S	0.28 U		1.17 J		0.39 U	0.79 U	0.24 U	
			B16W10S		0.94 U	-0.08 U		0.25 U	0.91 U	0 U	
			B16W11S	35.36	23.29	24.17		19.85	13.58	17.73	
			B16W12S	3.78 J	2.24 J	2.57 J		2.96 J	1.25 J	2.01 J	
			B16W13SR	20.2	20.21	20.37		44.7	20.88	25.82	
			DW20		0.94 UJ	-0.06 U					
			DW21		-0.26 UJ	-0.13 U	0.16 U	0.2 U	0.59 U	-0.06 U	0.25 U

* Total Uranium value calculated from isotopic uranium sample results except where noted with an *.
U = Reported concentration below sample quantitation limit based on "laboratory" or "review qualifier".
J = Reported concentration is estimated value
NA = Not applicable. No MCL available for this analyte.

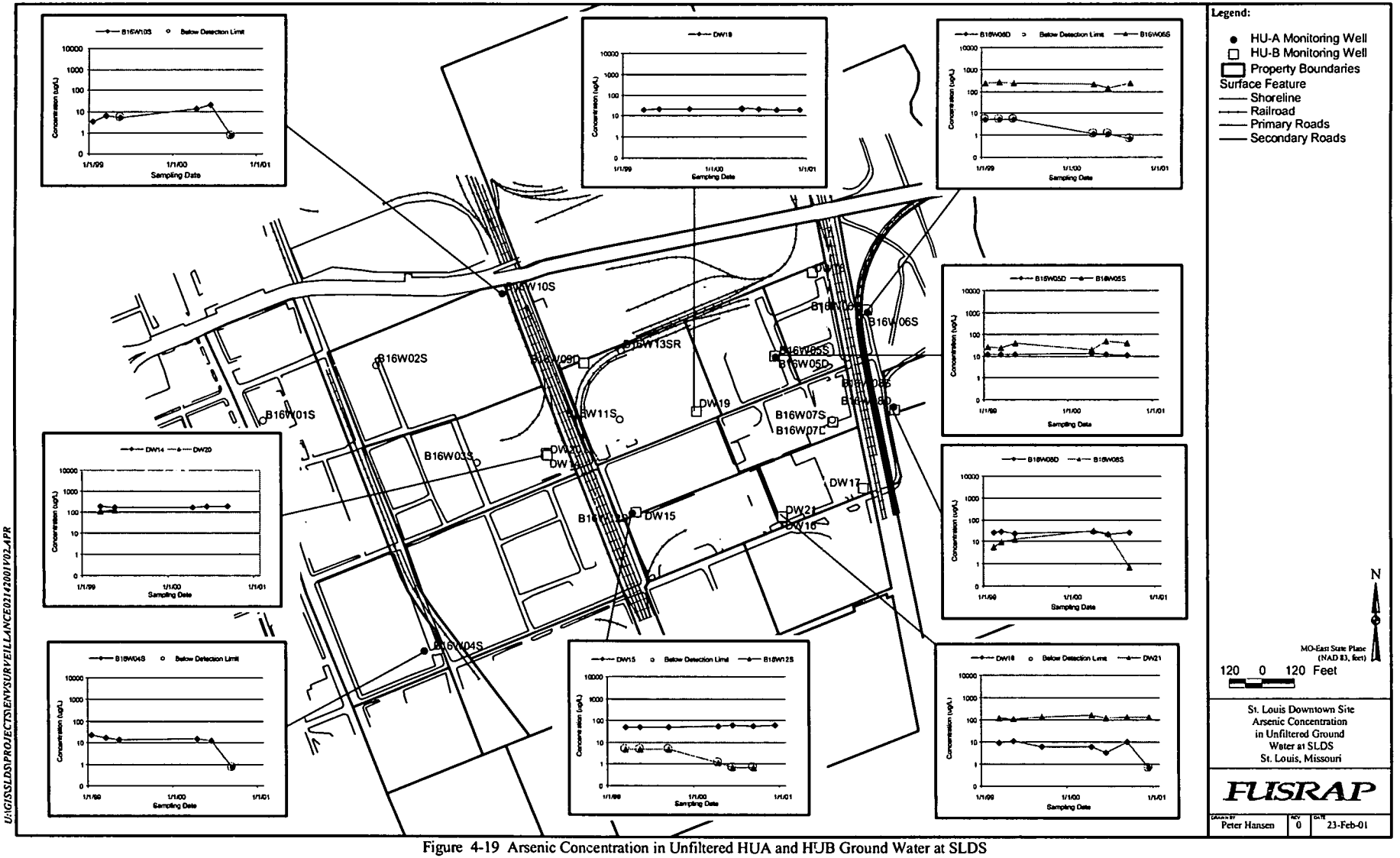

Figure 4-19 Arsenic Concentration in Unfiltered HUA and HUB Ground Water at SLDS

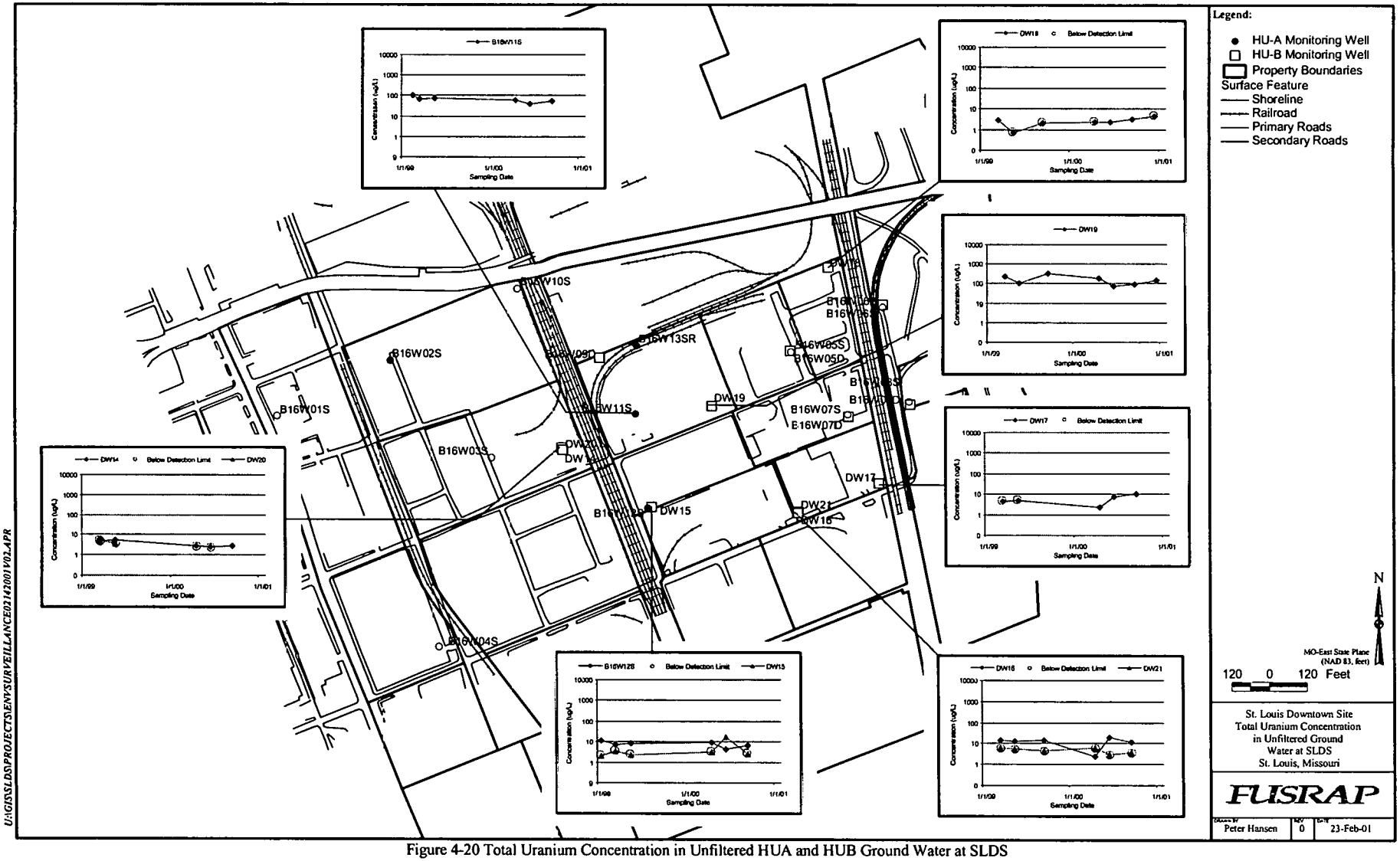

Figure 4-20 Total Uranium Concentration in Unfiltered HUA and HUB Ground Water at SLDS

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The results of exceeding the Total Uranium IL in DW19 indicates that a GRAAA should be initiated. While B16W11S [just west of DW19] may be related to HU-B, the samples from B16W11S may be attenuated and not truly reflect HU-B. The likely source of Uranium transport may only be speculated at this point. The Corps will initiate in FY02 a phased evaluation of the GRAAA. The first phase will be equivalent in process to a Preliminary Assessment. The purpose of the GRAAA, should all process phases require completion, would be to evaluate "MED/AEC COC fate and transport, risk to the public and the environment, practical and efficient technologies to reduce the COCs, the likely concentrations to be removed, the likely concentrations of the COC(s) remaining post-treatment, impact of Mississippi River flooding inflows to the B Unit, and a recommendation for action in the Mississippi Alluvial Aquifer, the B Unit" (USACE, 1998d).

4.3.3 Evaluation of the CY00 Potentiometric Surfaces at SLDS

Ground-water elevations were measured in monitoring wells at SLDS in April, June, September, and December of CY00. Potentiometric surface maps were created from the June and December measurements to illustrate ground-water flow conditions in the wet and dry seasons, respectively. The potentiometric maps for both HU-A and HU-B are presented in Figures 4-21 through 4-24. The top of casing elevations for all of the monitoring wells at the SLDS were resurveyed on 12/4/00 due to concerns and uncertainty with the elevations of some of the wells. The resurvey resulted in some minor modifications of the elevations for a few of the monitoring wells. The values in the CY99 EMDAR did not include these corrections; therefore the potentiometric surface appears to be different. The piezometric surfaces have been plotted under the same elevation references. The 1999 when corrected, surfaces are consistent with the 2000 surfaces, provided herein.

The ground-water flow direction in HU-A under the eastern portion of the Mallinckrodt plant is generally eastward, toward the Mississippi River (Figures 4-21 and 4-23). Near the center of the plant, a pronounced ground-water low is present, as illustrated by the radial flow pattern surrounding wells B16W11S and DW20. The cause of this anomaly is not known, but it is suspected that the presence of thick sections of permeable soils or drainage structures in the area may be impacting ground-water flow patterns in this area. Flow conditions show some seasonal variation, with ground-water elevations averaging 2 ft higher during the wet season (June) than during the dry season (December). This difference in elevations is most evident in the two wells located in the ground-water low; the HZ-A potentiometric surface based on June measurement indicate that HU-A ground-water elevations in these two central wells are 7 to 8 ft higher than the ground-water elevations measured in these wells during December CY00. Aside from this difference in the central wells, ground-water flow directions and gradients in HU-A at SLDS appear similar for the June and December conditions.

The data indicate that the HU-B potentiometric surface is relatively flat (Figures 4-22 and 4-24). Because ground water in HU-B is hydraulically connected to the Mississippi River, ground-water flow direction and gradient are strongly influenced by river stage. The water levels measured at SLDS indicate that HU-B ground-water elevations were 10 to 12 ft higher on June 13 than on December 4; this corresponds to the difference in the daily river stage, which was approximately 12 ft higher on June 13 than on December 4. The flow gradient is generally steeper toward the east during conditions of low flow (December), indicating an increased rate of ground-water discharge into the river.

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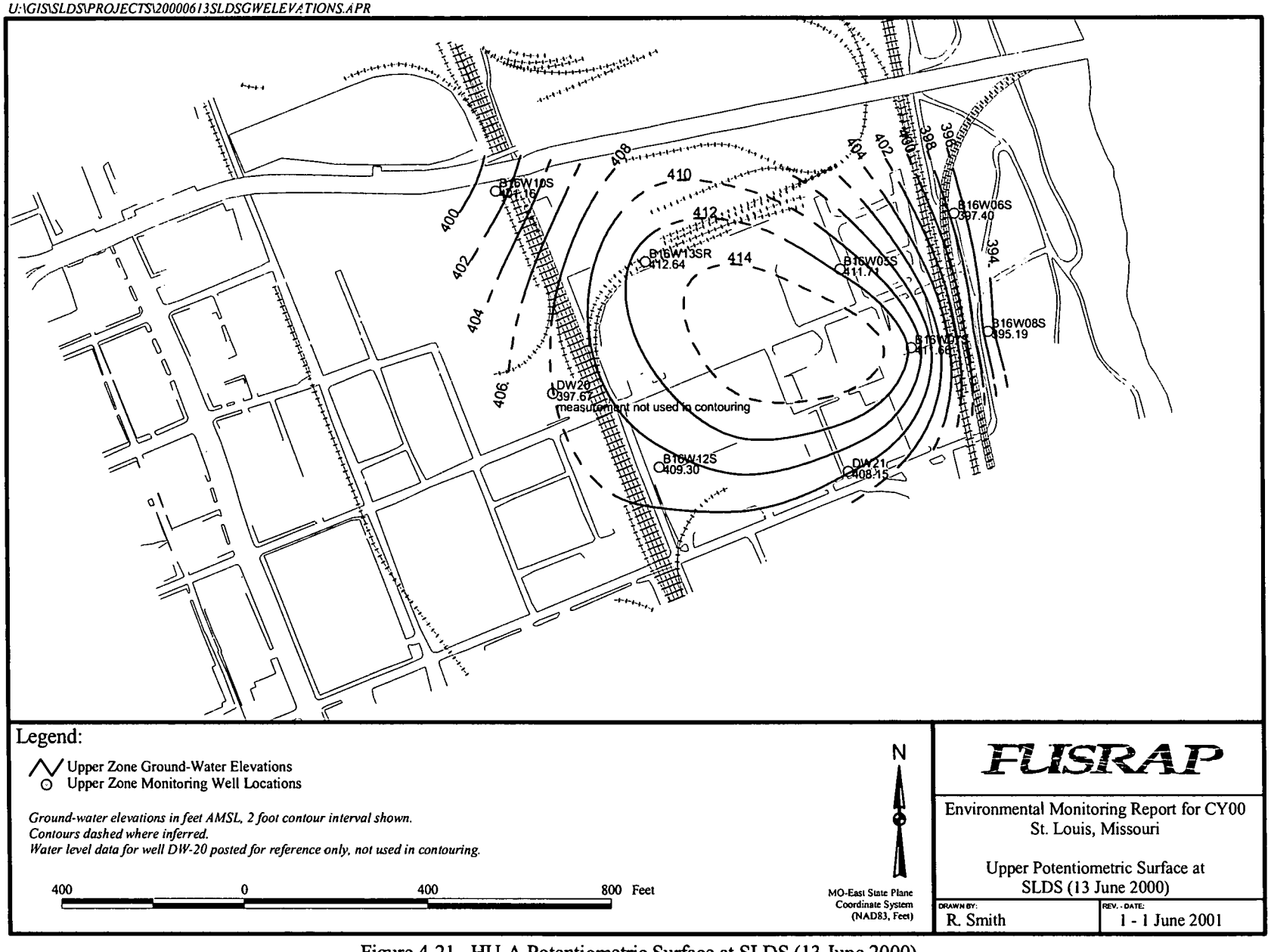

Figure 4-21. HU-A Potentiometric Surface at SLDS (13 June 2000)

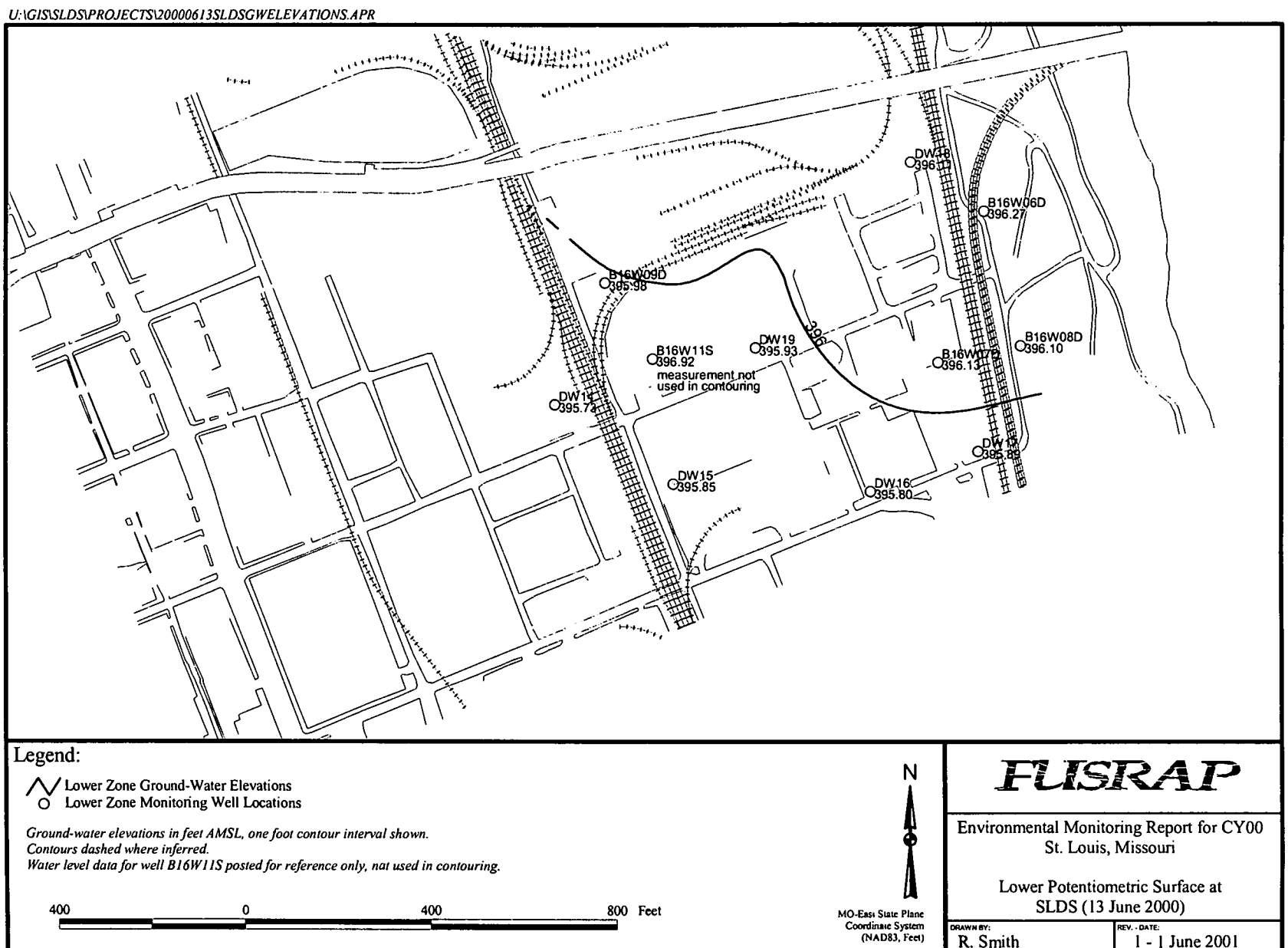

Figure 4-22. HU-B Potentiometric Surface at SLDS (13 June 2000)

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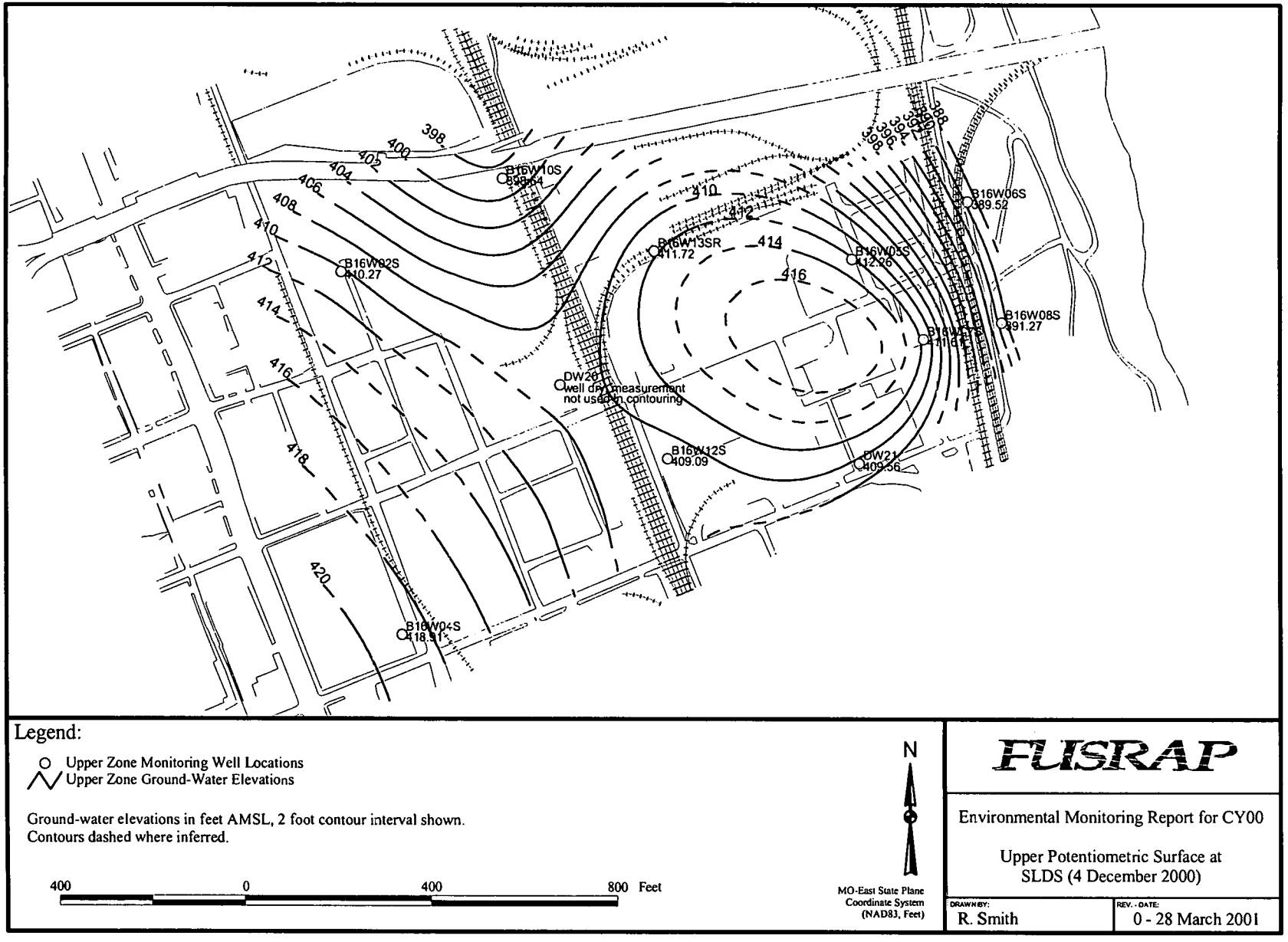

Figure 4-23. Upper Potentiometric Surface at SLDS (4 December 2000)

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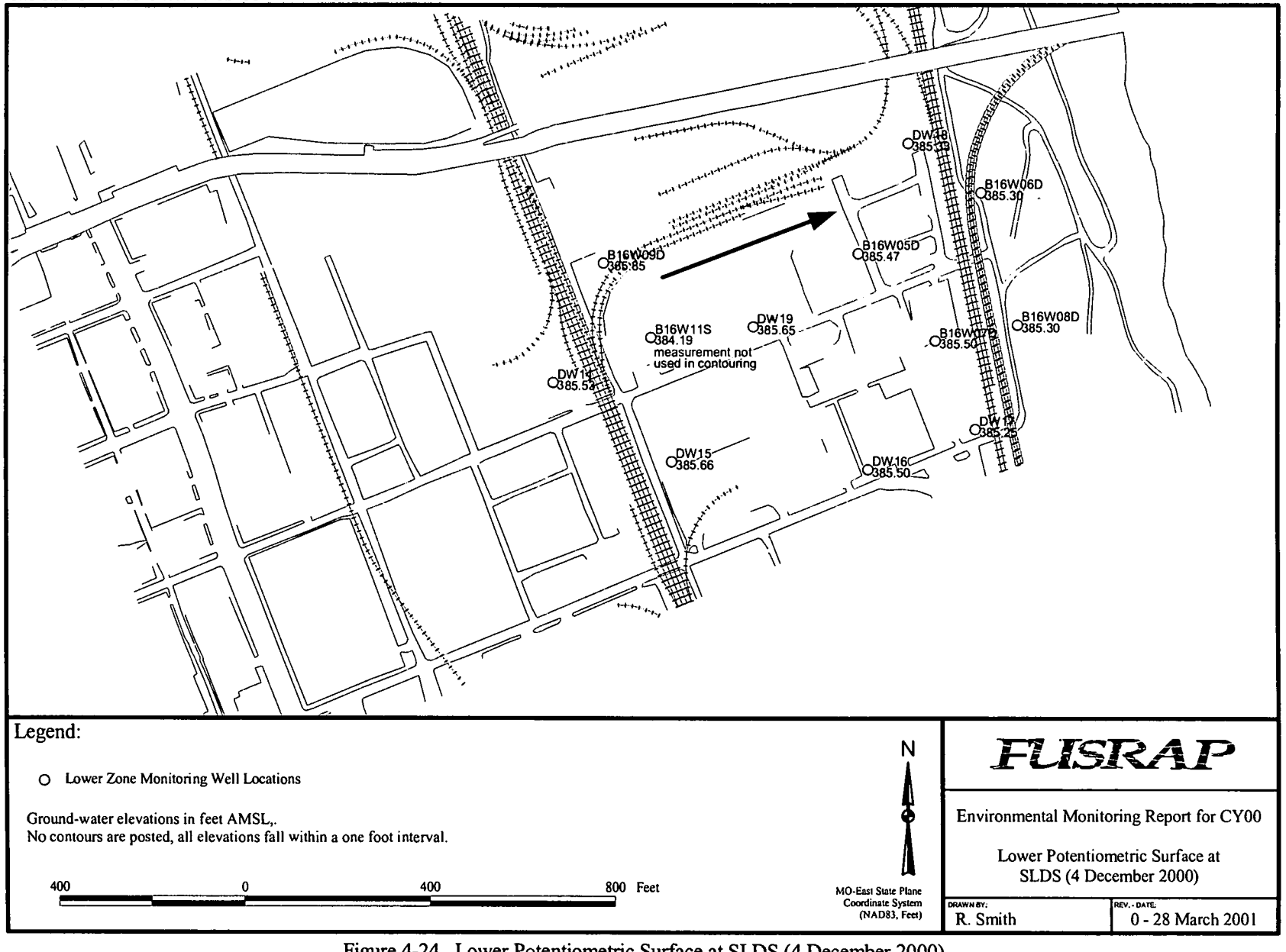

Figure 4-24. Lower Potentiometric Surface at SLDS (4 December 2000)

4.4 FILTERED AND NON-FILTERED GROUND-WATER RESULTS FOR SLS CY00

In addition to the ground-water samples that were discussed previously, the CY00 EMP ground-water sampling included the collection of filtered samples at each of the three SLS. Filtered samples were collected when field parameter testing indicated the turbidity of the ground water in a well was greater than 50 nephelometric turbidity units (NTU). At SLAPS, sampling at eleven wells, four at HISS and at SLDS there were sixteen monitoring wells that required filtered samples in CY00. Table 4-21 summarizes the monitoring wells requiring filtered samples. Table 4-21 through 4-24 provides a statistical comparison of filtered and unfiltered ground-water sampling results. These samples were analyzed for radiological isotopes and target analyte list (TAL) metals.

At the SLAPS the parameters that illustrated a statistical significance based on the arithmetic means were aluminum, iron, vanadium and zinc as shown in Table 4-22. The unfiltered results for aluminum were significant in B53W6D in second quarter, PW35 in the third and fourth quarters; and PW42 in the third quarter. The unfiltered results were three times higher in second quarter in well B53W06D; 63 and 34 times higher in the third quarter for wells PW35 and PW42, respectively; and 10 times higher in fourth quarter in PW35. The aluminum results were at or below the detection levels for all of the filtered samples and were detected in four of fourteen unfiltered samples at SLAPS. The unfiltered results for iron were significantly higher in three monitoring wells, B53W04D, PW35, and PW42. The results range from twice as high in PW42 in fourth quarter to seven times higher in B53W04D in third quarter; while the results were four and half times as high in PW35. The unfiltered results for MW-33-98 were estimated at levels nine times as high as the filtered results. For vanadium the unfiltered results were twice as high in MW-34-98 in first quarter; seventeen times as high in PW35 for third quarter and nine times as high in PW42 in third quarter. The unfiltered zinc results for third quarter in monitoring wells B53W06D (six times), B53W14S (twice) and PW35 (seventeen times) exhibited higher results than the filtered results. The filtered zinc results in PW35 for the fourth quarter were over three times higher than the unfiltered results. There is no explanation for these anomalous results. All of these wells represent water quality from the deeper zones, HZ-C (except B53W14S) and HZ-E (PW35, only). These wells typically have poor water quality and contain higher amounts of colloidal materials; therefore these common metals are higher in the unfiltered samples from these wells.

At the HISS the parameters that were statistically significant based on the geometric mean were aluminum and iron as shown in Table 4-23. A comparison the unfiltered and filtered results for U-238 and Th-230 appear to be statistically significant when viewed in Table 4-23; however, the results of all samples were estimated values or not detected. The unfiltered results for aluminum in HISS-16 in third quarter were 617 µg/L whereas they were not detected in the filtered sample. For iron the unfiltered results ranged from twice as high in the filtered samples as the unfiltered to almost four times as high (HISS-09 at 15.8 µg/L filtered and 24.1 µg/L unfiltered; and HISS-18 (510 µg/L to 1980 µg/L).

There were thirteen SLDS ground-water wells from which a filtered sample was collected in CY00. There were no statistical significance between unfiltered and filtered sample results in CY00 as shown in Table 4-24.

Table 4-21. Summary of Monitoring Wells above 50 NTU in CY00

Site	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Comments
SLAPS	B53W14S MW-33-98 MW-34-98 PW36	B53W6D B53W19S M10-8S	B53W04D B53W06D B53W14S B53W19S B10-15S PW35 PW36 PW42	B53W14S PW35	NOTE: Negative turbidity was recorded at least once in all quarters except the first quarter.
HISS	HISS-09 HISS-10	None	HISS-16 HISS-18	None	NOTE: Negative turbidity was recorded at least once in all quarters
SLDS	B16W5S B16W09D B16W10S DW14 DW15	B16W04S B16W07D B16W07S B16W08S B16W09D B16W10S B16W11S DW15 DW16 DW17 DW18 DW19 DW21	B16W05D B16W05S B16W11S DW14	None	NOTE: Negative turbidity was recorded at least once in all quarters

Table 4-22. SLAPS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration[1]	Number of Detects	Detects			Mean Concentration[1]	Number of Detects	
		Minimum	Maximum	Average			Minimum	Maximum	Average			
Aluminum	µg/L				21.45	0	148	5400	2235	652	4	14
Antimony	µg/L				1.1	0				1.1	0	15
Arsenic	µg/L	3.7	235	58.7	51.0	13	1.4	233	51.1	44.4	13	15
Barium	µg/L	146	646	396	396	15	4.2	865	389.3	389.3	15	15
Beryllium	µg/L				0	0				0.3	0	15
Boron	µg/L	33.2	333	183.8	160.1	13	36.2	346	181.6	158.1	13	15
Cadmium	µg/L	0.4	0.4	0.4	0.44	1	0.31	0.36	0.34	0.45	2	15
Calcium	µg/L	61200	734000	155233	155233	15	6.4	701000	146654	146654	15	15
Chromium	µg/L	5.4	20	12.7	2.4	2	2.7	26	13.9	3.6	3	15
Cobalt	µg/L	1.1	10.4	4.6	2.0	4	1.2	6.8	4.5	1.8	3	15
Copper	µg/L	3.4	3.4	3.4	2.3	1	2.4	10.7	6.5	2.9	2	15
Iron	µg/L	0.6	18600	8483.0	7877.4	13	4.6	21900	10701	9937	13	14
Lead	µg/L				0.9	0	3.6	3.6	3.6	1.1	1	15
Lithium	µg/L	63.8	63.8	63.8	8.3	1	15.1	77	46.1	10.2	2	14
Magnesium	µg/L	13.3	362000	63547.6	63547.6	15	13.3	346000	62674	62674	15	15
Manganese	µg/L	7.4	1770	456.0	456.0	15	18.7	1800	602.7	602.7	15	15
Mercury	µg/L				0.1	0				0.05	0	15
Molybdenum	µg/L	6.5	16.2	11.1	3.7	4	6.6	12.8	8.95	3.09	4	15
Nickel	µg/L	174	174	174	16.2	1	17.5	151	67.2	17.2	3	15
Potassium	µg/L	7.4	38500	13032.9	5723.2	6	1610	34400	10321	5918	8	15
Radium-226	pCi/L	2.64	5.18	3.91	1.94	2	8.62	8.62	8.62	2.15	1	11
Selenium	µg/L	2.6	738	389.9	78.8	3	2.7	751	394.2	79.7	3	15
Silver	µg/L				1.2	0				1.2	0	15
Sodium	µg/L	19500	422000	83093	83093	15	6.9	420000	82647	82647	15	15
Strontium	µg/L	294	2980	907.8	907.8	15	2.4	2980	875.0	875.0	15	15
Thallium	µg/L				1.42	0				1.4	0	15
Thorium-228	pCi/L	0.21	0.69	0.45	0.78	2	0.49	1.3	0.76	0.81	3	10
Thorium-230	pCi/L	0.41	1.14	0.8	0.67	3	0.25	2	1.17	0.87	5	11
Thorium-232	pCi/L				0.5	0				0.5	0	11
Uranium	µg/L				42.28	0				42.28	0	15
Uranium-234	pCi/L	10.08	22.92	16.50	3.78	2	3.39	16.41	9.9	2.42	2	10
Uranium-235	pCi/L				0.68	0	1.91	1.91	1.91	0.65	1	11
Uranium-238	pCi/L	2.41	17.26	9.52	2.99	3	1.88	15.17	6.54	2.06	3	11
Vanadium	µg/L	9.6	9.6	9.6	2.0	1	1.5	17.8	7.8	4.1	6	15
Zinc	µg/L	4.9	70.3	20.24	7.7	5	12.3	69.5	37.3	13.3	5	15

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of Detection Limit were substituted for non-detect values

Table 4-23. HISS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration[1]	Number of Detects	Detects			Mean Concentration[1]	Number of Detects	
		Minimum	Maximum	Average			Minimum	Maximum	Average			
Aluminum	µg/L				20.81	0	576	617	596.5	249.9	2	5
Antimony	µg/L				1.22	0				1.22	0	5
Arsenic	µg/L	1.5	1.5	1.5	1.02	1	1.5	3.3	2.4	1.54	2	5
Barium	µg/L	113	407	208.8	208.8	5	112	421	213.4	213.4	5	5
Beryllium	µg/L				0.32	0				0.32	0	5
Boron	µg/L	271	271	271	70.6	1	284	284	284	73.85	1	4
Cadmium	µg/L				0.75	0				0.75	0	5
Calcium	µg/L	47400	121000	88820	88820	5	48100	123000	89560	89560	5	5
Chromium	µg/L				1.8	0	2.1	2.1	2.1	2.14	1	5
Cobalt	µg/L				0.49	0				0.49	0	5
Copper	µg/L				1.8	0				1.8	0	5
Iron	µg/L	15.8	7160	2561.9	1544.3	3	24.1	8410	2219.4	2219.4	5	5
Lead	µg/L				1.1	0	2	2	2	1.31	1	5
Lithium	µg/L				4	0				4	0	5
Magnesium	µg/L	12200	59400	41780	41780	5	12000	59900	41960	41960	5	5
Manganese	µg/L	41.9	514	242.0	145.5	3	9.4	563	176.2	176.2	5	5
Mercury	µg/L				0.05	0				0.05	0	5
Molybdenum	µg/L	2.6	14.5	7.3	4.6	3	2.6	14.8	7.37	4.64	3	5
Nickel	µg/L	5.1	5.1	5.1	3.88	1	6.4	13.7	10.1	5.5	2	5
Potassium	µg/L	1560	33400	17480	7492	2	31800	31800	31800	7010	1	5
Radium-226	pCi/L	4.87	4.87	4.87	2.11	1				1.20	0	4
Selenium	µg/L	10.9	10.9	10.9	3	1	10.2	10.2	10.2	2.86	1	5
Silver	µg/L	1.3	1.3	1.3	0.74	1				0.61	0	5
Sodium	µg/L	20300	80300	40120	40120	5	20500	81600	40100	40100	5	5
Strontium	µg/L	277	1190	571.6	571.6	5	278	1120	561	561	5	5
Thallium	µg/L				1.6	0				1.6	0	5
Thorium-228	pCi/L	1.41	1.95	1.68	1.24	2	1.25	3.35	2.3	1.58	2	4
Thorium-230	pCi/L	-0.12	4.49	1.82	1.82	4	1.49	6.78	3.21	3.21	4	4
Thorium-232	pCi/L				0.4	0				0.5	0	3
Uranium	µg/L				36.7	0				36.7	0	5
Uranium-234	pCi/L	1.19	2.81	2	1.44	2	1.14	2.14	1.7	1.7	3	3
Uranium-235	pCi/L				0.4	0				0.4	0	4
Uranium-238	pCi/L	2.17	2.56	2.36	1.82	2	1.22	1.22	1.22	0.75	1	3
Vanadium	µg/L				1.71	0	7.9	7.9	7.9	2.6	1	5
Zinc	µg/L	5.9	7.4	6.47	4.37	3	3.4	27.2	10.94	10.94	5	5

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of Detection Limit were substituted for non-detect values

Table 4-24. SLDS Filtered and Unfiltered Comparison

Chemical	Units	Filtered					Unfiltered					Total Samples
		Detects			Mean Concentration[1]	Number of Detects	Detects			Mean Concentration[1]	Number of Detects	
		Minimum	Maximum	Average			Minimum	Maximum	Average			
Aluminum	µg/L				10.9	0				10.9	0	1
Antimony	µg/L				19.6	0				19.6	0	1
Arsenic	µg/L	6.2	173	37.2	35.1	16	6.1	176	38.1	35.9	16	17
Barium	µg/L	57.2	57.2	57.2	57.2	1	58.3	58.3	58.3	58.3	1	1
Beryllium	µg/L				0.3	0				0.3	0	1
Boron	µg/L	2820	2820	2820	2820	1	2810	2810	2810	2810	1	1
Cadmium	µg/L				0.3	0	1	1	1	0.4	1	17
Calcium	µg/L	376000	376000	376000	376000	1	377000	377000	377000	377000	1	1
Chromium	µg/L				3.8	0				3.8	0	1
Cobalt	µg/L				2.3	0				2.3	0	1
Copper	µg/L				3.2	0				3.2	0	1
Iron	µg/L	34800	34800	34800	34800	1	35500	35500	35500	35500	1	1
Lead	µg/L				0.9	0				0.9	0	1
Lithium	µg/L	78.2	78.2	78.2	78.2	1	74.6	74.6	74.6	74.6	1	1
Magnesium	µg/L	89800	89800	89800	89800	1	89000	89000	89000	89000	1	1
Manganese	µg/L	2810	2810	2810	2810	1	2800	2800	2800	2800	1	1
Mercury	µg/L				0.05	0	0.12	0.12	0.12	0.12	1	1
Molybdenum	µg/L				5.4	0				5.4	0	1
Nickel	µg/L				6.7	0				6.7	0	1
Potassium	µg/L	18700	18700	18700	18700	1	19500	19500	19500	19500	1	1
Radium-226	pCi/L	4.87	8.13	6.50	2.24	2	2.2	6.11	4.16	1.91	2	17
Selenium	µg/L				1.2	0				1.2	0	1
Silver	µg/L				0.7	0				0.7	0	1
Sodium	µg/L	199000	199000	199000	199000	1	198000	198000	198000	198000	1	1
Strontium	µg/L	2420	2420	2420	2420	1	2410	2410	2410	2410	1	1
Thallium	µg/L				1.7	0				1.7	0	1
Thorium-228	pCi/L	1.43	1.43	1.43	0.78	1				0.76	0	17
Thorium-230	pCi/L	1.07	4.33	2	1.21	7	0.7	2.52	1.61	0.90	6	16
Thorium-232	pCi/L				0.4	0				0.4	0	17
Uranium	µg/L				75.6	0				75.6	0	1
Uranium-234	pCi/L	14.24	27.91	21.08	2.92	2	1.36	23.32	10.34	3.38	5	17
Uranium-235	pCi/L	2.46	2.46	2.46	0.60	1	1.49	1.49	1.49	0.52	1	17
Uranium-238	pCi/L	10.99	33.19	22.09	3.05	2	2.48	20.5	9.67	3.08	5	17
Vanadium	µg/L	24.2	24.2	24.2	24.2	1	21.3	21.3	21.3	21.3	1	1
Zinc	µg/L	7.2	7.2	7.2	7.2	1	6.8	6.8	6.8	6.8	1	1

1. Mean Concentration: Calculated using all data, but values equal to 1/2 of Detection Limit were substituted for non-detect values

4.5 NEW MONITORING WELLS

Five new ground-water monitoring wells were installed at SLAPS during July and August CY00. These monitoring wells are identified as PW39, PW40, PW41, PW42, and PW43. Monitoring wells PW39 and PW40 represent a nested pair, approximately 5 ft apart, located on the western part of SLAPS, just east of the Sediment Basin. These two wells were installed to provide chemical and radiological data for HZ-A ground water in an area located along the outside (cutting) edge of a former Coldwater Creek meander. (The former stream meander is visible in historical aerial photos of the site as a dark semicircular area.) PW39 and PW40 are intended to monitor ground-water within the center of the meander zone and at the top of the meander zone, respectively. Monitoring well PW41 is located at the southern edge of the parking lot of SLAPS, just outside of the northeast edge of Holding Tank 1. The placement of PW41 allows continuous monitoring, as the parking lot is outside areas where future construction or remediation activities would require well abandonment. Monitoring wells PW42 and PW43 are located across McDonnell Boulevard from SLAPS in the ballfield area along the southern rim of Coldwater Creek. PW42 and PW43 provide ground-water monitoring data for HZ-C and HZ-A, respectively, in an area where ground-water data is needed (i.e., west of monitoring wells B53W07S and B53W07D and adjacent to Coldwater Creek) to help define contaminant migration pathways and ground-water/surface water interactions. The locations for these new ground-water monitoring wells are shown on Figure 4-4.

Three new ground-water monitoring wells were installed at HISS during August CY00. These wells are identified as HW21, HW22, and HW23. Monitoring well HW21, is located on the eastern berm of the drainage ditch, just east of the railroad spur. HW21 was installed west of the East Piles to monitor potential impacts to HZ-A ground water resulting from ongoing remedial actions. Monitoring wells HW22 and HW23 represent a nested pair, approximately 5 ft apart, located just outside of the southern boundary of HISS proper. HW22 and HW23 are intended to monitor HZ-A and HZ-C ground-water respectively, upgradient of HISS. The locations for these new ground-water monitoring wells are shown on Figure 4-5.

One new ground-water monitoring well was installed at SLDS in August of CY00. This well, located at the eastern edge of a Mallinckrodt employee parking lot, was intended to serve as upgradient monitoring well for SLDS. The well did not encounter a sand unit of HU-B and will be decommissioned. This location provided exploration data, but is not worthy of well development and sampling for HU-B.

4.5.1 Objectives

Eight new ground-water monitoring wells at SLAPS and HISS during CY00 were installed to: provide potentiometric data of specific HZs; determine background chemistry parameters; further define subsurface geologic conditions; confirm the impacts of radionuclide, organic, and inorganic constituents to selected ground-water HZs; and, replace selected decommissioned wells for compliance monitoring. A summary of the well installation methods, geologic conditions, and the results of associated soil sampling are provided below.

4.5.2 Method of Monitoring Well Installation and Soil Sampling

The installation of ground-water monitoring wells at HISS, SLAPS, and SLDS was completed in accordance with the protocol and specifications of the SLAPS *Sampling and Analysis Guide for the St. Louis Sites* (SAG) (USACE, 1998h). The Monitor Well Design, Installation, and Documentation Manual (USACE, 1994a) provides the basic elements for consideration for monitoring well work such as drilling operations, borehole logging, well installation, and other elements. Requirements of the MDNR regarding well drilling, installation, and construction (10 CSR 23) were followed as applicable for the installation of monitoring wells at SLAPS. A Missouri licensed driller and well installer completed each of the wells. The soil/rock cutting and fluids produced by the drilling and installation of new wells were managed as investigation derived wastes (IDW) as outlined in the SAG. A well construction log was prepared for each of the monitoring wells. The drilling and well installation logs for these monitoring wells are provided in Appendix D.

The monitoring wells, PW39, PW40, and PW41 were installed and soil samples were collected for inspection and analysis using a CME 75 auger rig equipped with a 5-ft CME sampler. Monitoring wells PW42, PW43, HW21, HW22, and HW23 were installed and soil samples were collected using a mobile B-59 auger rig equipped with a 5-ft continuous sampler. All sampling equipment that contacted the soil during collection activities was decontaminated between sample collection points. Decontamination procedures for drilling and sampling equipment are presented in the *Site Safety and Health Plan* (SSHP) (USACE, 2000c).

Retrieved soil and geologic material were screened in the field for the relative concentration of total VOCs and total radioactivity. An organic vapor analyzer (OVA) equipped with a photoionization detector (PID) was used to screen the soil for the presence of VOCs. Each soil sample was also screened with an alpha and a beta-gamma (total radioactivity) detector prior to sample handling. Calibration procedures for this equipment are presented in the *Quality Assurance Project Plan* (QAPP) (SAIC, 1998).

Sampling protocols included the acquisition of continuous split-spoon samples of the nonlithified sediments to total depth. Soil samples were collected and lithologically described for all of the monitoring wells. A soil sample was also collected at the screened interval for each of the monitoring wells installed.

Each completed monitoring well was constructed using 2-inch diameter polyvinyl chloride (PVC) screen and riser pipe. The wells were installed in a minimum 6-inch diameter borehole made by hollow-stem augering methods. The screened intervals were packed with appropriate-size sand by use of a tremie pipe. A minimum 3 ft bentonite seal was placed above the sand pack. Bentonite pellets were used to form the seal below the water table. A cement/bentonite grout was generally placed from the bentonite seal to surface, and a side-discharging tremie pipe was used for grout placement. A protective steel riser with a locking cap was installed on each of the completed monitoring wells at HISS and SLAPS. The well construction materials and details are also shown in Appendix D.

4.5.3 Results of Soil Analysis

A total of thirteen soil samples were collected during installation of the eight monitoring wells. The samples were submitted for analysis of radiological parameters, including iso-thorium (Th-228, Th-230 and Th-232) analysis by alpha spectroscopy and a gamma spectroscopy scan for radionuclides [including Ac-227, americium-241 (Am-241), cesium-137 (Cs-137), K-40, Pa-231, Ra-226, Ra-228, U-235 and U-238]. Analyses were conducted by the on-site USACE radiological laboratory. The analytical data from this sampling was validated in accordance with the QAPP (SAIC, 1998).

Monitoring well PW39 was installed into Unit HZ-A and was screened from 19.41 to 23.87 ft below ground surface. One sample was collected within the screened interval (20 to 22.5 ft), at location PW39 during installation. PW40 was installed into Unit HZ-A (silty clay) with a screened interval from 7.04 to 11.54 ft below ground surface. One sample was collected from this location, PW40, during installation, within the screened interval at 10 to 12 ft. PW41 was installed into Unit HZ-A (clayey soil), and was screened from 12.19 to 21.66 ft below ground surface. One sample was collected from location PW41 during installation at 15 to 17.5 ft below ground surface.

Monitoring well PW42 was installed with a sand pack and screened from 83 to 85 ft below ground surface into a silty clay gravel zone, Unit HZ-C. Two samples were collected from PW42 during installation, one from 0 to 3.4 ft, and one within the screened interval at 83 to 85 ft below ground surface. PW43 was installed into clayey silt loess, Unit HZ-A, with a screened interval from 15.33 to 24.5 ft below ground surface. Two samples were collected from PW43 during installation, one at 0 to 3 ft and one within the screened interval at 20 to 25 ft below ground surface.

Monitoring well HW21 was installed into silty clay loess (HZ-A) and was screened from 19.98 to 24.37 ft below ground surface. Two samples were collected from location HW21, one at 0 to 5 ft and one within the screened interval at 20 to 25 ft below ground surface. HW22 was installed into silty clay loess (HZ-A), and was screened from 19.29 to 28.74 ft below ground surface. Two samples were collected from location HW22, one at 0 to 4.1 ft, and one within the screened interval at 25 to 27 ft below ground surface. HW23 was installed with a sand pack and screened from 91.5 to 93.5 ft below ground surface, into a silty sand (HZ-C). Two samples were collected from location HW23, one at 0 to 5 ft, and one within the screened interval at 91.5 to 93.5 ft below ground surface.

Soil screening results are shown on the well installation logs (see Appendix D). The results of this screening showed no elevated areas of VOCs, based on the OVA/PID readings taken in the field. Results of the radioactivity screening indicated that the materials removed from each of the boreholes were within normal background levels.

A statistical summary of the radionuclide analyses for soil samples collected from the five new SLAPS monitoring wells (PW39 through PW43) is provided in Table 4-25. These results were compared to applicable background values (USACE, 2000a). No analytes were detected at levels exceeding background criteria at SLAPS.

Table 4-25. Comparison of New Well Soil Sampling Results to Background Criteria at SLAPS

Media	Chemical	Units	Detection Frequency	Detects			Mean[1] Conc.	Background Criteria[2]	Number > Background
				Minimum	Maximum	Mean			
Soil < 5 ft bgs	Actinium-227	pCi/g	0 / 2				0.10	0.82	0
	Americium-241	pCi/g	0 / 2				0.06	0	0
	Cesium-137	pCi/g	0 / 2				0.02	0.57	0
	Potassium-40	pCi/g	2 / 2	15.47	16.74	16.11	16.11	16.8	0
	Protactinium-231	pCi/g	0 / 2				0.44	1.13	0
	Radium-226	pCi/g	2 / 2	0.67	0.79	0.73	0.73	1.55	0
	Radium-228	pCi/g	2 / 2	0.91	0.94	0.93	0.93	1.24	0
	Thorium-228	pCi/g	4 / 4	0.91	1.27	1.09	1.09	2.04	0
	Thorium-230	pCi/g	2 / 4	1.92	2.13	2.03	3.38	2.89	0
	Thorium-232	pCi/g	4 / 4	0.91	1.19	1.00	1.00	1.83	0
	Uranium-235	pCi/g	0 / 2				0.09	0.25	0
	Uranium-238	pCi/g	0 / 2				2.07	2.02	0
Soil > 5 ft bgs	Actinium-227	pCi/g	0 / 5				0.07	0.82	0
	Americium-241	pCi/g	0 / 5				0.03	0	0
	Cesium-137	pCi/g	0 / 5				0.01	0.57	0
	Potassium-40	pCi/g	5 / 5	11.89	15.03	13.69	13.69	16.8	0
	Protactinium-231	pCi/g	0 / 5				0.30	1.13	0
	Radium-226	pCi/g	5 / 5	0.63	0.93	0.72	0.72	1.55	0
	Radium-228	pCi/g	5 / 5	0.76	0.88	0.82	0.82	1.24	0
	Thorium-228	pCi/g	10 / 10	0.76	1.51	1.04	1.04	2.04	0
	Thorium-230	pCi/g	5 / 10	1.34	1.93	1.63	2.28	2.89	0
	Thorium-232	pCi/g	10 / 10	0.76	1.37	0.95	0.95	1.83	0
	Uranium-235	pCi/g	0 / 5				0.07	0.25	0
	Uranium-238	pCi/g	0 / 5				1.51	2.02	0

[1] Mean concentration calculated using all data, but substituting a value = 1/2 detection limit for all nondetect results.
[2] North County Feasibility Study Subsurface Soil Background Concentrations

A summary of the soil sampling results for the three new HISS monitoring wells (HW21, HW22, and HW23) is provided in Table 4-26. A comparison of the results to subsurface soil background criteria established in the North County Feasibility Study indicates that six radionuclides (Ra-226, Th-230, U-235, U-238, Ac-227 and Pa-231) exceed background criteria. Thorium-230 was found above its subsurface soil background value of 2.89 pCi/g in eight soil samples, six of these from shallow (<5 ft below ground surface) samples. The highest levels were detected in the 0 to 5 ft below ground surface samples from HW21 (maximum 169.9 pCi/g) and HW23 (maximum 30.62 pCi/g). Lower levels (maximum 6.07 pCi/g) were detected in the 0 to 4.1 ft below ground surface sample from HW22. Thorium-230 also exceeded the subsurface soil background concentrations in two deeper samples (20 to 25 ft below ground surface) collected from HW21. The maximum detected value, 12.68 pCi/g, exceeds background but is below the proposed Th-230 remediation goal of 15 pCi/g presented in the North County Feasibility Study (USACE, 2000a). Radium-226 was detected above its background level of 1.55 pCi/g in two samples. The maximum concentration, 3.32 pCi/g, was detected in the 0-5 ft sample from HW21. The second Ra-226 result exceeding background, 3.22 pCi/g, was detected in the 0-5 ft sample from HW23. Uranium-235 and U-238 were detected above their background levels of 0.25 pCi/g and 3.08 pCi/g, respectively, in shallow samples from HW21 and HW23. The maximum concentrations, 1.08 pCi/g U-235 and 5.68 pCi/g U-238, were detected in the 0-5 ft sample from HW21. Uranium-235 also exceeded background levels in the 0-5 ft sample from HW23, with a concentration of 0.3 pCi/g. Actinium-227 (1.24 pCi/g) and Pa-231 (1.52 pCi/g) were detected in the shallow (0 to 5 ft below ground surface) soil sample from HW21 at a concentrations slightly exceeding their background levels (0.82 pCi/g and 1.13 pCi/g, respectively). No other analytes exceeded background criteria in the new well soil sampling at HISS.

A comparison of the new well soil sampling results to the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) background criteria developed for subsurface soils is presented in Table 4-27. An analysis of the calculated sum of ratios (SOR) (based on a 5/15/50 investigative limits for Ra-226, Th-230, and U-238, respectively) indicates that some of the soil samples collected from the new monitoring well locations exhibited above background values of SOR. In particular, the shallow (< 5 ft below ground surface) samples from all three new HISS wells (HW21, HW22, and HW23) and the 20 to 25 ft samples from HW21 exceeded the mean MARSSIM subsurface background criterion of 0.22. None of the calculated SOR values from samples collected at the five new SLAPS wells were above the mean MARSSIM subsurface background criterion.

Two soil samples were collected during installation of the new ground-water monitoring well at SLDS. One sample was collected at a depth of 0 to 5 ft and the other was collected within the screened interval at 35 to 40 ft below ground surface. The samples were submitted for radiological analysis, including Th-228, Th-230 and Th-232 analysis by alpha spectroscopy and a gamma spectroscopy scan for the radionuclides Ac-227, Am-241, Cs-137, K-40, Pa-231, Ra-226, Ra-228, U-235 and U-238. The results of the sampling are provided in Table 4-28. A comparison of the data to the results of the SLDS background soil study conducted in CY98 indicate concentrations of radionuclides present in these two samples are generally within the range of expected background concentrations.

Table 4-26. Comparison of New Well Soil Sampling Results to Background Criteria at HISS

Media	Chemical	Units	Detection Frequency	Detects			Mean[1] Conc.	Background Criteria[2]	Number > Background
				Minimum	Maximum	Mean			
Soil < 5 ft bgs	Actinium-227	pCi/g	2 / 3	0.56	1.24	0.90	0.63	0.82	1
	Americium-241	pCi/g	0 / 3				0.03	0	0
	Cesium-137	pCi/g	0 / 3				0.02	0.57	0
	Potassium-40	pCi/g	3 / 3	14.87	16.01	15.50	15.50	16.8	0
	Protactinium-231	pCi/g	1 / 3	1.52	1.52	1.52	0.77	1.13	1
	Radium-226	pCi/g	3 / 3	1.05	3.32	2.53	2.53	1.55	2
	Radium-228	pCi/g	3 / 3	0.88	1.05	0.95	0.95	1.24	0
	Thorium-228	pCi/g	6 / 6	0.88	1.4	1.14	1.14	2.04	0
	Thorium-230	pCi/g	6 / 6	5.55	169.9	54.56	54.56	2.89	6
	Thorium-232	pCi/g	6 / 6	0.81	1.43	1.04	1.04	1.83	0
	Uranium-235	pCi/g	2 / 3	0.3	1.08	0.69	0.49	0.25	2
	Uranium-238	pCi/g	1 / 3	5.68	5.68	5.68	3.08	2.02	1
Soil > 5 ft bgs	Actinium-227	pCi/g	0 / 3				0.08	0.82	0
	Americium-241	pCi/g	0 / 3				0.02	0	0
	Cesium-137	pCi/g	0 / 3				0.01	0.57	0
	Potassium-40	pCi/g	3 / 3	10.97	13.48	12.04	12.04	16.8	0
	Protactinium-231	pCi/g	0 / 3				0.34	1.13	0
	Radium-226	pCi/g	3 / 3	0.76	0.91	0.86	0.86	1.55	0
	Radium-228	pCi/g	3 / 3	0.78	0.96	0.89	0.89	1.24	0
	Thorium-228	pCi/g	6 / 6	0.78	1.36	1.07	1.07	2.04	0
	Thorium-230	pCi/g	4 / 6	1.21	12.68	5.44	4.38	2.89	2
	Thorium-232	pCi/g	6 / 6	0.78	1.2	0.97	0.97	1.83	0
	Uranium-235	pCi/g	0 / 3				0.07	0.25	0
	Uranium-238	pCi/g	0 / 3				1.53	2.02	0

[1] Mean concentration calculated using all data, but substituting a value = 1/2 detection limit for all nondetect results.
[2] North County Feasibility Study Subsurface Soil Background Concentrations (USACE, 2000a).

Table 4-27. Comparison of New Well Soil Sampling with MARSSIM Subsurface Background Criteria at SLAPS and HISS

Site	Station	Sampling ID	Sampling Depth (ft)	Sampling Date	Ra-226 (pCi/g)	Ra-228 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-238[1] (pCi/g)	SOR[2] (15/15/50)
HISS	HW21	HIS00772	0 - 5	8/10/00	3.32	1.05	169.9	1.43	5.68	**11.29**
		HIS00773	20 - 25	8/10/00	0.91	0.93	12.68	0.8	*2.71*	**0.74**
	HW22	HIS00774	0 - 4.1	8/9/00	1.05	0.92	5.55	0.81	*3.32*	**0.28**
		HIS00775	25 - 27	8/9/00	0.76	0.96	1.21	1.15	*3.05*	0.03
	HW23	HIS00777	0 - 5	8/3/00	3.22	0.88	30.62	1.14	*3.82*	**1.96**
		HIS00776	91.5 - 93.5	8/7/00	0.9	0.78	1.67	1.2	*3.4*	0.04
SLAPS	PW39	SLA06665	20 -22.5	7/5/00	0.64	0.76	1.34	1.04	*2.44*	0.02
	PW40	SLA06667	10 - 12	7/10/00	0.77	0.86	1.93	1.02	*2.73*	0.03
	PW41	SLA06669	15 - 17.5	7/7/00	0.65	0.82	1.69	1	*2.75*	0.03
	PW42	SLA06671	0 - 3.4	8/15/00	0.79	0.94	2.13	0.96	*4.28*	0.07
		SLA06670	83 - 85	8/16/00	0.93	0.79	1.82	1.37	*3.62*	0.05
	PW43	SLA06672	0 - 3	8/21/00	0.67	0.91	1.92	1.19	*4*	0.05
		SLA06673	20 -25	8/21/00	0.63	0.88	1.36	0.91	*3.52*	0.04

[1] Where numbers are shown in italics, detection limits have been substituted for values reported as less than the detection limit.

[2] SOR values in bold represent calculated sample results exceeding the mean background value for North County MARSSIM subsurface soils.

Table 4-28. Comparison of New Well Soil Sampling Results to Background Criteria at SLDS

Sampling Depth	Analyte Type[1]	Analyte	Results	Qualifier[2]	Error	Background Criteria[3]
0-5 ft	RGAMM	Actinium-227	0.06	U	0.09	0.18
	RGAMM	Americium-241	0.02	U	0.04	
	RGAMM	Cesium-137	0.07		0.02	0.00
	RGAMM	Potassium-40	5.77		0.7	15.3
	RGAMM	Protactinium-231	0	U	0.4	1.12
	RGAMM	Radium-226	1.66		0.1	1.35
	RGAMM	Radium-228	0.41		0.05	1.00
	RALPHA	Thorium-228	0.66	J	0.4	1.26
	RGAMM		0.41		0.05	1.00
	RALPHA	Thorium-230	2.82		0.91	2.18
	RGAMM		-0.62	U	2.78	
	RALPHA	Thorium-232	0.78	J	0.44	1.18
	RGAMM		0.41		0.05	1.00
	RGAMM	Uranium-235	0.19	U	0.15	0.1
	RGAMM	Uranium-238	1.9	U	0.47	1.67
35-40 ft	RGAMM	Actinium-227	0.07	U	0.09	0.18
	RGAMM	Americium-241	0	U	0.03	
	RGAMM	Cesium-137	0	U	0.01	0.00
	RGAMM	Potassium-40	15.2		1.52	15.3
	RGAMM	Protactinium-231	0.18	U	0.38	1.12
	RGAMM	Radium-226	0.64		0.05	1.35
	RGAMM	Radium-228	0.71		0.07	1.00
	RALPHA	Thorium-228	0.75	J	0.38	1.26
	RGAMM		0.71		0.07	1.00
	RALPHA	Thorium-230	1.15	J	0.46	2.18
	RGAMM		0.69	U	2.58	
	RALPHA	Thorium-232	0.74		0.36	1.18
	RGAMM		0.71		0.07	1.00
	RGAMM	Uranium-235	0.03	U	0.08	0.10
	RGAMM	Uranium-238	0.85	U	0.38	1.67

[1] RGAMM denotes Gamma Spec Analysis, RALPHA denotes Alpha Spec Analysis.

[2] U Qualifier indicates compound was analyzed for but not detected; J Qualifier denotes an estimated value.

[3] Background values are based on the 95%UCL values listed in the SLDS Background Soils Report (USACE, 1999d).

5.0 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM

5.1 PROGRAM OVERVIEW

The environmental quality assurance program includes management of the quality assurance and quality control programs, plans, and procedures governing environmental monitoring activities at the FUSRAP SLS and at subcontracted vendor laboratories. This section discusses the environmental monitoring standards at FUSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides FUSRAP with reliable, accurate, and precise monitoring data. The program furnished guidance and directives to detect and prevent quality problems from the time a sample was collected until the associated data were evaluated and utilized. Key elements in achieving the goals of this program are: compliance with the quality assurance program; personnel training; compliance assessments; use of quality control samples; documentation of field activities and laboratory analyses; and, a review of data documents for precision, accuracy, and completeness.

General objectives are as follows:

- To provide data of sufficient quality and quantity to support ongoing remedial efforts, aid in defining potential contaminants of concerns (PCOCs), meet the requirements of the Environmental Monitoring Guide (EMG), supplement the Feasibility Study (FS), and develop a ROD for the site.

- To provide data of sufficient quality to meet applicable State of Missouri and federal concerns (e.g., reporting requirements).

- To ensure samples were collected using approved techniques and are representative of existing site conditions.

5.2 QUALITY ASSURANCE PROGRAM PLAN (QAPP)

The QAPP for activities performed at SLS is described within Section 3.0 of the SAG for the SLS (USACE, 2000b). The QAPP provides the organization, objectives, functional activities and specific Quality Assurance (QA) and Quality Control (QC) activities associated with investigations and sampling activities at SLS.

QA/QC procedures are performed in accordance with applicable professional technical standards, EPA requirements, government regulations and guidelines, and specific project goals and requirements. The QAPP was prepared in accordance with EPA and USACE guidance documents, including *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA, 1991), *EPA Requirements for Quality Assurance Project Plans for*

Environmental Data Operations (EPA, 1994), and *Requirements for the Preparation of Sampling and Analysis Plans* (USACE, 1994b).

5.3 SAMPLING AND ANALYSIS GUIDE (SAG)

The SAG summarizes standard operating procedures (SOPs) and data quality requirements for collecting and analyzing environmental data. The SAG integrates protocols and methodologies, identified under various USACE and regulatory guidance, and describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. The structure for identified sampling/monitoring was delineated through programmatic documents such as the EMG for SLS (USACE, 1999a), which is an upper tier companion document to the SAG.

Flexibility to address non-periodic environmental sampling, such as boundary delineation for remedial design, verification sampling, or in-situ waste characterization was provided for in this integrated strategy by issuance of a Work Description (WD) and/or Final Status Surveys. Environmental monitoring data obtained through these upper and lower tier plans were typically reported to the EPA Region VII quarterly as required by the FFA.

5.4 FIELD SAMPLE COLLECTION AND MEASUREMENT

Prior to beginning field sampling, field personnel were trained, as necessary, and participated in a project-specific readiness review. These activities ensured that standard procedures were followed in sample collection and in completing field logbooks, chain-of-custody forms, labels, and custody seals. Documentation of training and readiness were submitted to the project file.

The master field investigation document are the site field logbooks. The primary purpose of these documents is to record each day's field activities; personnel on each sampling team; and any administrative occurrences, conditions, or activities that may have affected the fieldwork or data quality of any environmental samples for any given day. Guidance for documenting specific types of field sampling activities in field logbooks or log sheets is provided in Appendix C of EM-200-1-3 (USACE, 1994a).

At any point in the process of sample collection or data or document review, a non-conformance report (NCR) may be initiated if nonconformances are identified, and data entered into the database may be flagged accordingly.

5.5 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits of both field and laboratory activities were conducted to verify that sampling and analysis activities were performed in accordance with the procedures established in the SAG and activity-specific WD.

5.5.1 Field Assessments

Internal assessments (audit or surveillance) of field activities (sampling and measurements) were conducted by the QA/QC Officer (or designee). Assessments include an examination of field sampling records, field instrument operating records, sample collection, handling and packaging in compliance with the established procedures, maintenance of QA procedures, and chain-of-custody. These assessments occurred at the onset of the project to verify that all established procedures were followed (systems audit).

Performance assessments followed to ensure that deficiencies had been corrected and to verify that QA practices/procedures were being maintained throughout the duration of the project work effort. These assessments involved reviewing field measurement records, instrumentation calibration records, and sample documentation.

External audits may be conducted at the discretion of the USACE, EPA Region VII, or the State of Missouri.

5.5.2 Laboratory Audits

The USACE HTRW CX conducts on-site audits and validates laboratories on a regular basis. Every eighteen months, these USACE independent on-site systems audits, in conjunction with performance evaluation samples (performance audits), qualify laboratories to perform USACE environmental analyses.

These system audits include examining laboratory documentation of sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records. Performance audits consist of sending performance evaluation samples to USACE laboratories for ongoing assessment of laboratory precision and accuracy. The analytical results of the analysis of performance evaluation samples are evaluated by USACE HTRW CX to ensure that laboratories maintain acceptable performance.

Internal performance and system audits of laboratories were conducted by the Laboratory QA Manager as directed in the laboratory QA plan. These system audits included an examination of laboratory documentation of sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, and instrument operating records against the requirements of the laboratory's SOPs. Internal performance audits were also conducted on a regular basis. Single-blind performance samples were prepared and submitted along with project samples to the laboratory for analysis. The Laboratory QA Manager evaluated the analytical results of these single-blind performance samples to ensure that the laboratory maintained acceptable performance.

The contractor is not contracted to perform laboratory audits; however, additional audits of laboratories were planned and budgeted within specific USACE task scopes. These project-specific laboratory performance review audits were conducted by the contractor only at the direction of, and in conjunction with, the USACE.

External audits may be conducted in conjunction with, or at the direction of the EPA or the State of Missouri regulatory agency.

5.6 SUBCONTRACTED LABORATORY PROGRAMS

All samples collected during environmental monitoring activities were analyzed by USACE-approved laboratories and were reviewed and validated. QA samples were collected for ground water, soil, air, and direct radiation monitoring and were analyzed by the designated USACE QA laboratory. Each laboratory supporting this work maintained statements of qualifications including organizational structure, QA Manual, and SOPs.

Samples collected during these investigations were analyzed by EPA SW-846 methods and other documented EPA or nationally recognized methods. Laboratory SOPs are based on the methods as published by the EPA in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846*, Third Edition (EPA, 1993).

5.7 QA AND QC SAMPLES

These samples were analyzed for the purpose of assessing the quality of the sampling effort and the reported analytical data. QA and QC samples to be used are duplicates, equipment rinsate blanks, trip blanks, source-water blanks, and split samples.

5.7.1 Field Duplicate QC Samples

These samples were collected by the sampling team for analysis by the on-site laboratory or contract laboratory. The identity of duplicate QC samples is held blind to the analysts and the purpose of these samples is to provide activity-specific, field-originated information regarding the homogeneity of the sampled matrix and the consistency of the sampling effort. These samples were collected concurrently with the primary environmental samples and equally represent the medium at a given time and location. Duplicate samples were collected from each medium addressed by this project, and were submitted to the contractor laboratory for analysis.

5.7.2 USACE QA Split Samples

QA split samples for chemical analysis were collected by the sampling team and sent to a USACE QA laboratory for analysis to provide an independent assessment of contractor and subcontractor laboratory performance. QA split samples for radiological analysis were collected by the contractor and submitted to the USACE-approved radiological QA laboratory.

5.7.3 Trip Blank Samples

These samples consist of containers of organic-free reagent water that are kept with the field sample containers from the time they leave the laboratory until they are returned for analysis. The purpose of trip blanks is to determine whether samples are being contaminated from VOCs during transit or sample collection.

5.7.4 Equipment Rinsate Blanks

These samples were taken from the water rinsate collected from equipment decontamination activities. They are comprised of samples of analyte-free water, which have been rinsed over decontaminated sampling equipment, collected, and submitted for analysis of the parameters of interest. Equipment rinsate blanks were employed to assess the effectiveness of the decontamination process, the potential for cross contamination between sampling locations and incidental field contamination. No rinsate blanks are required for disposable or dedicated sampling equipment.

5.7.5 Source-water Blanks

A sample from the site water supply used for equipment decontamination, well development, and other activities was acquired and submitted for analysis with the primary samples. In addition, samples of on-site, analyte-free water sources were also submitted for analysis. For radon flux sampling, un-deployed carbon canisters were submitted for analysis with the exposed canisters. Generally, no more than one sample is needed for a sampling task.

5.8 DATA VERIFICATION AND VALIDATION

All data packages received from the analytical laboratory were reviewed, evaluated, and validated by data management personnel.

Data validation is the systematic process of ensuring that the precision and accuracy of the analytical data are adequate for their intended use. Validation was performed in accordance with EPA regional or National Functional Guidelines, or project-specific guidelines. General chemical data quality management guidance found in ER-1110-1-263 (USACE, 1998a) was also used when planning for chemical data management and evaluation. Additional details of data review, evaluation, and validation are provided in the FUSRAP Laboratory Data Management Process (SAIC, 1999). Data assessment guidance, to determine the usability of data from HTRW projects, was provided in EM-200-1-6 (USACE, 1997).

One hundred percent of the data generated from all analytical laboratories underwent independent data review and evaluation. Data review documents the possible effects on the data that result from various QC failures, it does not determine data usability, nor does it include assignment of data qualifier flags. Data evaluation uses the results of the data review to determine the usability of the data. Data evaluation summarizes the potential effects of QA/QC failures on the data, and the District Chemist or District Health Physicist assesses their impact on the attainment of the project-specific data quality objectives (DQOs) and contract compliance.

Consistent with the data quality requirements, as defined in the DQOs, greater than 10 percent of all project data was validated and qualified per the outcome of the review.

5.9 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPARABILITY AND COMPLETENESS

Precision was determined through the use of spike analyses conducted on duplicate pairs of environmental samples (matrix spike/matrix spike duplicate) or comparison of positive duplicate pair responses. The relative percent difference (RPD) between the two results was calculated and used as an indication of the precision of the analyses performed. Sample collection precision was measured in the laboratory by the analyses of field duplicates. With the exception of a few outliers, which were qualified accordingly, the overall precision for the CY00 environmental monitoring sampling activities was very good.

The fundamental QA objectives for precision and accuracy of laboratory analytical data are the QC acceptance criteria of the analytical protocols. Analytical accuracy is expressed as the percent recovery of an analyte that has been added to a blank sample or environmental sample at a known concentration before analysis. Accuracy was determined in the laboratory through the use of matrix spike analyses, laboratory control sample (LCS) analyses, and blank spike analyses. The percent recoveries for specific target analytes were calculated and used as an indication of the accuracy of the analyses performed.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that depends upon the proper design of the sampling program and proper laboratory protocol. Representativeness was satisfied through proper design of the sampling network, use of proper sampling techniques, following proper analytical procedures, and not exceeding holding times of the samples. Representativeness was determined by assessing the combined aspects of the QA program, QC measures, and data evaluations. The overall representativeness of the CY00 environmental monitoring sampling activities was good.

Comparability expresses the confidence with which one data set can be compared with another. The extent to which analytical data will be comparable depends upon the similarity of sampling and analytical methods as well as sample-to-sample and historical comparability. Standardized and consistent procedures used to obtain analytical data are expected to provide comparable results. These new analytical data, however, may not be directly comparable to existing data because of differences in QA objectives.

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under normal conditions. It is expected that laboratories will provide data meeting QC acceptance criteria for all samples tested. For the CY00 environmental monitoring sampling activities, the data completeness was 99.2 percent (FUSRAP DQO for completeness is 90 percent).

6.0 DOSE ASSESSMENT

This section evaluates the cumulative dose to a hypothetically impacted individual from exposure to radiological contaminants at the SLS. The regulatory dose limit for members of the public is 100 mrem/yr as stated in 10 CFR 20.1301. Compliance with the dose limit in §20.1301 can be demonstrated in one of the two following ways [§20.13.02(b)(1) and (2)]:

1. Demonstrating by measurement or calculation that the TEDE to the individual likely to receive the highest dose from SLS operations does not exceed the annual dose limit (i.e., 100 mrem/yr); or
2. Demonstrating that: (*i*) the annual average concentration of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to Part 20; and (*ii*) if an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 2 mrem/yr and 50 mrem/yr.

The SLS has elected to demonstrate compliance by calculation of the TEDE to a hypothetical individual likely to receive the highest dose from SLS operations (method 1 above). This section describes the methodology employed for this evaluation.

Dose calculations are presented for hypothetical maximally exposed individuals at SLAPS, SLDS, HISS, and Coldwater Creek. In addition, a dose calculation is presented for a transient receptor who frequently passes SLAPS on McDonnell Boulevard. The monitoring data used in the dose calculations are reported in respective environmental monitoring sections of this report.

Dose calculations related to airborne emissions as required by 40 CFR 61, Subpart I (*National Emission Standards for Emissions of Radionuclides Other Than Radon From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered By Subpart H)* are presented in Attachment 1, the NESHAPs Report.

Although the SLS has elected to demonstrate compliance as stated above, measurements of effluent water concentrations and dose from external sources are also taken at site boundaries (i.e., method 2 (*i*) above). The average annual concentration for contaminants of concern at the SLS (i.e., HISS, SLAPS, and SLDS) in water effluents are less than the values specified in Table 2 to Appendix B of Part 20 and doses at site boundaries from external sources are less than those specified in §20.1302(b)(2)(*ii*).

6.1 HIGHLIGHTS

- The TEDE from SLAPS to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 6.6 mrem/yr, estimated for an individual who works full time at a location approximately 160 m south of the SLAPS perimeter.

- The TEDE from HISS to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 2.7 mrem/yr, estimated for an individual who works full time at a location approximately 50 m east of the HISS perimeter.

- The TEDE from SLDS to the receptor from all complete/applicable pathways combined was less than 0.1 mrem/yr, estimated for an individual who works full-time at a location approximately 50 m southeast of the SLDS perimeter.

- The TEDE from Coldwater Creek to a hypothetical maximally exposed individual from all complete/applicable pathways combined was 0.2 mrem/yr, estimated for a youth spending time as a recreational user of Coldwater Creek.

- The TEDE from SLAPS to a hypothetical exposed transient receptor from all complete/applicable pathways combined was 2.5 mrem/yr.

6.2 PATHWAY ANALYSIS

Table 6-1 lists the six complete pathways for exposure from radiological contaminants evaluated by the St. Louis FUSRAP EMP. These pathways are used to identify data gaps in the EMP and to estimate potential radiological exposures from the site. Of the six complete pathways, four were applicable in CY00, and were thus incorporated into radiological dose estimates.

Table 6-1. Complete Radiological Exposure Pathways for SLS

Exposure Pathway	Pathway Description	Applicable to 1999 Dose Estimate				
		SLAPS	HISS	SLDS	Coldwater Creek	Transient
Liquid A	Ingestion of ground water from local wells down-gradient from the site.	N	N	N	N	N
Liquid B	Ingestion of fish inhabiting Coldwater Creek.	NC	NC	NC	N	N
Liquid C	Ingestion of surface water[1] and sediments.	NC	NC	NC	Y[2]	N
Airborne A	Inhalation of particulates dispersed through wind erosion and remedial action.	Y	Y	Y	NC	Y
Airborne B	Inhalation of Rn-222 and decay products emitted from contaminated soils/wastes.	Y	Y	Y	NC	Y
External	Direct gamma radiation from contaminated soils/wastes.	Y	Y	Y	N	Y

[1] Surface water includes stormwater run-off from SLS, MSD discharges, and the water in Coldwater Creek.

[2] The pathway is only applicable to a recreational receptor (youth) exposed to contaminants present in Coldwater Creek water and sediments. Data from SLS stormwater discharges and MSD discharges are not applicable to the hypothesized recreational receptor, therefore, that data is not evaluated in Section 6, "Dose Assessment".

NC Not a complete pathway for the respective site.
N not applicable
Y applicable

In developing specific elements of the St. Louis FUSRAP EMP, potential exposure pathways of the radioactive materials present on-site are reviewed to determine which pathways are complete. Evaluation of each exposure pathway is based on hypothesized sources, release mechanisms, types, probable environmental fates of contaminants, and the locations and activities of potential receptors. Pathways are then reviewed to determine whether a link exists between one or more radiological contaminant sources, or between one or more environmental transport processes, to an exposure point where human receptors are present. If it is determined that a link exists, the pathway is termed complete. Each complete pathway is reviewed to determine whether a potential for exposure was present during CY00. If this is the case, the pathway is termed applicable. Only applicable pathways are considered in estimates of dose.

Table 6-1 shows the pathways that are not applicable to the CY00 dose estimates for SLS and Coldwater Creek. The pathways that are not complete were not considered in the dose assessment and are only listed in Table 6-1 because they were complete for at least one receptor location. The pathways listed as not applicable were not applicable in CY00 for the following reasons:

- Liquid A is not applicable because the aquifer is considered to be of naturally low quality and it is not known to be used for any domestic purpose in the vicinity of the St. Louis FUSRAP Sites (ANL, 1992).

- Liquid B is not applicable at Coldwater Creek or for the SLAPS transient receptor because it is unlikely that a game fish would be caught and eaten by the receptor. A survey was conducted and 97 percent of the fish collected at Coldwater Creek during the survey (Parker and Szlemp, 1987) were fathead minnows.

- The dose equivalent from Coldwater Creek to the receptor from contaminants in the water/sediment was estimated by using the Microshield Version 5.03 computer-modeling program. The scenario used was a youth playing in the creek bed (1 ft of water shielding and dry) for 52 hours per year. The highest estimated whole body dose to the youth was 0.3 microrem per year (μrem/yr). Therefore, the external gamma pathway (from contaminants in the creek water/sediment) is not applicable for the Coldwater Creek receptor because the gamma dose rate emitting from the contaminants is indistinguishable from background gamma radiation.

The applicable radiological public dose limits for the SLS are as follows:

- NESHAPs limit of 10 millirem (mrem) effective dose equivalent annually due to airborne emissions other than Rn-222 at off-site receptor locations.

- Nuclear Regulatory Commission (NRC) limit of 100 mrem TEDE for all exposure pathways on an annual basis (excluding background).

6.3 EXPOSURE SCENARIOS

Dose calculations were performed for maximally exposed individuals at critical receptor locations for applicable exposure pathways (see Table 6-1) to assess dose due to radiological releases from the SLS. First, conditions were set to determine the TEDE to a maximally exposed individual at each of the main site locations (SLAPS, SLDS, and HISS). A second dose equivalent for Coldwater Creek was calculated. A third set of dose equivalent calculations were performed to meet NESHAPs requirements (Attachment 1).

The scenarios and models used to evaluate these radiological exposures are conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual using the methods prescribed here. Dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable but conservative scenario. This method is acceptable when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case for the St. Louis FUSRAP. The UCL-95 concentrations (i.e., 95 percent upper confidence limit of the mean value of the data) of each radionuclide for the corresponding media was used in the calculations as would be required for CERCLA risk determinations. This methodology provides for reasonable potential exposure to the public and maintains a conservative approach. The scenarios and resulting estimated doses are outlined in Section 6.4.

All ingestion calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 and 30 for a fifty-year committed effective dose equivalent (CEDE). Fifty-year CEDE conversion factors were obtained from the EPA *Federal Guidance Report No. 11* (EPA, 1989d).

6.4 DOSE EQUIVALENT ESTIMATES EXPOSURE SCENARIOS

Dose equivalent estimates for the exposure scenarios were calculated using CY00 monitoring data. Calculations for dose scenarios are provided in Appendix E. Dose equivalent estimates are well below the standards set by the NRC for annual public exposure and EPA NESHAPs limits.

The CY00 TEDEs for hypothetical maximally exposed individuals near the SLAPS, HISS, SLDS, and Coldwater Creek are 6.6 mrem/yr, 2.7 mrem/yr, < 0.1 mrem/yr, and 0.2 mrem/yr, respectively. In comparison, the annual average exposure to natural background radiation in the United States results in a TEDE of approximately 300 mrem (BEIR V, 1990). Assumptions are detailed in the following sections.

6.4.1 Radiation Dose Equivalent from SLAPS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of SLAPS and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence

time that is less than 100 percent. A full time employee business receptor was considered to be the maximally exposed individual from SLAPS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was calculated using air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to calculate dose to the receptor (SAIC, 2001b).

- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the perimeter between the source and the receptor. The site is assumed to represent a line-source to the receptor.

- Exposure from external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 160 m south of the SLAPS perimeter. Exposure time is 2,000 hours per year (SAIC, 2001b).

- Exposure from Rn-222 (and progeny) was calculated using Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor and then running the CAP-88 PC modeling code to calculate dose to the receptor (SAIC, 2001b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor facility 160 m from the SLAPS perimeter received 6.4 mrem/yr from airborne radioactive particulates, 0.1 mrem/yr from external gamma, and 0.1 mrem/yr from Rn-222 for a TEDE of 6.6 mrem/yr (SAIC, 2001b).

6.4.2 Radiation Dose Equivalent from HISS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothctical maximally exposed individual assumed to frequent the perimeter of HISS and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent. A full time employee business receptor was considered to be the maximally exposed individual from HISS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was calculated using soil characterization data and air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to calculate dose to the receptor (SAIC, 2001a).

- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the site perimeter between the source and the receptor. The site is assumed to represent a line-source to the receptor.

- Exposure from external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 m east of the HISS perimeter. Exposure time is 2,000 hours per year (SAIC, 2001a).

- Exposure from Rn-222 (and progeny) was calculated using Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor and then running the CAP-88 PC modeling code to calculate dose to the receptor located 50 m east of the HISS perimeter (SAIC, 2001a).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility 50 m east from the HISS perimeter received 2.1 mrem/yr from airborne radioactive particulates, 0.2 mrem/yr from external gamma, and 0.4 mrem/yr from Rn-222 for a TEDE of 2.7 mrem/yr (SAIC, 2001a).

6.4.3 Radiation Dose Equivalent from SLDS to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent the perimeter of SLDS and receive a radiation dose by the exposure pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent. A full time employee business receptor was considered to be the maximally exposed individual from SLDS.

The exposure scenario assumptions are as follows:

- Exposure from airborne radioactive particulates was estimated using air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor (SAIC, 2001c).

- Exposure from external gamma radiation was calculated using environmental TLD monitoring data at the site perimeter between the source and the receptor. The site is assumed to represent a line-source to the receptor.

- Exposure from external gamma radiation occurs to the maximally exposed individual while working full-time outside at the receptor location facility located approximately 50 m southeast of the SLDS perimeter. Exposure time is 2,000 hours per year (SAIC, 2001c).

- Exposure from Rn-222 (and progeny) was calculated using Rn-222 (alpha track) monitoring data at the site perimeter between the source and receptor and then running the CAP-88PC modeling code to calculate dose to the receptor located 50 m southeast of the SLDS perimeter (SAIC, 2001c).

Based on the exposure scenario and assumptions described above, a maximally exposed individual working outside at the receptor location facility 50 m southeast from SLDS received

less than 0.1 mrem/yr from airborne radioactive particulates, 0.0 mrem/yr from external gamma, and 0.0 mrem/yr from Rn-222 for a TEDE of less than 0.1 mrem/yr (SAIC, 2001c).

6.4.4 Radiation Dose Equivalent from Coldwater Creek to a Maximally Exposed Individual

This section discusses the estimated TEDE to a hypothetical maximally exposed individual assumed to frequent Coldwater Creek and receive a radiation dose by the exposure pathways identified above. The assumed scenario is for a recreational user. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time that is less than 100 percent. A youth spending time as a recreational user of Coldwater Creek is considered to be the maximally exposed individual from Coldwater Creek.

The exposure scenario assumptions are as follows:

- The youth spends 2 hours at Coldwater Creek during each visit, and visits once every two weeks. It is likely that activity would be greater in summer and less in winter, but the yearly average is 26 visits.

- The soil/sediment ingestion rate is 50 milligrams per day, and water ingestion rate is 2 liters per day (EPA, 1989c).

- UCL-95 radionuclide concentrations in Coldwater Creek surface water/sediment samples taken in CY00 were assumed to be present in the water/sediment ingested by the maximally exposed individual (SAIC, 2001d).

- Dose equivalent conversion factors for ingestion, are: Total U, 2.5E-5 millirem per picocurie (mrem/pCi); Ra-226, 1.33E-3 mrem/pCi; Ra-228, 1.44E-3 mrem/pCi; Th-228, 3.96E-4 mrem/pCi; Th-230, 5.48E-4 mrem/pCi; and Th-232, 2.73E-3 mrem/pCi (EPA, 1989b).

Based on the exposure scenario and assumptions described above, a maximally exposed individual using Coldwater Creek for recreational purposes received 0.03 mrem/yr from soil/sediment ingestion, and 0.15 mrem/yr from water ingestion for a TEDE of 0.18 mrem/yr (SAIC, 2001d).

6.4.5 Radiation Dose Equivalent from SLAPS to a Transient Receptor

This section discusses the estimated TEDE to a hypothetical transient receptor that passes SLAPS daily during the work week. Therefore, all calculations of dose equivalent due to the applicable pathway assume a realistic residence time is less than 100 percent.

The exposure scenario assumptions are:

- The transient spends 30 minutes per day passing SLAPS, and passes every day during the normal work year.

- Exposure from airborne particulate radionuclides was calculated using air particulate monitoring data to determine a source term and then running the CAP-88 PC modeling code to estimate dose to the receptor (SAIC, 2001b).

- Exposure from external gamma radiation occurs to the transient receptor passing the SLAPS at approximately 25 m north of the SLAPS perimeter. Exposure time is 125 hours per year (SAIC, 2001b).

- Exposure from Rn-222 (and progeny) was estimated using Rn-222 (alpha track) monitoring data at the site perimeter between the source and the receptor and then running the CAP-88 PC modeling code to calculate dose to the transient receptor located approximately 25 m north of the SLAPS perimeter along McDonnell Boulevard (SAIC, 2001b).

Based on the exposure scenario and assumptions described above, the exposed transient receptor passing SLAPS along McDonnell Boulevard 25 m north of the SLAPS perimeter received 2.3 mrem/yr from airborne particulate radionuclides, 0.1 mrem/yr from external gamma, and 0.1 mrem/yr from Rn-222 for a TEDE of 2.5 mrem/yr.

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10 CSR 23 – Missouri Well Construction Rules

10 CFR 20.1302, Compliance with dose limits for individual members of the public.

40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions from Federal Facilities Other then Nuclear Regulatory Commission Licenses and Not Covered by Subpart H.*

ATTACHMENT 1

ST. LOUIS FUSRAP SITES 2000 RADIONUCLIDE EMISSIONS NESHAP REPORT SUBMITTED IN ACCORDANCE WITH REQUIREMENTS OF 40 CFR 61 SUBPART I

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ACRONYMS AND ABBREVIATIONS

$\mu Ci/cm^3$	microcurie per cubic centimeter
$\mu Ci/mL$	microcurie per milliliter
AEC	Atomic Energy Commission
C°	degree(s) Celsius (centigrade)
CFR	Code of Federal Regulations
Ci/yr	curie per year
cm/yr	centimeter per year
CY	calendar year
DOE	Department of Energy
EDE	effective dose equivalent
EPA	Environmental Protection Agency
ft	feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
ha	hectares
HEPA	high efficiency particulate air
HISS	Hazelwood Interim Storage Site
IA	investigation area
m	meter (s)
m/min	meters per minute
MED	Manhattan Engineering District
mrem/yr	millirem per year
NESHAP	National Emission Standard for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
pCi/g	picocurie per gram
SLAPS	St. Louis Airport Site
SLDS	St. Louis Downtown Site
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geologic Survey
VP	vicinity property
yd^3	cubic yards

EXECUTIVE SUMMARY AND DECLARATION STATEMENT

This report presents the results of National Emission Standard for Hazardous Air Pollutants (NESHAP) calculations for the St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) Sites for calendar year 2000 (CY00). NESHAP requires the calculation of the effective dose equivalent from radionuclide emissions to critical receptors. The report follows the requirements and procedures contained in 40 CFR 61, Subpart I, *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

This report evaluates three sites: the St. Louis Airport Site (SLAPS), the St. Louis Downtown Site (SLDS), and the Hazelwood Interim Storage Site (HISS). Emissions from sites were evaluated during periods of active remediation and during periods of no activity; these results were then added to provide a conservative estimate of total emissions.

The NESHAP standard of effective dose equivalent (EDE) to a critical receptor from radionuclide emissions is 10 millirem per year (mrem/yr). None of the sites exceeded this standard. The EDE from radionuclide emissions at the HISS, SLAPS, and SLDS were calculated using soil characterization data, air particulate monitoring data, and the Environmental Protection Agency (EPA) CAP-88PC modeling code, which resulted in EDEs of 8.1 mrem/yr, 6.4 mrem/yr, and 9.4 mrem/yr, respectively.

Evaluations for the SLDS resulted in less than 10% of the dose standard in 40 CFR 61.102. This site is exempt from the reporting requirements of 40 CFR 61.104(a).

DECLARATION STATEMENT – 40 CFR 61.104(a)(xvi)

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

_____ _____

Signature Date

Office: U.S. Army Corp of Engineers, St. Louis District Office
Address: 9170 Latty Ave.
Berkeley, MO 63134
Contact: Dennis Chambers, CHP

1.0 PURPOSE

This report calculates the effective dose equivalent (EDE) from radionuclide emissions (exclusive of radon) to critical receptors from each of the three St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) locations: St. Louis Airport Site (SLAPS), Hazelwood Interim Storage Site (HISS), and St. Louis Downtown Site (SLDS). The air emissions from each site are ground releases of particulate radionuclides in soil from windblown *in situ* and remedial activity sources.

2.0 METHOD

Emission rates were modeled using guidance documents referenced in 40 CFR 61, Subpart I, Appendix E (EPA, 1989) and measured by collection of environmental air samples. Emission rates were input into the EPA computer code CAP88-PC along with appropriate meteorological data and distances to critical receptors[1] to obtain the EDE from the air emissions.

2.1 EMISSION RATE

Two methods were used to determine particulate radionuclide emission rates from the sites: (1) Regulatory Guide 3.59, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations* (NRC, 1987), and (2) environmental air samples collected from the perimeter of a site. NRC 1987 is referenced in 40 CFR 61 Appendix E, *Compliance Methods for Determining Compliance with Subpart I* [2]. Emissions for periods of no activity (*in situ* windblown emissions) and during excavations were evaluated and summed together to obtain the annual emission rate for each site.

2.2 EFFECTIVE DOSE EQUIVALENT

The EDE to critical receptors is obtained using EPA computer code CAP88-PC Version 2.0 (EPA, 1997a). CAP88-PC uses a Gaussian plume equation to estimate the dispersion of radionuclides and is referenced by the EPA to demonstrate compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) emissions criterion in 40 CFR 61.

The EDE is calculated by combining doses from ingestion, inhalation, air immersion, and external ground surface. CAP88-PC contains historical weather data libraries for major airports across the country, and the results can be modeled for receptors at multiple distances from the emissions source.

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[1] "Critical receptors," as used in this report, are the locations for the nearest residence, school, business, and farm.

[2] It is recognized that there are more recent EPA publications which could be used to perform these calculations equally well. The publications referenced within the regulations are used in this assessment to provide a consistent and clear path to compliance with 40 CFR 61.

3.0 METEOROLOGICAL DATA

Meteorological data was obtained from the CAP88-PC code for the St. Louis Lambert International Airport (wind file 13994.WND). Data in the file was accumulated from 1988 through 1992.

Average Annual Wind Velocity	4.446 meters/second
Average Annual Precipitation Rate	111 cm/yr
Average Annual Air Temperature	14.18 °C

Wind speed frequency data was obtained from St. Louis Lambert International Airport (see Table 3-1).

Table 3-1. St. Louis Wind Speed Frequency

Wind Speed Group, Knots*	Frequency
0 – 3	0.10
4 – 7	0.29
8 – 12	0.36
13 – 18	0.21
19 – 24	0.03
25 – 31	0.01

*knot = 1.151 miles/hr

Wind direction frequency was obtained from the CAP-88 wind file, 13994.WND (see Table 3-2).

Table 3-2. St. Louis Wind Rose Frequency

Wind direction (wind towards)	Wind From	Wind Frequency	Wind direction (wind towards)	Wind From	Wind Frequency
N	S	0.1310	S	N	0.056
NNW	SSE	0.074	SSE	NNW	0.043
NW	SE	0.068	SE	NW	0.061
WNW	ESE	0.069	ESE	WNW	0.087
W	E	0.055	E	W	0.090
WSW	ENE	0.028	ENE	WSW	0.068
SW	NE	0.031	NE	SW	0.054
SSW	NNE	0.037	NNE	SSW	0.050

4.0 ST. LOUIS AIRPORT SITE AND ADJACENT VICINITY PROPERTIES UNDER ACTIVE REMEDIATION

4.1 SITE DESCRIPTION

The SLAPS is an unincorporated property, owned by the City of St. Louis, in St. Louis County. The SLAPS is bounded on the north and east by McDonnell Boulevard, on the south by Banshee Road, the Norfolk and Western Railroad, and St. Louis Lambert International Airport, and by Coldwater Creek on the north and west. The SLAPS covers 8.8 hectares (ha) (22 acres).

Site History

The Manhattan Engineering District (MED) acquired the SLAPS in 1946 to store uranium-bearing residuals generated at the SLDS from 1946 until 1966. In 1966, these residuals were purchased by Continental Mining and Milling Company of Chicago, removed from the SLAPS, and placed in storage at the Latty Avenue HISS under an Atomic Energy Commission (AEC) license. After most of the residuals were removed, site structures were demolished and buried on the property along with approximately 60 truckloads of scrap metal and a vehicle that had become contaminated. In 1973, the U.S. Government and the City of St. Louis agreed to transfer ownership from AEC to the St. Louis Airport Authority. Various characterization studies have been performed on the site.

4.2 MATERIAL HANDLING AND PROCESSING FOR CY00

Excavation activities were performed at the SLAPS at the East End, ACM soils, and Radium Pit areas of the site. The excavated soils were removed from the site by rail and truck. Environmental air samples were collected around the perimeter of the site during CY00 with the results used to determine the excavation and windblown *in situ* emissions.

4.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations, as they exist in the surface soils at the SLAPS, were obtained from statistical summaries of the investigative areas (IAs) contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Appendix A contains a summary table of the radionuclide concentrations for each area or site used to calculate the emission rate from each area or site, as applicable. For the SLAPS, areas IA-1 through IA-8 were averaged to determine the radionuclide concentrations to apply to site emissions. For calculations that apply to specific areas, the average for the area is used.

4.4 LIST OF ASSUMED AIR RELEASES FOR CY00

Wind erosion during periods of site inactivity and the remedial action excavations are assumed for the particulate radionuclide emission determinations from the SLAPS. Vicinity properties (VPs) do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetation cover.

4.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 4-1 and Table 4-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5-minute Florissant Quadrangle Map.

Table 4-1. SLAPS Critical Receptors

Receptor	Direction from site	Distance (mi)	Distance (m)
Nearest Resident	E	1	1,600
School	SE	1.4	2,300
Business	S	0.1	160[1]
Farm	NE	0.84	1,400

[1] Distance from receptor to fenceline is 160 meters. Distance from receptor to center of source is 314 meters for emissions determination.

4.6 EMISSIONS DETERMINATION

4.6.1 Measured Particulate Emissions

Particulate air samples are collected from six locations around the perimeter of the SLAPS to measure the radionuclide emissions. The samplers were established in the second quarter of CY99 and provide the basis for determining the radionuclide emission rates during all of CY00. The average gross alpha and beta concentrations [microcurie per milliliter (μCi/mL)] are determined for each plant location for CY00. The site gross alpha and beta emission concentration is determined by averaging the six locations. The location and the site average concentrations are presented in Table 4-2.

Table 4-2. SLAPS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration (μCi/mL)	
	alpha	beta
PAP1	5.88E-15	4.02E-14
PAP2	2.04E-15	3.74E-14
PAP3	2.18E-15	4.11E-14
PAP4	4.83E-15	4.04E-14
PAP5	2.73E-15	4.60E-14
Average Concentration =	**3.53E-15**	**4.10E-14**

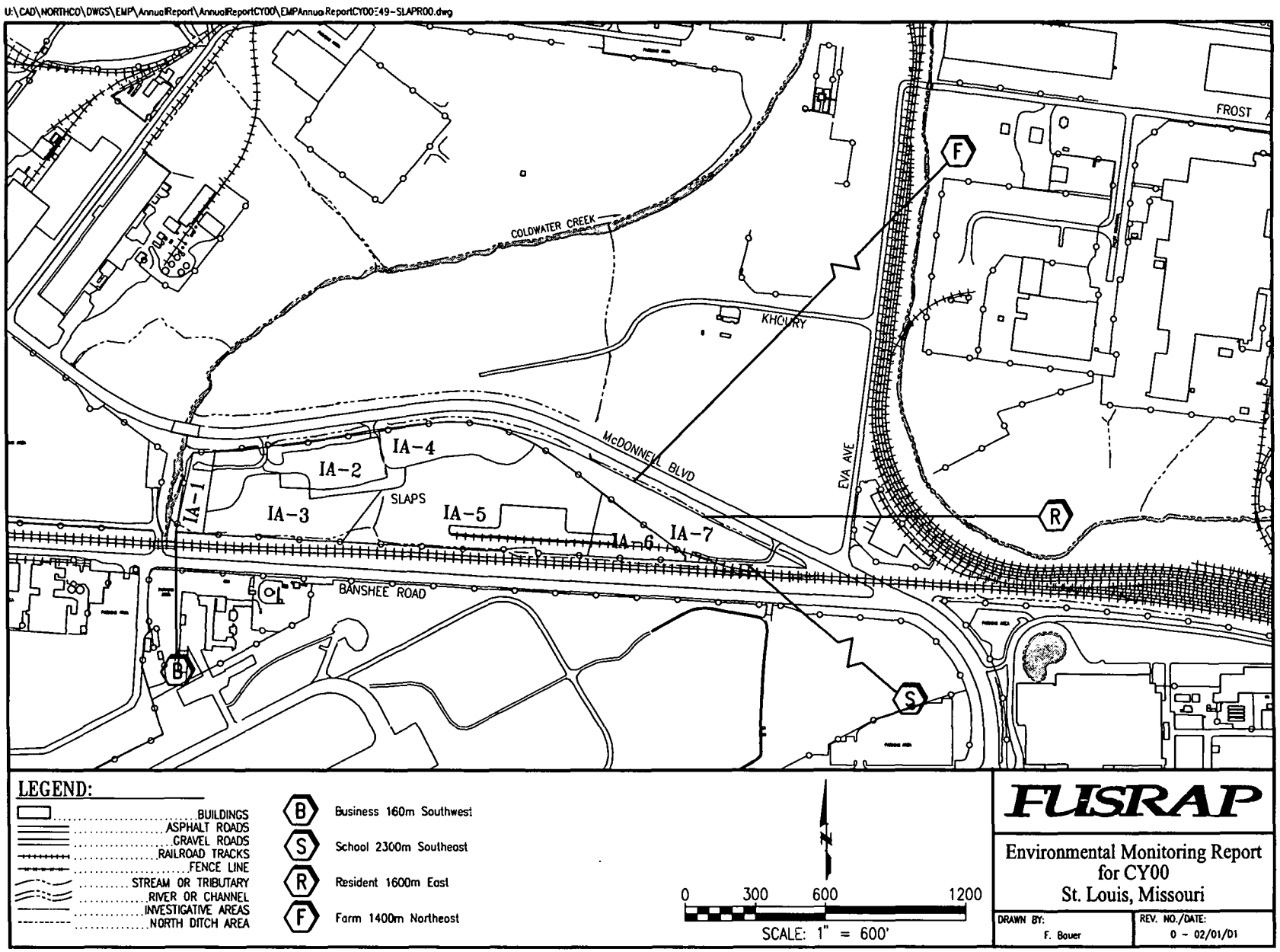

Figure 4-1. St. Louis Airport Site Critical Receptors

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration [microcurie per cubic centimeter ($\mu Ci/cm^3$)]. The gross average concentration ($\mu Ci/cm^3$) is converted to a release rate [curie per year (Ci/yr)] using Equations (1) and (2) below and illustrated in Table 4-3.

EPA 1989 [page 3-21, (2)] provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

$$D = (1.3\ A)^{1/2} \qquad \textbf{Equation (1)}$$

where
D is the effective diameter of the release [meters (m)], and
A is the area of the stack, vent, or release point [square meters (m^2)].

For the SLAPS, the area within the perimeter of the air samples is 88,000 m^2 resulting in an effective diameter of 338 m.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through a stack with an effective diameter of 338 m is completed using Equation (2).

$$V = (4)\ F / \pi\ (D)^2 \qquad \textbf{Equation (2)}$$

where
V is the wind velocity (m/min) = 266.76 m/min,
F is the flow rate (m^3/min),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above (m).

Converting the velocity of emissions from the site to an effective flow rate results in a site release flow rate of 2.4E+7 m^3/min. The product of the flow rate, the average radionuclide concentration for the SLAPS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 4-3.

Table 4-3. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	[8]Activity Fraction	[9]Emission Conc. (μCi/cm^3)	[10]Emission Rate(Ci/yr)
U-238	7.5E-02	3.0E-16	3.8E-03
U-235	3.5E-03	1.4E-17	1.8E-04
U-234	7.7E-02	3.1E-16	3.9E-03
Ra-226	7.0E-02	2.8E-16	3.5E-03
Th-232	5.4E-03	2.2E-17	2.7E-04
Th-230	7.6E-01	3.0E-15	3.8E-02
Th-228	3.2E-03	1.3E-17	1.6E-04
[1]Ra-224	3.2E-03	1.3E-17	1.6E-04
[2]Th-234	4.7E-01	1.9E-15	2.4E-02
[3]Pa-234m	4.7E-01	1.9E-15	2.4E-02
[4]Th-231	2.2E-02	8.8E-17	1.1E-03
Ra-228	1.5E-02	6.2E-17	7.8E-04
[5]Ac-228	1.5E-02	6.2E-17	7.8E-04
[6]Pa-231	3.5E-03	1.4E-17	1.8E-04
[7]Ac-227	3.5E-03	1.4E-17	1.8E-04

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.
[8] Derived from the average soil radionuclide concentrations for SLAPS IA-1 to IA-8 as presented in USACE 1999.
[9] Product of gross alpha or beta emission concentration from Table 4-2 and the radionuclide activity fraction.
[10] Emission rate based on 365 day sampling period at a flow rate of 2.4E+7 m^3/min as determined from Equations (1) and (2).

4.6.2 SLAPS Total Emission Rates

The total CY00 emission rates which were input into the EPA codes are shown in Table 4-4 as the measured emission rates from the air samples collected from the perimeter of the site.

Table 4-4. CY00 SLAPS Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	3.8E-03
U-235	1.8E-04
U-234	3.9E-03
Ra-226	3.5E-03
Th-232	2.7E-04
Th-230	3.8E-02
Th-228	1.6E-04
[1]Ra-224	1.6E-04
[2]Th-234	2.4E-02
[3]Pa-234m	2.4E-02
[4]Th-231	1.1E-03
Ra-228	7.8E-04
[5]Ac-228	7.8E-04

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.

4.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was the total for the SLAPS of 88,000 m^2. Results show compliance with the 10 millirem per year (mrem/yr) criterion for all critical receptors. Table 4-5 summarizes the results.

Table 4-5. SLAPS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	E	1,600	3.4
School[1]	SE	2,300	0.3
Business[1]	S	160[2]	6.4
Farm	NE	1400	2.3

[1] Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

[2] Distance from receptor to fenceline is 160 m. Distance from receptor to center of source is 314 m for emissions determination.

4.8 COMPARISON OF CAP88-PC WITH COMPLY

In the 1998 NESHAP report for the SLAPS, a comparison run was made for the highest critical receptor (business) located 160 m from the site in the south sector using COMPLY Version 1.5d and CAP88-PC. COMPLY provided an EDE result of 5.1 mrem/yr with CAP88-PC providing a result of 7.6 mrem/yr. The general agreement of these two results and the CAP88-PC results providing a greater annual EDE result indicates that CAP88-PC is a comparable method of demonstrating compliance with 40 CFR 61 Subpart I.

5.0 ST. LOUIS DOWNTOWN SITE PROPERTIES UNDER ACTIVE REMEDIATION

5.1 SITE DESCRIPTION

SLDS and its VPs comprise 45-acres of industrial property within the easternmost portion of St. Louis. These sites are located approximately 300 feet (ft) west of the Mississippi River. SLDS is owned by Mallinckrodt Inc., which produces various chemical products. Mallinckrodt Inc.'s facility consists of a number of separate production complexes (plants) and auxiliary support buildings and offices. The VPs potentially impacted by SLDS operations include McKinley Iron Company to the north, PVO Foods (defunct) and City of St. Louis properties to the east, and Thomas and Proetz Lumber Company and Gunther Salt to the south. The St. Louis Terminal Railroad Association; Norfolk and Western Railroad; and the Chicago, Burlington, and Quincy Railroad all have active rail lines passing through the Mallinckrodt facility.

Site History

From 1942 until 1957, Mallinckrodt Chemical Works was contracted by MED and AEC to process uranium ore for the production of uranium metal. Residuals of the process, including spent pitchblende ore, process chemicals, and radium, thorium, and uranium, were inadvertently released from the Mallinckrodt Plant and into the environment through handling and disposal practices. Residuals from the uranium process had elevated levels of radioactive radium, thorium, and uranium. From 1942 to 1945, Plants 1, 2, and 4 (now Plant 10) were involved in the development of uranium-processing techniques, uranium compounds and metal production, and uranium metal recovery from residues and scrap. Uranium-bearing process residues from these operations were stored at the SLAPS and the Latty Avenue Properties from 1946 to 1966. Relocation and storage of these processed wastes at SLAPS and the Latty Avenue Properties resulted in the subsequent contamination of the SLAPS VPs. Mallinckrodt decontaminated Plants 1 and 2 from 1948 through 1950 to meet the AEC criteria then in effect, and the AEC released these plants for use without radiological restrictions in 1951.

5.2 MATERIAL HANDLING AND PROCESSING FOR CY00

Excavation activities were performed at SLDS Plant 1 and Plant 2 areas of the site. The excavated soils were removed from the site by rail and truck. General area air samples were collected around excavation perimeters during CY00 with the results used to determine the excavation and windblown *in situ* emissions. *In situ* emissions from inactive areas of SLDS were not calculated because the ground surface soil at SLDS is generally covered with asphalt or concrete which limits the potential for material to become airborne.

5.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations, as they exist in the soils at SLDS, were obtained from statistical summaries of Plant areas contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Appendix A contains a summary table of the radionuclide concentrations for each area or Plant used to calculate the emission rate from each area or at each Plant, as applicable. For the SLDS, Plants 1 and 2 air particulate concentrations were averaged at each plant to determine the radionuclide concentrations to apply to site emissions during the active excavations.

5.4 LIST OF ASSUMED AIR RELEASES FOR CY00

Wind erosion during periods of remedial action excavations are assumed for the particulate radionuclide emission determinations from the SLDS. VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and cover.

5.5 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 5-1 and Table 5-1. Distances and directions to critical receptors are based on measurements on the USGS 7.5 minute Florissant Quadrangle Map.

Table 5-1. SLDS Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	NE	0.6	970
School	SW	2.8	4500
Business	SE	0.03	50[1]
Farm	NE	0.6	970

[1] Distance from receptor to fenceline is 50 m. Distance from receptor to center of source is 267 m for emissions determination.

5.6 EMISSIONS DETERMINATION

5.6.1 Measured Particulate Emissions

Particulate air samples were collected from several locations around the perimeter of the Plant 1 and Plant 2 excavations to measure the radionuclide emissions from remedial activities. The samplers were established at the start of remedial activity and provide the basis for determining the radionuclide emission rates during all of CY00. The average gross alpha and beta concentrations (μCi/mL) are determined for each plant location for the CY00. The site gross alpha and beta emission concentration is determined by averaging the locations surrounding the excavation. The plant average concentrations are presented in Table 5-2.

Table 5-2. SLDS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration (μCi/mL)	
	alpha	beta
Plant 1	1.36E-14	1.30E-13
Plant 2	1.03E-14	1.21E-13
Average Concentration[1] =	**1.2E-14**	**1.26E-13**

[1] Average concentration for combined Plant 1 and Plant 2 data.

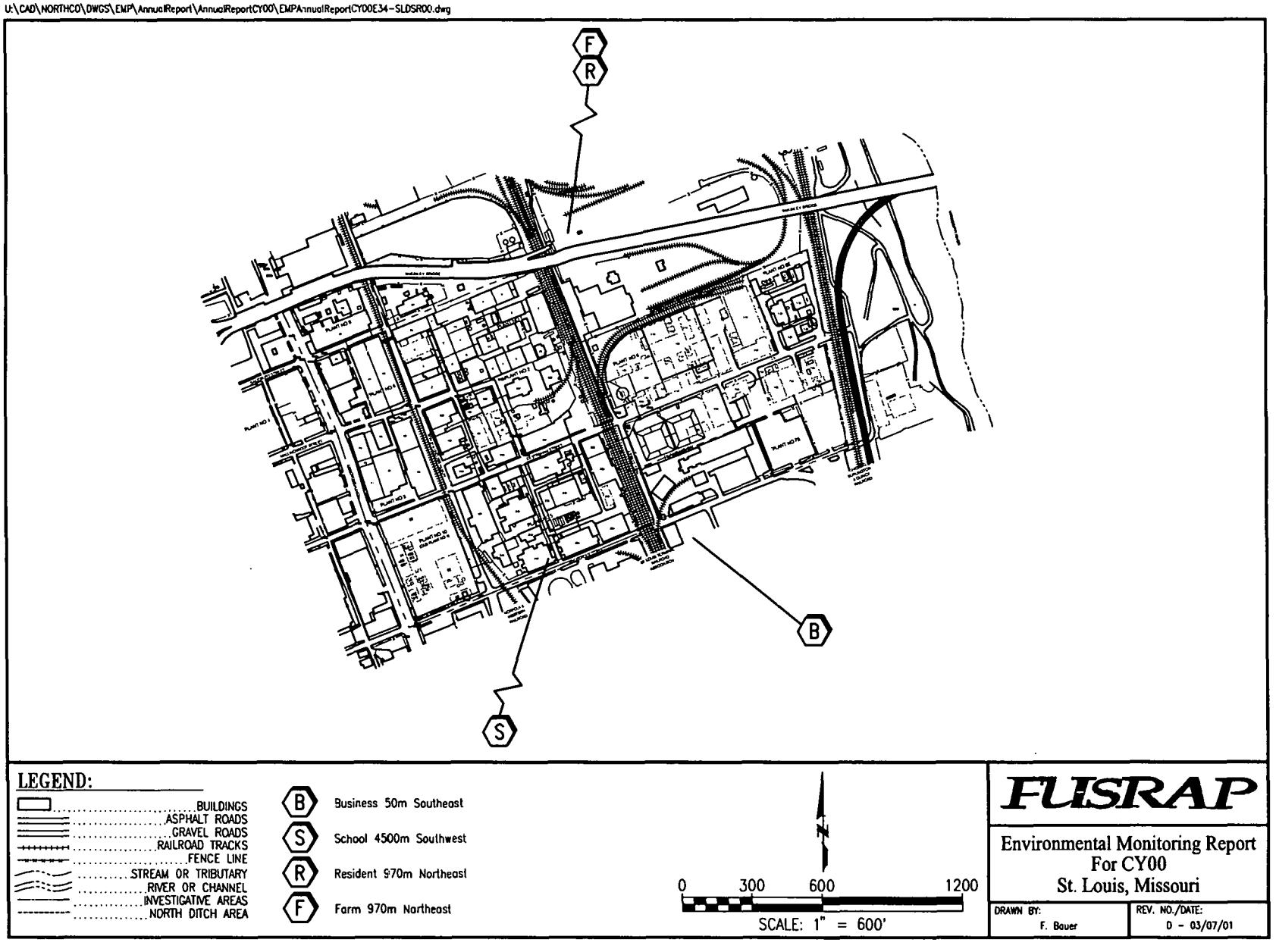

Figure 5-1. St. Louis Downtown Site Critical Receptors

Radionuclide activity fractions are determined for alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration ($\mu Ci/cm^3$). The gross average concentration ($\mu Ci/cm^3$) is converted to a release rate (Ci/yr) using Equations (1) and (2) below and illustrated in Table 5-3.

EPA 1989 [page 3-21, (2)] provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

$$D = (1.3\ A)^{1/2} \qquad \textbf{Equation (1)}$$

where
D is the effective diameter of the release (m), and
A is the area of the stack, vent or release point (m^2).

For Plant 1 and Plant 2 excavations, the area within the perimeter of the air samples is 265 m^2 and 787 m^2, respectively. This results in an effective diameter of 19 m and 32 m, respectively.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through stacks with effective diameters of 19 and 32 m is completed using Equation (2).

$$V = (4)\ F / \pi\ (D)^2 \qquad \textbf{Equation (2)}$$

where
V is the wind velocity (m/min) = 266.76 m/min,
F is the flow rate (m^3/min),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above (m).

Converting the velocity of emissions from the site to an effective flow rate results in a site release flow rate of 7.6E4 m^3/min for Plant 1 and 2.1E5 m^3/min for Plant 2. The product of the flow rate, the average radionuclide concentration for the SLDS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 5-3.

Table 5-3. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	[6]Activity Fraction	[7]Emission Conc. ($\mu Ci/cm^3$)	[8]Emission Rate (Ci/yr)
Plant 1			
U-238	1.4E-01	2.0E-15	1.7E-05
U-235	6.4E-03	8.8E-17	7.5E-07
U-234	1.4E-01	2.0E-15	1.7E-05
Ra-226	5.5E-01	7.7E-17	6.6E-05
Th-232	1.4E-02	2.0E-16	1.7E-06
Th-230	1.1E-01	1.5E-15	1.3E-05
Th-228	1.4E-02	2.0E-16	1.7E-06
[1]Ra-224	1.4E-02	2.0E-16	1.7E-06
[2]Th-234	4.5E-01	5.8E-14	4.9E-04
[3]Pa-234m	4.5E-01	5.8E-14	4.9E-04
[4]Th-231	2.0E-02	2.6E-15	2.2E-05
Ra-228	4.5E-02	5.8E-15	4.9E-05
[5]Ac-228	4.5E-02	5.8E-15	4.9E-05
[6]Pa-231	6.4E-03	6.3E-17	5.4E-07
[7]Ac-227	6.4E-03	6.3E-17	5.4E-07
Plant 2			
U-238	4.2E-01	4.2E-15	1.1E-04
U-235	2.0E-02	2.0E-16	4.9E-06
U-234	4.2E-01	4.2E-15	1.1E-04
Ra-226	4.2E-03	4.2E-17	1.0E-06
Th-232	7.5E-04	7.0E-18	1.7E-07
Th-230	8.8E-02	8.8E-16	2.2E-05
Th-228	7.5E-04	7.0E-18	1.7E-07
[1]Ra-224	7.5E-04	7.0E-18	1.7E-07
[2]Th-234	4.9E-01	5.9E-14	1.5E-03
[3]Pa-234m	4.9E-01	5.9E-14	1.5E-03
[4]Th-231	2.3E-02	2.8E-15	6.8E-05
Ra-228	8.6E-04	1.1E-16	2.7E-06
[5]Ac-228	8.6E-04	1.1E-16	2.7E-06
[6]Pa-231	2.0E-02	2.0E-16	4.9E-06
[7]Ac-227	2.0E-02	2.0E-16	4.9E-06

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.
[8] Derived from the average soil radionuclide concentrations for Plant 1 and Plant 2 as presented in USACE 1999.
[9] Product of gross alpha or beta emission concentration from Table 4-2 and the radionuclide activity fraction.
[10] Emission rate based on 78 day (Plant 1) and 82 day (Plant 2) sampling period at a flow rate of 7.6E4 m^3/min (Plant 1) and 2.1E5 m^3/min (Plant 2) as determined from Equations (1) and (2).

5.6.2 SLDS Total Emission Rates

The total CY00 emission rates which were input into the EPA codes are shown in Table 5-4 and are calculated based on the measured emission rates from the air samples collected from the perimeter of the Plant 1 and Plant 2 excavations.

Table 5-4. CY00 SLDS Total Emission Rates

Radionuclide	Emission (Ci/yr)
Plant 1	
U-238	1.7E-05
U-235	7.5E-07
U-234	1.7E-05
Ra-226	6.6E-05
Th-232	1.7E-06
Th-230	1.3E-05
Th-228	1.7E-06
[1]Ra-224	1.7E-06
[2]Th-234	4.9E-04
[3]Pa-234m	4.9E-04
[4]Th-231	2.2E-05
Ra-228	4.9E-05
[5]Ac-228	4.9E-05
[6]Pa-231	5.4E-07
[7]Ac-227	5.4E-07
Plant 2	
U-238	1.1E-04
U-235	4.9E-06
U-234	1.1E-04
Ra-226	1.0E-06
Th-232	1.7E-07
Th-230	2.2E-05
Th-228	1.7E-07
[1]Ra-224	1.7E-07
[2]Th-234	1.5E-03
[3]Pa-234m	1.5E-03
[4]Th-231	6.8E-05
Ra-228	2.7E-06
[5]Ac-228	2.7E-06
[6]Pa-231	4.9E-06
[7]Ac-227	4.9E-06

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.

5.7 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was 265 and 787 m^2 for Plant 1 and Plant 2, respectively. This evaluation shows that all SLDS critical receptors remain less than 10 percent of the dose standard in 40 CFR 61.102 and therefore, SLDS is exempt from the reporting requirements of 40 CFR 61.104(a). Table 5-5 summarizes the results.

Table 5-5. SLDS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	NE	970	<0.1
School[1]	SW	4500	<0.1
Business[1]	SE	50[2]	<0.1
Farm	NE	970	<0.1

[1] Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

[2] Distance from receptor to fenceline is 50 m. Distance from receptor to center of source is 267 m for emissions determination.

6.0 HAZELWOOD INTERIM STORAGE SITE AND ADJACENT VICINITY PROPERTIES UNDER ACTIVE REMEDIATION

6.1 SITE DESCRIPTION

HISS is an 11-acre industrial site located in northern St. Louis County approximately 1 mile northeast of SLAPS. The site is located on Latty Avenue and is bordered to the east by the Stone Container Property (known as Latty Ave VP-2). HISS is bordered to its north by Latty Avenue and other VPs, to the south by undeveloped lots, and to the west by Futura Coatings. Multiple rail lines owned by the Norfolk and Western Railroad also lie to the west and south of the site. The primary waste materials that were historically stored at the HISS were uranium extraction and refining residues. These materials included an estimated 106,000 tons of barium sulfate cake and 350 tons of miscellaneous waste.

Site History

In 1966, Continental Mining and Milling Company of Chicago, Illinois, purchased the wastes stored at SLAPS and began moving them to a property at 9200 Latty Avenue for storage. In 1967, the Commercial Discount Corporation of Chicago, Illinois, purchased the residues and shipped much of the material to Canon City, Colorado, after drying. Cotter Corporation purchased the remaining residues in 1969 and dried and shipped more material to Canon City during 1970. In 1973, the remaining undried material was shipped to Canon City and leached barium sulfate was mixed with soil and transported to a St. Louis County landfill. During these activities, improper storage, handling, and transportation of materials caused the spread of materials along haul routes and to the adjacent VPs.

In 1979, the owner of the property excavated approximately 13,000 cubic yards (yd^3) from the western half of the property prior to constructing a manufacturing facility. The material excavated at this time was stockpiled on the eastern half of the property, which now constitutes the HISS. In 1984, Bechtel National, Inc. performed remedial action activities, including clearing, cleanup, and excavation of the property at 9200 Latty Avenue and surrounding VPs. This action created about 14,000 yd^3 of additional contaminated soil, which was stockpiled on HISS.

In 1986, the U.S. Department of Energy (DOE) provided radiological support to the cities of Hazelwood and Berkeley for a drainage and road improvement project. Soil with constituents in excess of DOE remedial action guidelines was excavated and stored at HISS. This action resulted in an additional 4,600 yd^3 of material being placed at HISS in a supplemental storage pile.

In 1996, the owner of the property to the east of the HISS, General Investment Funds Real Estate Holding Company, in consultation with DOE, made commercial parking and drainage improvements on the property. This action resulted in the stockpiling of approximately 8,000 yd^3 of soil and debris in two interim storage piles located in the southwestern portion of the Latty Avenue VP-2. These piles will be referred to as the Eastern Piles.

6.2 MATERIAL HANDLING AND PROCESSING FOR CY00

Excavation activities were performed at the HISS East Piles, North Spoils Pile, South Spoils Pile, Supplemental Pile, and Main Pile. The excavated soils were removed from the site by rail. The site, volume of soil excavated, and calendar quarter in which the soil was excavated are shown in Table 6-1. Environmental air samples were collected around the perimeter of the site during CY00 from October to December with the results used to determine the excavation and windblown *in situ* emissions during that time.

Table 6-1. CY00 HISS Excavations[1]

Area	East Piles	Supplemental Pile	North Spoils	South Spoils
Quarter	Excavation Volumes (yd^3)			
1	---	---	---	---
2	---	---	---	2,705
3	10,440	---	3,390	---
4	---	3,060	---	---
Total	10,440	3,060	3,390	2,705

[1] Information obtained from RA Contractor. Main pile excavation occurred during fourth quarter when site perimeter air sampling was in place; therefore, excavation information was not needed.

6.3 SOURCE DESCRIPTION – RADIONUCLIDE SOIL CONCENTRATIONS

The radionuclide concentrations, as they exist in the soil piles at the HISS, were obtained from statistical summaries of the piles contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). Appendix A contains a summary table of the radionuclide concentrations for each pile used to calculate the emission rate from each pile, as applicable.

6.4 LIST OF ASSUMED AIR RELEASES FOR CY00

Wind erosion during periods of site inactivity and the remedial action excavations are assumed for the particulate radionuclide emission determinations from the HISS. VPs do not contribute to the emission determinations for periods of inactivity due to the low activity and vegetation cover.

6.5 EFFLUENT CONTROLS

Effluent controls for the HISS *in situ* windblown emissions include various cover materials that will reduce particulate emissions. Emission reduction factors were obtained from Appendix C of NRC 1987. Table 6-2 lists the areas, the surface area of each area, the cover materials and the assumed reduction in particulate emissions. The HISS effective emission reduction parameter that will be used to calculate *in situ* emissions is determined from the information contained in the table. Emissions at HISS for October through December were measured by environmental air samples; therefore, the emission reduction factors are not applied to emissions from HISS during this time. The excavation area, duration, and cover materials are determined from information contained in the *Federal Facilities Agreement Progress Report* from the USACE to the EPA (USACE, 2001).

Table 6-2. HISS *In situ* Emission Reduction Factor

Area	Surface Area (m^2)	Cover	Time Excavating	Backfilled	Reduction Factor[1]
East Piles	5,244	30%	12%	58%	0.93[2]
Spoils Piles	2,220	22%	3%	75%	0.96[3]
Balance of HISS	10,318	75%	0%	0%	0.56[4]

[1] Emission reduction factors from Appendix C of NRC 1987. Calculated: Σ_p(fraction of cover x reduction factor x period of cover)$_p$, for all periods, p.

[2] $(0.30 \times 0.75) + (0.12 \times 1.0) + (0.58 \times 1.0) = 0.93$

[3] $(0.22 \times 0.75) + (0.03 \times 1.0) + (0.75 \times 1.0) = 0.96$

[4] $(0.75 \times 0.75) + (0.0 \times 1.0) + (0.0 \times 1.0) = 0.56$

All excavations were conducted using water spray to suppress fugitive dust emissions and therefore, the particulate radionuclide emissions. Water spray is reported to reduce emissions by 50 percent (NRC, 1987).

6.6 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown in Figure 6-1 and Table 6-3. Distances and directions to critical receptors are based on measurements on the USGS 7.5-minute Florissant Quadrangle Map.

Table 6-3. HISS Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	E	0.8	1300
School	SE	1.3	2100
Business	E	0.1	50[1]
Farm	E	0.8	1300

[1] Distance from receptor to fenceline is 50 m. Distance from receptor to emissions sources from the HISS, south spoils, north spoils, and east piles are 110 m, 65 m, 168 m, and 214 m, respectively.

6.7 EMISSIONS DETERMINATIONS

6.7.1 Calculated *In Situ* Windblown Particle Emissions

Windblown particle emissions per unit area are estimated using Equation 2 from NRC 1987. The equation is:

$$E_w = \frac{3.156E7}{0.5} \times \sum R_s F_s$$

where

E_w is the annual dust loss per unit area (g/m^2yr),
F_s is the annual average wind speed frequency for St. Louis (Table 3-1),
R_s is the resuspension rate at the average wind speed for particles < 20 μm (g/m^2s), Table 6-4 below,
3.156E7 is the number of seconds per year, and
0.5 is the fraction of dust loss by particles < 20 μm.

Table 6-4. *In Situ* Windblown Dust Emission Calculation

Wind Speed Group, Knots	Frequency F_s	Resuspension Rate R_s (g/m^2s)	$F_s R_s$
0 – 3	0.10	0	0
4 – 7	0.29	0	0
8 – 12	0.36	3.92 E-7	1.41 E-7
13 – 18	0.21	9.68 E-6	2.03 E-6
19 – 24	0.03	5.71 E-5	1.71 E-6
25 – 31	0.01	2.08 E-4	2.08 E-6
		Σ =	5.96 E-6

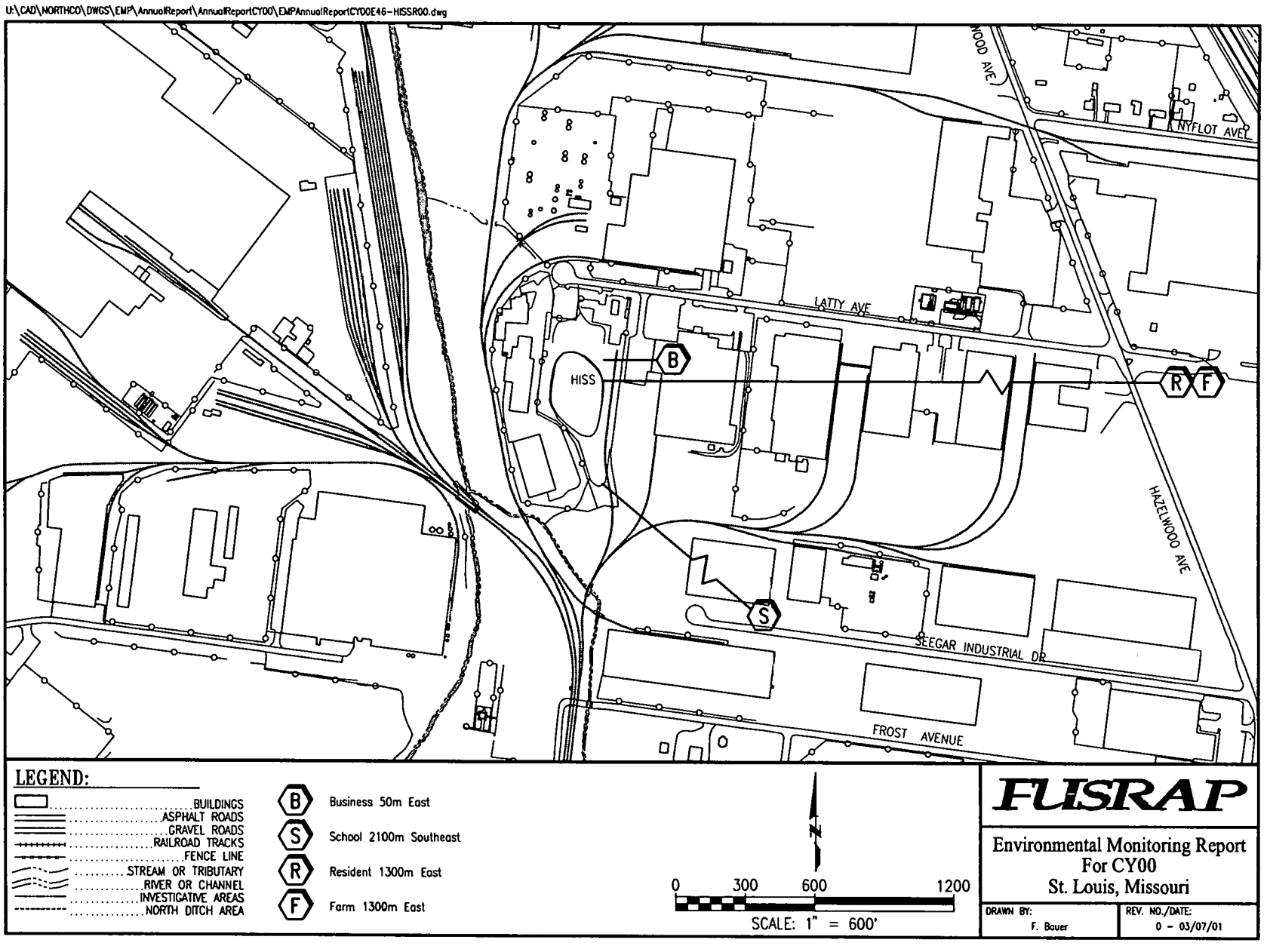

Figure 6-1. Hazelwood Interim Storage Site Critical Receptors

The annual dust loss per unit area is calculated to be **377 g/m^{2}yr**.

The total annual wind blown *in situ* emission rate, by radionuclide, for the HISS is calculated using Equation 3 from NRC 1987.

$$S_{Ci/yr} = E_w \times A \times C_{pCi/g} \times \frac{Ci}{10^{12} pCi} \times (1-R)$$

where

E_w is the annual dust loss per unit area = 377 g/m^{2}y,

A is the surface area of HISS = 1022 m^2, 1198 m^2, 5244 m^2, and 10,318 m^2, for North Spoils, South Spoils, East Piles, and the balance of the HISS, respectively,

C is the soil concentration (Appendix A average values), and

R is a unitless factor of 0.96, 0.93, and 0.56 for Spoils Piles, East Piles and the balance of HISS, respectively, for Effective Reduction in Emissions as determined in Table 6-2.

Wind blown *in situ* emission rates for each radionuclide are calculated and presented in Table 6-5.

Table 6-5. CY00 HISS Calculated *In Situ* Emission Rates

Radionuclide	Emission Rate (Ci/yr)
North Spoils	
U-238	2.2E-06
U-235	1.0E-07
U-234	2.2E-06
Ra-226	4.2E-07
Th-232	1.0E-07
Th-230	8.0E-07
Th-228	1.0E-07
[1]Ra-224	1.0E-07
[2]Th-234	2.2E-06
[3]Pa-234m	2.2E-06
[4]Th-231	1.0E-07
Ra-228	4.2E-07
[5]Ac-228	4.2E-07
[6]Pa-231	1.0E-07
[7]Ac-227	1.0E-07
South Spoils	
U-238	3.8E-07
U-235	1.8E-08
U-234	3.8E-07
Ra-226	2.3E-07
Th-232	9.0E-08
Th-230	2.5E-07
Th-228	9.0E-08
[1]Ra-224	9.0E-08
[2]Th-234	3.8E-07
[3]Pa-234m	3.8E-07

Table 6-5. CY00 HISS Calculated *In Situ* Emission Rates (Cont'd)

Radionuclide	Emission Rate (Ci/yr)
South Piles (Cont'd)	
[4]Th-231	1.8E-08
Ra-228	2.3E-07
[5]Ac-228	2.3E-07
[6]Pa-231	1.8E-08
[7]Ac-227	1.8E-08
East Piles	
U-238	3.2E-06
U-235	1.5E-07
U-234	3.2E-06
Ra-226	2.9E-06
Th-232	9.7E-07
Th-230	7.9E-06
Th-228	9.7E-07
[1]Ra-224	9.7E-07
[2]Th-234	3.2E-06
[3]Pa-234m	3.2E-06
[4]Th-231	1.5E-07
Ra-228	2.9E-06
[5]Ac-228	2.9E-06
[6]Pa-231	1.5E-07
[7]Ac-227	1.5E-07
Balance of HISS	
U-238	8.1E-05
U-235	3.8E-06
U-234	8.1E-05
Ra-226	2.0E-05
Th-232	5.8E-06
Th-230	3.3E-05
Th-228	5.8E-06
[1]Ra-224	5.8E-06
[2]Th-234	8.1E-05
[3]Pa-234m	8.1E-05
[4]Th-231	3.8E-06
Ra-228	2.0E-05
[5]Ac-228	2.0E-05
[6]Pa-231	3.8E-06
[7]Ac-227	3.8E-06

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.

6.7.2 Calculated Emissions From Excavations

The emission rate from the excavation areas is calculated using Equation 1 of NRC 1987. The concentrations of radionuclides for each pile removal is taken from the average radionuclide concentration for that pile as contained in the *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999) and illustrated in Appendix A of this NESHAPs Report. Results are shown in Table 6-6.

$$S_{Ci/yr} = M \times C \times E \times \frac{Ci}{10^{12}\,pCi} \times \frac{454\,g}{lb} \times (1-R)$$

where

M is the volume (yd^3) of material excavated,
C is the soil concentration [picocuries per gram (pCi/g)],
E is the emission factor = 0.04 lb/yd^3 for truck end dump (Appendix B of NRC, 1987), and
R is the emission reduction factor = 50 percent for water spray.

Table 6-6. CY00 HISS Calculated Excavation Emission Rate

Radionuclide	Emission (Ci/yr)
North Spoil	
U-238	4.3E-06
U-235	2.0E-07
U-234	4.3E-06
Ra-226	8.3E-07
Th-232	2.0E-07
Th-230	1.6E-06
Th-228	2.0E-07
[1]Ra-224	2.0E-07
[2]Th-234	4.3E-06
[3]Pa-234m	4.3E-06
[4]Th-231	2.0E-07
Ra-228	8.3E-07
[5]Ac-228	8.3E-07
[6]Pa-231	2.0E-07
[7]Ac-227	2.0E-07
South Spoils	
U-238	5.2E-07
U-235	2.5E-08
U-234	5.2E-07
Ra-226	3.2E-07
Th-232	1.2E-07
Th-230	3.4E-07
Th-228	1.2E-07
[1]Ra-224	1.2E-07
[2]Th-234	5.2E-07

Table 6-6. CY00 HISS Calculated Excavation Emission Rate (Cont'd)

Radionuclide	Emission (Ci/yr)
South Spoils (Cont'd)	
[3]Pa-234m	5.2E-07
[4]Th-231	2.5E-08
Ra-228	3.2E-07
[5]Ac-228	3.2E-07
[6]Pa-231	2.5E-08
[7]Ac-227	2.5E-08
East Piles	
U-238	2.2E-06
U-235	1.0E-07
U-234	2.2E-06
Ra-226	2.0E-06
Th-232	6.6E-07
Th-230	5.4E-06
Th-228	6.6E-07
[1]Ra-224	6.6E-07
[2]Th-234	2.2E-06
[3]Pa-234m	2.2E-06
[4]Th-231	1.0E-07
Ra-228	2.0E-06
[5]Ac-228	2.0E-06
[6]Pa-231	1.0E-07
[7]Ac-227	1.0E-07

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.

6.7.3 Measured Particulate Emissions

Particulate air samples are collected from four locations around the perimeter of the HISS to measure the radionuclide emissions. The samplers were established in October of CY00 and provide the basis for determining the radionuclide emission rates during the fourth quarter. The average gross alpha and beta concentrations (μCi/mL) are determined for each sample location for CY00. The site gross alpha and beta emission concentration is determined by averaging the four locations. The location and site average concentrations are presented in Table 6-7.

Table 6-7. HISS Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration (μCi/mL)	
	Alpha	Beta
HAP1	2.03E-15	2.91E-15
HAP2	2.02E-15	3.15E-15
HAP3	2.09E-15	2.99E-15
HAP4	1.96E-15	3.16E-15
Average Concentration =	**2.02E-15**	**3.05E-14**

Radionuclide activity fractions for are determined alpha and beta from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration ($\mu Ci/cm^3$). The gross average concentration ($\mu Ci/cm^3$) is converted to a release rate (Ci/yr) using Equations (1) and (2) below and illustrated in Table 6-8.

EPA 1989 [page 3-21, (2)] provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

$$D = (1.3\ A)^{1/2} \qquad \textbf{Equation (1)}$$

where
D is the effective diameter of the release (m), and
A is the area of the stack, vent, or release point (m^2).

For the HISS, the area within the perimeter of the air samples is 22,000 m^2 resulting in an effective diameter of 169 m.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through a stack with an effective diameter of 169 m is completed using Equation (2).

$$V = (4)\ F / \pi\ (D)^2 \qquad \textbf{Equation (2)}$$

where
V is the wind velocity (m/min) = 266.76 m/min,
F is the flow rate (m^3/min),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above (m).

Converting the velocity of emissions from the site to an effective flow rate results in a site release flow rate of 6.0E6 m^3/min. The product of the flow rate, the average radionuclide concentration for the HISS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 6-8.

Table 6-8. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	[8]Activity Fraction	[9]Emission Conc. (μCi/cm^3)	[10]Emission Rate (Ci/yr)
U-238	0.40	8.09E-16	5.7E-04
U-235	0.02	3.8E-17	2.7E-05
U-234	0.40	8.09E-16	5.7E-04
Ra-226	0.04	8.64E-17	6.1E-05
Th-232	0.01	1.24E-17	8.8E-06
Th-230	0.11	2.202E-16	1.6E-04
Th-228	0.01	1.24E-17	8.8E-06
[1]Ra-224	0.01	1.24E-17	8.8E-06
[2]Th-234	0.48	1.4439E-14	1.1E-02
[3]Pa-234m	0.48	1.4439E-14	1.1E-02
[4]Th-231	0.02	6.78E-16	5.0E-04
Ra-228	0.01	2.22E-16	1.6E-04
[5]Ac-228	0.01	2.22E-16	1.6E-04
[6]Pa-231			2.7E-05
[7]Ac-227			2.7E-05

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.
[8] Derived from the average soil radionuclide concentrations for HISS Piles as presented in USACE 1999.
[9] Product of gross alpha or beta emission concentration from Table 6-7 and the radionuclide activity fraction.
[10] Emission rate based on 85 day sampling period at a flow rate of 6.0E+6 m^3/min as determined from Equations (1) and (2).

6.7.4 HISS Total Emission Rates

The HISS total CY00 emission rates which were not input into the EPA codes. The total emission rates are shown in Table 6-9 as the sum of: (1) calculated emission rates from excavations, (2) measured emission rates from the air samples collected from the perimeter of the site, and (3) in-situ emission rates during periods of inactivity. The excavation emission rates, measured emission rates, and *in situ* emission rates were input into the EPA CAP-88PC code separately to accurately represent distance from the source to the receptor and the area of the individual sources contributing to emissions.

6.8 CAP88-PC RESULTS

The CAP88-PC reports for HISS are contained in Appendix B. The individual area factor inputs were 1022 m^2, 1198 m^2, 5,244 m^2, 10,318 and 22,000 m^2 for the North Spoils Piles, South Spoils Pile, East Piles, area around all piles on the HISS, and the entire HISS, respectively. Results show compliance with the 10 mrem/yr criterion for all critical receptors. Table 6-10 summarizes the results.

Table 6-9. CY00 HISS Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	6.7E-04
U-235	3.1E-05
U-234	6.7E-04
Ra-226	8.8E-05
Th-232	1.7E-05
Th-230	2.1E-04
Th-228	1.7E-05
[1]Ra-224	1.7E-05
[2]Th-234	1.1E-02
[3]Pa-234m	1.1E-02
[4]Th-231	5.0E-04
Ra-228	1.9E-04
[5]Ac-228	1.9E-04
[6]Pa-231	3.1E-05
[7]Ac-227	3.1E-05

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.

Table 6-10. HISS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident		1,300	0.2
School[1]		2,100	<0.1
Business[1]	E	50[2]	2.1
Farm		1,300	0.2

[1] Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).
[2] Distance from receptor to fenceline is 50 m. Distance from receptor to emission sources from the HISS, South Spoils, North Spoils, and East Piles are 110 m, 65 m, 168 m, and 214 m, respectively.

7.0 USACE RADIOANALYTICAL LABORATORY

7.1 SITE DESCRIPTION

The USACE radioanalytical laboratory is located on VP-38. The laboratory was moved from the HISS to VP-38 during CY00. VP-38 is a St. Louis FUSRAP VP, owned by SuperValue, Inc. The VP-38 is bounded on the north, east, and west by SuperValue, Inc. property and on the south by Latty Avenue. The laboratory site covers approximately one acre of VP-38.

7.2 SITE HISTORY

The MED acquired the SLAPS in 1946 to store uranium-bearing residuals generated at the SLDS from 1946 until 1966. In 1966, these residuals were purchased by Continental Mining and Milling Company of Chicago, removed from the SLAPS, and placed in storage at the Latty Avenue, HISS under an AEC license. The contamination present at VP-38 is most likely due to the transport of materials from the SLAPS to the HISS. The USACE radioanalytical laboratory was moved from the HISS to VP-38 after the laboratory site was remediated during CY00.

7.3 MATERIAL HANDLING AND PROCESSING FOR CY00

VP-38 was remediated prior to moving the laboratory from the HISS. The excavated soils were removed from the site by truck and transported to the SLAPS. The site, volume of soil excavated, and calendar quarter in which the soil was excavated are shown in Table 7-1. Air samples were collected around the perimeter of the excavation with the results used to determine the excavation emission rate.

[1]Table 7-1. CY00 VP-38 Excavations

Area	VP-38
Quarter	Excavation Volumes (yd^3)
1	1,600
2	5,005
3	0
4	0
Total	2,105

[1] Information obtained from USACE 2001.

7.4 LIST OF ASSUMED AIR RELEASES FOR CY00

Remedial action excavations and emissions from USACE Radioanalytical Laboratory operations are assumed for the particulate radionuclide emission determinations from the Laboratory Site. The VP is assumed not to have contributed to the emission determinations for the period of time prior to the start of remedial activities during CY00 due to low activity and vegetation cover.

7.5 EFFLUENT CONTROLS

Emissions at VP-38 during remedial action were measured by air samples collected at the perimeter of the excavation. The excavation area, and duration were taken from the *Federal Facilitates Agreement Progress Report* from the USACE to the EPA (USACE, 2001). All excavations were conducted using water spray to suppress the fugitive dust emission and therefore the particulate radionuclide emissions. Water spray is reported to reduce the emission by 50 percent (NRC, 1987).

The effluent controls at the USACE laboratory during operations includes performing all radioanalytical activities in fume hoods that exhaust to the outside air after passing through a high efficiency particulate air (HEPA) filter.

7.6 DISTANCES TO CRITICAL RECEPTORS

The distances to critical receptors are shown on Figure 7-1 and in Table 7-2. Distances and directions to critical receptors are based on measurements on the USGS 7.5 minute Florissant Quadrangle Map.

Table 7-2. Laboratory Site Critical Receptors

Receptor	Direction from site	Distance (miles)	Distance (m)
Nearest Resident	E	0.5	830
School	SE	1.2	1950
Business	S	0.04	60
Farm	E	0.5	830

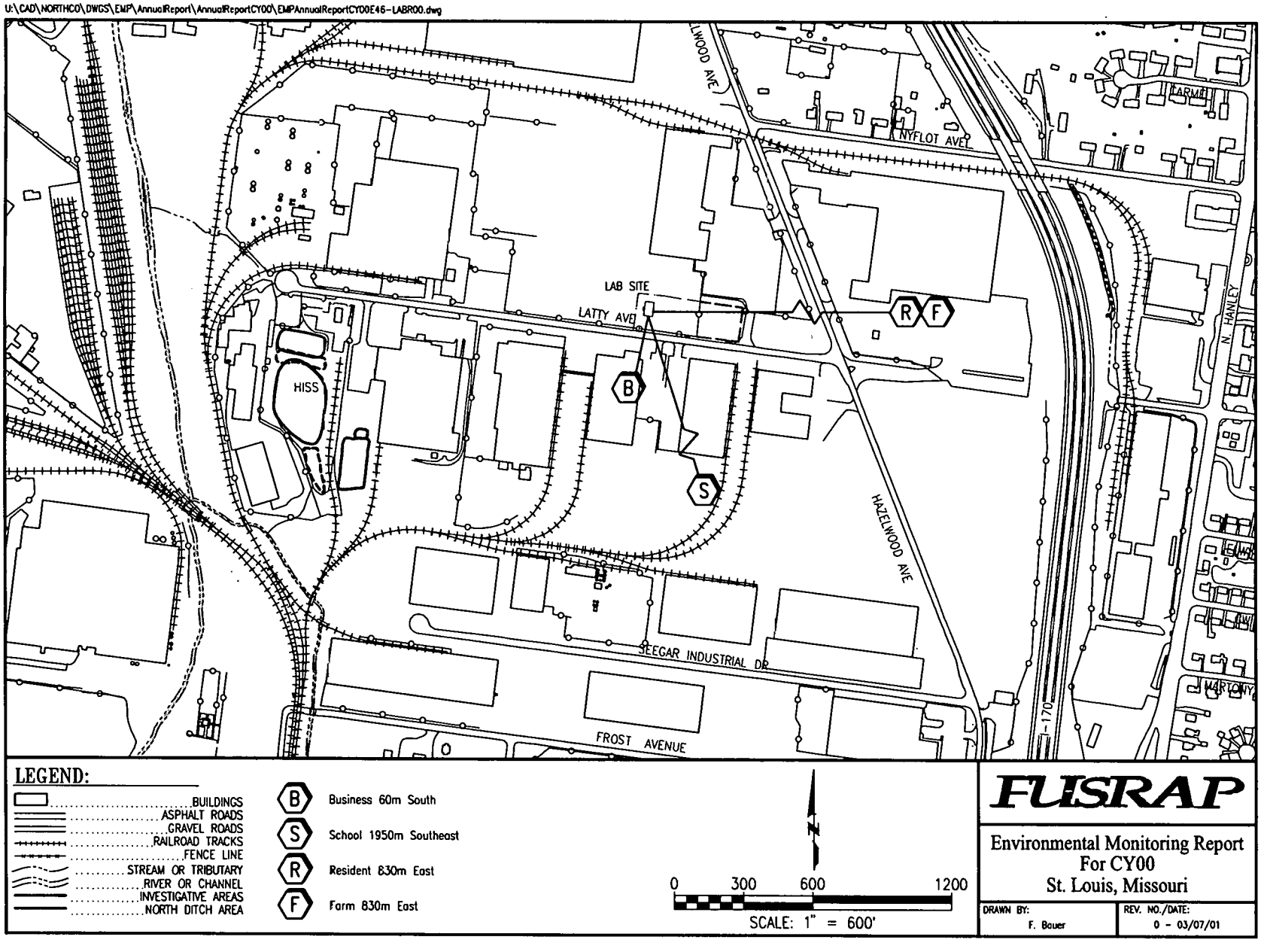

Figure 7-1. Laboratory Site Critical Receptors

7.7 EMISSIONS DETERMINATIONS

7.7.1 Measured Particulate Emissions

Particulate air samples were collected from several locations around the perimeter of the VP-38 excavations to measure the radionuclide emissions. The average gross alpha and beta concentrations (μCi/mL) were determined for the duration of excavation activities at VP-38 for CY00. The site gross alpha and beta emission concentration is determined by averaging all excavation perimeter samples collected during excavation activities. The site average concentrations are illustrated in Table 7-3.

Table 7-3. VP-38 Average Gross Alpha and Beta Particulate Emissions

Sampler Location	Average Concentration (μCi/mL)	
	alpha	beta
Average Concentration =	2.3E-15	3.5E-14

Radionuclide activity fractions for alpha and beta are determined from the average radionuclide concentration data contained in the *St. Louis FUSRAP Internal Dosimetry Technical Basis Manual* (USACE, 1999). The product of each radionuclide activity fraction and the gross concentration provides the radionuclide emission concentration (μCi/cm^3). The gross average concentration (μCi/cm^3) is converted to a release rate (Ci/yr) using Equations (1) and (2) below and illustrated in Table 7-4.

EPA 1989 [page 3-21, (2)] provides Equation (1) for determination of the effective diameter of a non-circular stack or vent.

$$D = (1.3\ A)^{1/2} \qquad \textbf{Equation (1)}$$

where
D is the effective diameter of the release, and
A is the area of the stack, vent or release point.

For VP-38, the area within the perimeter of the air samples is 4050 m^2, resulting in an effective diameter of 73 m.

The average annual wind speed for the St. Louis Lambert International Airport is provided in CAP88-PC as 4.446 meters/second. Conversion of this wind speed to a flow rate through a stack with an effective diameter of 73 m is completed using Equation (2).

$$V\ (m/min) = (4)\ F/\ \pi\ (D)^2 \qquad \textbf{Equation (2)}$$

where
V is the wind velocity (m/min) = 266.76 m/min,

F is the flow rate (m^3/min),
π is a mathematical constant, and
D is the effective diameter of the release determined using Equation (1) above.

Converting the velocity of emissions from the site to an effective flow rate results in a site release flow rate of 1.1 E+6 m^3/min. The product of the flow rate, the average radionuclide concentration for the SLAPS, and the appropriate conversion factors provide the site emission rate for each radionuclide as illustrated in Table 7-4.

Table 7-4. Particulate Radionuclide Emission Rates Based on Site Perimeter Air Samples

Radionuclide	[8]Activity Fraction	[9]Emission Conc. (μCi/cm^3)	[10]Emission Rate (Ci/yr)
U-238	1.27E-01	5.1E-16	1.2E-04
U-235	5.88E-03	2.4E-17	5.7E-06
U-234	1.31E-01	5.2E-16	1.3E-04
Ra-226	2.08E-02	8.3E-17	2.0E-05
Th-232	1.18E-02	4.7E-17	1.1E-05
Th-230	6.78E-01	2.7E-15	6.6E-04
Th-228	6.78E-03	2.7E-17	6.6E-06
[1]Ra-224	6.78E-03	2.7E-17	6.6E-06
[2]Th-234	4.72E-01	1.9E-13	4.7E-02
[3]Pa-234m	4.72E-01	1.9E-13	4.7E-02
[4]Th-231	2.19E-02	9.0E-15	2.2E-03
Ra-228	1.69E-02	6.9E-15	1.7E-03
[5]Ac-228	1.69E-02	6.9E-15	1.7E-03
[6] Pa-231	5.88E-03	2.4E-17	5.7E-06
[7] Ac-227	5.88E-03	2.4E-17	5.7E-06

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.
[8] Derived from the average soil radionuclide concentrations for SLAPS VPs as presented in Table 2-2 of USACE 1999.
[9] Product of gross alpha or beta emission concentration from Table 7-3 and the radionuclide activity fraction.
[10] Emission rate based on 56 day sampling period @ a flow rate of 1.14 E+6 m^3/min. as determined from Equations (1) and (2).

7.7.2 Stack Emissions from USACE Laboratory Operations

There are two potential sources of emissions from laboratory operations:

1. The drying and grinding operations for soil samples, and
2. The dissolution of soil samples.

To obtain an estimate of the emissions that these operations might cause, the methodology in Appendix D of 40 CFR 61, "Methods for Estimating Radionuclide Emissions"

was utilized. For the drying and grinding operations, a factor of 0.001 (applicable to liquids and powders) was applied to the entire annual laboratory inventory to determine the emissions for the year. For the dissolution operation, however, only five grams of any sample are used. Since the dissolution involved heating samples to near boiling temperatures, no adjustment was made to the dissolution inventory to determine the emissions (a factor of 1.0 as specified in Appendix D). To account for the small aliquot utilized, the annual inventory was adjusted by a factor of 0.005 (the ratio of the 5-gram aliquot to the 1-kilogram sample mass) to estimate emissions. The two emission sources were then summed to determine the total laboratory source term.

Note that no credit is taken for emission controls serving the drying and grinding operations, even though Appendix D allows for credit to be taken for the HEPA filters installed on the grinder equipment. The calculated source term therefore provides a conservative basis on which to determine compliance with EPA guidance in 40 CFR 61.

To determine whether the laboratory complies with the 10 mrem/yr limit specified in 40 CFR 61, Subpart I, the annual inventory handled by the laboratory had to be determined. The actual number of samples handled by the laboratory was reported as shown in Table 7-5. With this data, the following equation was used to calculate laboratory emissions from the operations conducted in CY00.

$$\text{Emission Rate (Ci/yr)} = C * N * 1000\,\text{g/sample} * 1E-12\,\text{(Ci/pCi)}$$

where

C = the concentration of a radionuclide of concern in a sample type (pCi/g),
N = the number of samples of that type processed by the laboratory in CY00.

7.7.3 Laboratory Site Total Emission Rates

The Laboratory Site total CY00 emission rates were not input into the EPA codes. The total emission rates are shown in Table 7-5 as the sum of: (1) the measured emission rates from the air samples collected from the perimeter of excavation activities, and (2) calculated emissions from laboratory operations. The measured emission rates from remedial activities at VP-38 and the stack emissions from laboratory operations were input into the CAP88-PC code separately because of the differing input parameters (stack versus area emissions) available in the code. The results of the two evaluations were then summed to calculate total dose to the hypothetical maximally exposed receptor.

Table 7-5. Laboratory Site CY00 Total Emission Rates

Radionuclide	Emission (Ci/yr)
U-238	1.5E-04
U-235	6.8E-06
U-234	1.5E-04
Ra-226	2.3E-05
Th-232	1.2E-05
Th-230	6.7E-04
Th-228	6.8E-06
[1]Ra-224	6.8E-06
[2]Th-234	4.7E-02
[3]Pa-234m	4.7E-02
[4]Th-231	2.2E-03
Ra-228	1.7E-03
[5]Ac-228	1.7E-03
[6] Pa-231	6.8E-06
[7] Ac-227	6.8E-06

[1] Assumed to be in secular equilibrium with parent Th-228.
[2] Assumed to be in secular equilibrium with parent U-238.
[3] Assumed to be in secular equilibrium with parent Th-234.
[4] Assumed to be in secular equilibrium with parent U-235.
[5] Assumed to be in secular equilibrium with parent Ra-228.
[6] Assumed to be in secular equilibrium with parent Th-231.
[7] Assumed to be in secular equilibrium with parent Pa-231.

7.8 CAP88-PC RESULTS

The CAP88-PC report is contained in Appendix B. The area factor input was the total for VP-38 of 4050 m^2. Results show compliance with the 10 mrem/yr criterion for all critical receptors. Table 7-6 summarizes the results.

Table 7-6. SLAPS CAP88-PC Results for Critical Receptors

Receptor	Direction from site	Distance (m)	(mrem/yr)
Nearest Resident	E	830	0.6
School[1]	SE	1950	< 0.1
Business[1]	S	60	2.5
Farm	E	830	0.6

[1] Corrected for the 23 percent occupancy factor (50 weeks/yr 40 hours/wk).

8.0 REFERENCES

EPA 1989. EPA 520/1-89-002, *A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions From NRC-Licensed and Non-DOE Federal Facilities*, U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC, October.

EPA 1997a. CAP88-PC Version 2.0 Computer Code, U.S. Environmental Protection Agency.

EPA 1997b. CAP88-PC Version 2.0 User's Guide, U.S. Environmental Protection Agency, June 1997.

EPA 1998. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, September.

NRC 1987. Regulatory Guide 3.59, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March.

USACE 1999. *St. Louis-FUSRAP Internal Dosimetry Technical Basis Manual.* U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP, November.

USACE 2001. *Federal Facilities Agreement Progress Report for USACE St. Louis FUSRAP Sites*. U.S. Army Corps of Engineers, St. Louis District Office, FUSRAP.

40 CFR 61, Subpart I. *National Emission Standards for Radionuclide Emissions From Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H.*

40 CFR 61 Appendix E. *Compliance Procedures Methods for Determining Compliance with Subpart I.*

APPENDIX A

CALCULATED EMISSION RATES FROM SLS PROPERTIES

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.**													
2														
3	**SLAPS**	**Nuclide**											**Total Area Release Rate (Ci/y)**	**Total SLAPS Emissions (Ci/y)**
4	**Env. Air Sampling**												**Env. Air Sampling**	**Env. Air Sampling**
5	Exc and Insitu	U-238											3.8E-03	3.8E-03
6	Exc and Insitu	U-235											1.8E-04	1.8E-04
7	Exc and Insitu	U-234											3.9E-03	3.9E-03
8	Exc and Insitu	Ra-226											3.5E-03	3.5E-03
9	Exc and Insitu	Th-232											2.7E-04	2.7E-04
10	Exc and Insitu	Th-230											3.8E-02	3.8E-02
11	Exc and Insitu	Th-228											1.6E-04	1.6E-04
12	Exc and Insitu	Ra-224											1.6E-04	1.6E-04
13	Exc and Insitu	Th-234											2.4E-02	2.4E-02
14	Exc and Insitu	Pa-234m											2.4E-02	2.4E-02
15	Exc and Insitu	Th-231											1.1E-03	1.1E-03
16	Exc and Insitu	Ra-228											7.8E-04	7.8E-04
17	Exc and Insitu	Ac-228											7.8E-04	7.8E-04
18	Exc and Insitu	Pa-231											1.8E-04	1.8E-04
19	Exc and Insitu	Ac-227											1.8E-04	1.8E-04
20														
21	**SLDS**	**Nuclide**											**Total Area Release Rate (Ci/y)**	**Total SLDS Emissions (Ci/y)**
22	**Plant 1 Air Sampling**												**Plant 1 Air Sampling**	**Plant 1 & 2 Air Sampling**
23	Exc and Insitu	U-238											1.7E-05	1.2E-04
24	Exc and Insitu	U-235											7.5E-07	5.7E-06
25	Exc and Insitu	U-234											1.7E-05	1.2E-04
26	Exc and Insitu	Ra-226											6.6E-05	6.7E-05
27	Exc and Insitu	Th-232											1.7E-06	1.8E-06
28	Exc and Insitu	Th-230											1.3E-05	3.5E-05
29	Exc and Insitu	Th-228											1.7E-06	1.8E-06
30	Exc and Insitu	Ra-224											1.7E-06	1.8E-06
31	Exc and Insitu	Th-234											4.9E-04	1.9E-03
32	Exc and Insitu	Pa-234m											4.9E-04	1.9E-03
33	Exc and Insitu	Th-231											2.2E-05	9.1E-05
34	Exc and Insitu	Ra-228											4.9E-05	5.2E-05
35	Exc and Insitu	Ac-228											4.9E-05	5.2E-05
36	Exc and Insitu	Pa-231											7.0E-06	6.6E-05
37	Exc and Insitu	Ac-227											5.4E-07	5.5E-06
38														
39	**SLDS**	**Nuclide**											**Total Area Release Rate (Ci/y)**	
40	**Plant 2 Air Sampling**												**Plant 2 Air Sampling**	
41	Exc and Insitu	U-238											1.0E-04	
42	Exc and Insitu	U-235											4.9E-06	
43	Exc and Insitu	U-234											1.0E-04	
44	Exc and Insitu	Ra-226											1.0E-06	
45	Exc and Insitu	Th-232											1.7E-07	
46	Exc and Insitu	Th-230											2.2E-05	
47	Exc and Insitu	Th-228											1.7E-07	
48	Exc and Insitu	Ra-224											1.7E-07	
49	Exc and Insitu	Th-234											1.5E-03	
50	Exc and Insitu	Pa-234m											1.5E-03	
51	Exc and Insitu	Th-231											6.8E-05	
52	Exc and Insitu	Ra-228											2.7E-06	
53	Exc and Insitu	Ac-228											2.7E-06	
54	Exc and Insitu	Pa-231											5.9E-05	
55	Exc and Insitu	Ac-227											4.9E-06	
56														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.**													
57	**HISS**	**Nuclide**	**Avg Concentration (pCi/g)**	**SA (m^2)**	**Cover Factor**	***In Situ* Emission Rate (Ci/y)**	**Avg. Exc. Conc. (pCi/g)**	**Excavation Volume (yd^3)**	**Exc. Emis. Factor (lb/yd^3)**	**Emission Reduction Factor**	**Excavation Release Rate (Ci/y)**	**Excavation Emission Rate (Ci/y)**	**Total Area Release Rate (Ci/y)**	**Total HISS Emissions (Ci/y)**
58	**North Spoils**		**North Spoils**			**North Spoils**	**North Spoils**				**North Spoils**	**Total Emissions from HISS Exc**	**InSitu and Excavations**	
59	Exc and InSitu	U-238	140.0	1022	0.96	2.2E-06	140.0	3390	0.04	0.50	4.31E-06	7.01E-06	6.5E-06	6.7E-04
60	Exc and InSitu	U-235	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	3.32E-07	3.0E-07	3.1E-05
61	Exc and InSitu	U-234	140.0	1022	0.96	2.2E-06	140.0	3390	0.04	0.50	4.31E-06	7.01E-06	6.5E-06	6.7E-04
62	Exc and InSitu	Ra-226	27.0	1022	0.96	4.2E-07	27.0	3390	0.04	0.50	8.31E-07	3.14E-06	1.2E-06	8.8E-05
63	Exc and InSitu	Th-232	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	9.90E-07	3.0E-07	1.7E-05
64	Exc and InSitu	Th-230	52.0	1022	0.96	8.0E-07	52.0	3390	0.04	0.50	1.60E-06	7.35E-06	2.4E-06	2.1E-04
65	Exc and InSitu	Th-228	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	9.90E-07	3.0E-07	1.7E-05
66	Exc and InSitu	Ra-224	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	9.90E-07	3.0E-07	1.7E-05
67	Exc and InSitu	Th-234	140.0	1022	0.96	2.2E-06	140.0	3390	0.04	0.50	4.31E-06	7.01E-06	6.5E-06	1.1E-02
68	Exc and InSitu	Pa-234m	140.0	1022	0.96	2.2E-06	140.0	3390	0.04	0.50	4.31E-06	7.01E-06	6.5E-06	1.1E-02
69	Exc and InSitu	Th-231	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	3.32E-07	3.0E-07	5.0E-04
70	Exc and InSitu	Ra-228	27.0	1022	0.96	4.2E-07	27.0	3390	0.04	0.50	8.31E-07	3.14E-06	1.2E-06	1.9E-04
71	Exc and InSitu	Ac-228	27.0	1022	0.96	4.2E-07	27.0	3390	0.04	0.50	8.31E-07	3.14E-06	1.2E-06	1.9E-04
72	Exc and InSitu	Pa-231	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	3.32E-07	3.0E-07	3.1E-05
73	Exc and InSitu	Ac-227	6.6	1022	0.96	1.0E-07	6.6	3390	0.04	0.50	2.03E-07	3.32E-07	3.0E-07	3.1E-05
74														
75	**HISS**	**Nuclide**	**Avg Concentration (pCi/g)**	**SA (m^2)**	**Cover Factor**	***In Situ* Emission Rate (Ci/y)**	**Avg. Exc. Conc. (pCi/g)**	**Excavation Volume (yd^3)**	**Exc. Emis. Factor (lb/yd^3)**	**Emission Reduction Factor**	**Excavation Release Rate (Ci/y)**		**Total Area Release Rate (Ci/y)**	
76	**South Spoils**		**South Spoils**			**South Spoils**	**South Spoils**				**South Spoils**		**InSitu and Excavations**	
77	Exc and InSitu	U-238	21.0	1196	0.96	3.8E-07	21.0	2705	0.04	0.50	5.16E-07		8.9E-07	
78	Exc and InSitu	U-235	1.0	1198	0.96	1.8E-08	1.0	2705	0.04	0.50	2.46E-08		4.3E-08	
79	Exc and InSitu	U-234	21.0	1198	0.96	3.8E-07	21.0	2705	0.04	0.50	5.16E-07		8.9E-07	
80	Exc and InSitu	Ra-226	13.0	1198	0.96	2.3E-07	13.0	2705	0.04	0.50	3.19E-07		5.5E-07	
81	Exc and InSitu	Th-232	5.0	1196	0.96	9.0E-06	5.0	2705	0.04	0.50	1.23E-07		2.1E-07	
82	Exc and InSitu	Th-230	14.0	1198	0.96	2.5E-07	14.0	2705	0.04	0.50	3.44E-07		6.0E-07	
83	Exc and InSitu	Th-228	5.0	1198	0.96	9.0E-08	5.0	2705	0.04	0.50	1.23E-07		2.1E-07	
84	Exc and InSitu	Ra-224	5.0	1198	0.96	9.0E-08	5.0	2705	0.04	0.50	1.23E-07		2.1E-07	
85	Exc and InSitu	Th-234	21.0	1198	0.96	3.8E-07	21.0	2705	0.04	0.50	5.16E-07		8.9E-07	
86	Exc and InSitu	Pa-234m	21.0	1198	0.96	3.8E-07	21.0	2705	0.04	0.50	5.16E-07		8.9E-07	
87	Exc and InSitu	Th-231	1.0	1198	0.96	1.8E-08	1.0	2705	0.04	0.50	2.46E-08		4.3E-08	
88	Exc and InSitu	Ra-228	13.0	1198	0.96	2.3E-07	13.0	2705	0.04	0.50	3.19E-07		5.5E-07	
89	Exc and InSitu	Ac-228	13.0	1198	0.96	2.3E-07	13.0	2705	0.04	0.50	3.19E-07		5.5E-07	
90	Exc and InSitu	Pa-231	1.0	1198	0.96	1.8E-08	1.0	2705	0.04	0.50	2.46E-08		4.3E-08	
91	Exc and InSitu	Ac-227	1.0	1198	0.96	1.8E-08	1.0	2705	0.04	0.50	2.46E-08		4.3E-08	
92														
93	**HISS**	**Nuclide**	**Avg Concantration (pCi/g)**	**SA (m^2)**	**Cover Facter**	***In Situ* Emission Rate (Ci/y)**	**Avg. Exc. Conc. (pCi/g)**	**Excavation Volume (yd^3)**	**Exc. Emis. Facter (lb/yd^3)**	**Emission Reduction Factor**	**Excavation Release Rate (Ci/y)**		**Total Area Release Rate (Ci/y)**	
94	**East Piles**		**East Piles**			**East Piles**	**East Piles**		**East Piles**		**East Piles**		**East Piles**	
95	Exc and InSitu	U-238	23.0	5,244	0.93	3.2E-06	23.0	10441	0.04	0.50	2.18E-06		5.4E-06	
96	Exc and InSitu	U-235	1.1	5,244	0.93	1.5E-07	1.1	10441	0.04	0.50	1.04E-07		2.6E-07	
97	Exc and InSitu	U-234	23.0	5,244	0.93	3.2E-06	23.0	10441	0.04	0.50	2.18E-06		5.4E-06	
98	Exc and InSitu	Ra-226	21.0	5,244	0.93	2.9E-06	21.0	10441	0.04	0.50	1.99E-06		4.9E-06	
99	Exc and InSitu	Th-232	7.0	5,244	0.93	9.7E-07	7.0	10441	0.04	0.50	6.64E-07		1.6E-06	
100	Exc and InSitu	Th-230	57.0	5,244	0.93	7.9E-06	57.0	10441	0.04	0.50	5.40E-06		1.3E-05	
101	Exc and InSitu	Th-228	7.0	5,244	0.93	9.7E-07	7.0	10441	0.04	0.50	6.64E-07		1.6E-06	
102	Exc and InSitu	Ra-224	7.0	5,244	0.93	9.7E-07	7.0	10441	0.04	0.50	6.64E-07		1.6E-06	
103	Exc and InSitu	Th-234	23.0	5,244	0.93	3.2E-06	23.0	10441	0.04	0.50	2.18E-06		5.4E-06	
104	Exc and InSitu	Pa-234m	23.0	5,244	0.93	3.2E-06	23.0	10441	0.04	0.50	2.18E-06		5.4E-06	
105	Exc and InSitu	Th-231	1.1	5,244	0.93	1.5E-07	1.1	10441	0.04	0.50	1.04E-07		2.6E-07	
106	Exc and InSitu	Ra-228	21.0	5,244	0.93	2.9E-06	21.0	10441	0.04	0.50	1.99E-06		4.9E-06	
107	Exc and InSitu	Ac-228	21.0	5,244	0.93	2.9E-06	21.0	10441	0.04	0.50	1.99E-06		4.9E-06	
108	Exc and InSitu	Pa-231	1.1	5,244	0.93	1.5E-07	1.1	10441	0.04	0.50	1.04E-07		2.6E-07	
109	Exc and InSitu	Ac-227	1.1	5,244	0.93	1.5E-07	1.1	10441	0.04	0.50	1.04E-07		2.6E-07	
110														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.**													
111	**HISS InSitu Outside Piles**	**Nuclide**	**Avg Concentration (pCi/g) InSitu Outside Piles**	**SA (m^2)**	**Cover Factor**	***In Situ* Emission Rate (Ci/y) InSitu Outside Piles**							**Total Area Release Rate (Ci/y) InSitu Outside Piles**	
113	Insitu	U-238	80.5	10318	0.56	8.1E-05							8.1E-05	
114	Insitu	U-235	3.8	10318	0.56	3.8E-06							3.8E-06	
115	Insitu	U-234	80.5	10318	0.56	8.1E-05							8.1E-05	
116	Insitu	Ra-226	20.0	10318	0.56	2.0E-05							2.0E-05	
117	Insitu	Th-232	5.8	10318	0.56	5.8E-06							5.8E-06	
118	Insitu	Th-230	33.0	10318	0.56	3.3E-05							3.3E-05	
119	Insitu	Th-228	5.8	10318	0.56	5.8E-06							5.8E-06	
120	Insitu	Ra-224	5.8	10318	0.56	5.8E-06							5.8E-06	
121	Insitu	Th-234	80.5	10318	0.56	8.1E-05							8.1E-05	
122	Insitu	Pa-234m	80.5	10318	0.56	8.1E-05							8.1E-05	
123	Insitu	Th-231	3.8	10318	0.56	3.8E-06							3.8E-06	
124	Insitu	Ra-228	20.0	10318	0.56	2.0E-05							2.0E-05	
125	Insitu	Ac-228	20.0	10318	0.56	2.0E-05							2.0E-05	
126	Insitu	Pa-231	3.8	10318	0.56	3.8E-06							3.8E-06	
127	Insitu	Ac-227	3.8	10318	0.56	3.8E-06							3.8E-06	
129	**HISS**	**Nuclide**											**Total Area Release Rate (Ci/y)**	
130	**Env. Air Sampling**												**Env. Air Sampling**	
131	Exc and Insitu	U-238											5.7E-04	
132	Exc and Insitu	U-235											2.7E-05	
133	Exc and Insitu	U-234											5.7E-04	
134	Exc and Insitu	Ra-226											6.1E-05	
135	Exc and Insitu	Th-232											8.8E-06	
136	Exc and Insitu	Th-230											1.6E-04	
137	Exc and Insitu	Th-228											8.8E-06	
138	Exc and Insitu	Ra-224											8.8E-06	
139	Exc and Insitu	Th-234											1.1E-02	
140	Exc and Insitu	Pa-234m											1.1E-02	
141	Exc and Insitu	Th-231											5.0E-04	
142	Exc and Insitu	Ra-228											1.6E-04	
143	Exc and Insitu	Ac-228											1.6E-04	
144	Exc and Insitu	Pa-231											2.7E-05	
145	Exc and Insitu	Ac-227											2.7E-05	
147	**Laboratory Site**	**Nuclide**											**Total Area Release Rate (Ci/y)**	**Total Lab Emissions (Ci/y)**
148	**VP-38 Air Sampling**												**VP-38 Air Sampling**	**VP-38 and Stack Emissions**
149	Exc and Insitu	U-238											1.2E-04	1.5E-04
150	Exc and Insitu	U-235											5.7E-06	6.8E-06
151	Exc and Insitu	U-234											1.3E-04	1.5E-04
152	Exc and Insitu	Ra-226											2.0E-05	2.3E-05
153	Exc and Insitu	Th-232											1.1E-05	1.2E-05
154	Exc and Insitu	Th-230											6.6E-04	6.7E-04
155	Exc and Insitu	Th-228											6.6E-06	6.8E-06
156	Exc and Insitu	Ra-224											6.6E-06	6.8E-06
157	Exc and Insitu	Th-234											4.7E-02	4.7E-02
158	Exc and Insitu	Pa-234m											4.7E-02	4.7E-02
159	Exc and Insitu	Th-231											2.2E-03	2.2E-03
160	Exc and Insitu	Ra-228											1.7E-03	1.7E-03
161	Exc and Insitu	Ac-228											1.7E-03	1.7E-03
162	Exc and Insitu	Pa-231											5.7E-06	6.8E-06
163	Exc and Insitu	Ac-227											5.7E-06	6.8E-06

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Table 2. St. Louis FUSRAP Area Radionuclide Release Rates.**													
165	**Laboratory**	**Nuclide**											**Total Area Release Rate (Ci/y)**	
166	**Stack Emissions**												**Stack Emissions**	
167	Stack emissions	U-238											2.35E-05	
168	Stack emissions	U-235											1.10E-06	
169	Stack emissions	U-234											2.35E-05	
170	Stack emissions	Ra-226											2.49E-06	
171	Stack emissions	Th-232											2.69E-07	
172	Stack emissions	Th-230											9.05E-06	
173	Stack emissions	Th-228											2.60E-07	
174	Stack emissions	Ra-224											2.60E-07	
175	Stack emissions	Th-234											2.35E-05	
176	Stack emissions	Pa-234m											2.35E-05	
177	Stack emissions	Th-231											1.10E-06	
178	Stack emissions	Ra-228											2.56E-07	
179	Stack emissions	Ac-228											2.56E-07	
180	Stack emissions	Pa-231											1.10E-06	
181	Stack emissions	Ac-227											1.10E-06	

Table 3. St. Louis FUSRAP Sites Annual Radionuclide Emissions (Ci/y)[1]

Radionuclide	SLAPS	SLDS	HISS	LAB
U-238	3.8E-03	1.2E-04	6.7E-04	2.3E-05
U-235	1.8E-04	5.7E-06	3.1E-05	1.1E-06
U-234	3.9E-03	1.2E-04	6.7E-04	2.3E-05
Ra-226	3.5E-03	6.7E-05	8.8E-05	2.5E-06
Th-232	2.7E-04	1.8E-06	1.7E-05	2.7E-07
Th-230	3.8E-02	3.5E-05	2.1E-04	9.1E-06
Th-228	1.6E-04	1.8E-06	1.7E-05	2.6E-07
Ra-224	1.6E-04	1.8E-06	1.7E-05	2.6E-07
Th-234	2.4E-02	1.9E-03	1.1E-02	2.3E-05
Pa-234m	2.4E-02	1.9E-03	1.1E-02	2.3E-05
Th-231	1.1E-03	9.1E-05	5.0E-04	1.1E-06
Ra-228	7.8E-04	5.2E-05	1.9E-04	2.6E-07
Ac-228	7.8E-04	5.2E-05	1.9E-04	2.6E-07

1 Total emission rates from SLDS, HISS and the LAB are not usec to demonstrate compliance with NESHAPS.
The total area release rates are used in individual CAP88-PC rur s and results summed to demonstrate compliance.

Emission Reduction Factors for Calculated *In Situ* Emissions[1]

Area	Suraface Area (m^2)	Cover [6]	Active Exc	Backfilled	[2]Reduction Factor
[3]HISS East Piles	5,244	30%	12%	58%	0.93
[4]HISS Spoils Piles	2220	22%	3%	75%	0.96
[5] HISS Site	10318	75%	0	0	0.56

[1] The reduction factor is calculated by taking the sum of: site status percentaga * cover factor
[2] Reduction Factor calculated as sum of the products for each quarter: Sum_q = (covar fraction*cover factor from Reg Guide 3.59 Appendix C*time factor)$_q$, for all quarters q.
[3] Reduction Factor Calculation: (0.3*0.75)+(0.12*1)+(0.58*1) = 0.93
[4] Reduction Factor Calculation: (0.22*0.8)+(0.03*1)+(0.75*1) = 0.96
[5] Reduction Factor Calculation: (0.75*0.75) = 0.56
[6] Cover factors = vegetative cover (0.75); ConCover (0.80); Backfill & Active Remediation (1.0)

Table 1. *In Situ* Windblown Particle Emissions

Wind Velocity Group (knots)	Frequency (F_s)	Rasuspension Rate, R_s (g/m^2-s)	F_sR_s	E_w (g/m^2-y)
0 to 3	0.10	0	0	3.77E+02
4 to 7	0.29	0	0	
8 to 12	0.36	3.92E-07	1.41E-07	
13 to 18	0.21	9.68E-06	2.03E-06	
19 to 24	0.03	5.71E-05	1.71E-06	
25 to 31	0.01	2.08E-04	2.08E-06	
		Sum=	5.97E-06	

APPENDIX B

CAP88-PC RUNS FOR SLS PROPERTIES

C A P 8 8 - P C

Version 2.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 27, 2001 08:11 am

Facility: SLDS
Address: Broadway Ave
City: St. Louis
State: MO Zip: 63120

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Excavation Emissions from Plant 2 by Air Sampling

Dataset Name: Plant 2
Dataset Date: Mar 27, 2001 08:11 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	5.94E-03
BREAST	1.54E-03
R MAR	3.20E-01
LUNGS	3.04E+00
THYROID	1.28E-03
ENDOST	4.00E+00
RMNDR	2.84E-02
EFFEC	5.34E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	1.01E-02
INHALATION	5.23E-01
AIR IMMERSION	1.26E-07
GROUND SURFACE	4.19E-04
INTERNAL	5.33E-01
EXTERNAL	4.19E-04
TOTAL	5.34E-01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	9.95E-02
U-234	1.12E-01
U-235	5.19E-03
TH-230	4.62E-02
TH-231	5.75E-07
TH-232	5.14E-04
TH-234	6.24E-04
TH-228	3.60E-04
RA-224	5.02E-06
RA-226	9.98E-05
RA-228	8.97E-05
PA-234M	5.69E-08
AC-228	1.96E-06
AC-227	2.64E-02
PA-231	2.43E-01
TOTAL	5.34E-01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	2.54E-07
BONE	1.61E-07
THYROID	3.03E-10
BREAST	3.48E-09
LUNG	4.37E-06
STOMACH	1.88E-09
BOWEL	4.02E-09
LIVER	6.59E-08
PANCREAS	1.12E-09
URINARY	1.39E-08
OTHER	1.37E-09
TOTAL	4.87E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	4.03E-08
INHALATION	4.82E-06
AIR IMMERSION	2.89E-12
GROUND SURFACE	9.68E-09
INTERNAL	4.86E-06
EXTERNAL	9.68E-09
TOTAL	4.87E-06

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.32E-06
U-234	1.47E-06
U-235	6.97E-08
TH-230	3.81E-07
TH-231	1.68E-11
TH-232	2.90E-09
TH-234	2.80E-08
TH-228	7.24E-09
RA-224	1.14E-10
RA-226	1.80E-09
RA-228	1.17E-09
PA-234M	1.45E-12
AC-228	3.96E-11
AC-227	2.29E-07
PA-231	1.36E-06
TOTAL	4.87E-06

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	267	970	4500
N	5.3E-01	5.3E-02	1.1E-02
NNW	2.8E-01	3.1E-02	9.1E-03
NW	3.3E-01	3.5E-02	9.4E-03
WNW	4.0E-01	4.1E-02	9.9E-03
W	3.0E-01	3.3E-02	9.2E-03
WSW	1.5E-01	1.9E-02	8.2E-03
SW	2.1E-01	2.4E-02	8.5E-03
SSW	2.6E-01	2.8E-02	8.9E-03
S	2.2E-01	2.6E-02	8.7E-03
SSE	1.6E-01	2.1E-02	8.3E-03
SE	2.3E-01	2.7E-02	8.8E-03
ESE	3.8E-01	4.0E-02	9.8E-03
E	5.1E-01	5.0E-02	1.0E-02
ENE	4.2E-01	4.2E-02	9.9E-03
NE	2.6E-01	2.9E-02	8.9E-03
NNE	2.2E-01	2.5E-02	8.7E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 267	970	4500
N	4.9E-06	4.5E-07	6.2E-08
NNW	2.5E-06	2.5E-07	4.6E-08
NW	3.0E-06	2.8E-07	4.9E-08
WNW	3.6E-06	3.4E-07	5.3E-08
W	2.7E-06	2.6E-07	4.7E-08
WSW	1.3E-06	1.4E-07	3.8E-08
SW	1.9E-06	1.9E-07	4.1E-08
SSW	2.3E-06	2.2E-07	4.4E-08
S	2.0E-06	2.0E-07	4.3E-08
SSE	1.4E-06	1.5E-07	3.9E-08
SE	2.0E-06	2.1E-07	4.3E-08
ESE	3.5E-06	3.3E-07	5.2E-08
E	4.6E-06	4.2E-07	5.9E-08
ENE	3.8E-06	3.5E-07	5.4E-08
[illegible]	2.3E-06	2.3E-07	4.4E-08
	1.9E-06	2.0E-07	4.2E-08

C A P 8 8 - P C

Version 2.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 17, 2001 07:26 am

Facility: Hazelwood Interim Storage Site (HISS)
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: CY00 Emissions from Air Sampling Oct - Dec

Dataset Name: HISS AIR
Dataset Date: Mar 17, 2001 07:26 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	1.73E-01
BREAST	1.22E-01
R MAR	2.46E+00
LUNGS	5.49E+01
THYROID	1.19E-01
ENDOST	2.99E+01
RMNDR	4.73E-01
EFFEC	7.99E+00

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	1.57E-01
INHALATION	7.74E+00
AIR IMMERSION	7.05E-06
GROUND SURFACE	9.11E-02
INTERNAL	7.90E+00
EXTERNAL	9.11E-02
TOTAL	7.99E+00

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	2.37E+00
TH-234	1.97E-02
PA-234M	1.51E-04
U-234	2.67E+00
TH-230	1.40E+00
RA-226	2.61E-02
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	7.19E-03
BI-214	3.80E-02
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	2.38E-04
TH-232	1.11E-01
RA-228	2.32E-02
AC-228	1.71E-02
TH-228	7.80E-02
RA-224	1.28E-03
RN-220	9.41E-06
PO-216	2.50E-07
PB-212	2.84E-03
BI-212	3.12E-03
TL-208	1.90E-02
U-235	1.20E-01
TH-231	1.76E-05
AC-227	6.10E-01
PA-231	4.66E-01
TOTAL	7.99E+00

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	2.28E-06
BONE	1.34E-06
THYROID	4.86E-08
BREAST	4.26E-07
LUNG	8.72E-05
STOMACH	2.73E-07
BOWEL	2.34E-07
LIVER	9.90E-07
PANCREAS	1.77E-07
URINARY	4.45E-07
OTHER	2.16E-07
TOTAL	9.37E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	9.37E-05

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	8.40E-07
INHALATION	9.06E-05
AIR IMMERSION	1.66E-10
GROUND SURFACE	2.19E-06
INTERNAL	9.15E-05
EXTERNAL	2.19E-06
TOTAL	9.37E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	9.37E-05

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	3.15E-05
TH-234	8.64E-07
PA-234M	3.62E-09
U-234	3.51E-05
TH-230	1.16E-05
RA-226	4.62E-07
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	1.70E-07
BI-214	9.21E-07
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	1.26E-09
TH-232	6.28E-07
RA-228	2.96E-07
AC-228	4.08E-07
TH-228	1.57E-06
RA-224	2.91E-08
RN-220	2.25E-10
PO-216	6.00E-12
PB-212	6.62E-08
BI-212	7.51E-08
TL-208	4.64E-07
U-235	1.60E-06
TH-231	5.15E-10
AC-227	5.28E-06
PA-231	2.59E-06
TOTAL	9.37E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	9.37E-05

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

Direction	Distance (m) 110	1300	2100
N	6.5E+00	2.2E-01	1.6E-01
NNW	7.2E+00	1.7E-01	1.4E-01
NW	6.7E+00	1.8E-01	1.5E-01
WNW	6.3E+00	1.9E-01	1.5E-01
W	5.4E+00	1.7E-01	1.4E-01
WSW	4.5E+00	1.5E-01	1.3E-01
SW	4.1E+00	1.6E-01	1.4E-01
SSW	4.2E+00	1.7E-01	1.4E-01
S	4.1E+00	1.6E-01	1.4E-01
SSE	4.2E+00	1.5E-01	1.3E-01
SE	5.2E+00	1.6E-01	1.4E-01
ESE	7.0E+00	1.9E-01	1.5E-01
E	8.0E+00	2.1E-01	1.6E-01
ENE	7.4E+00	2.0E-01	1.5E-01
	6.3E+00	1.7E-01	1.4E-01
	6.6E+00	1.6E-01	1.4E-01

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 110	1300	2100
N	7.6E-05	1.8E-06	1.2E-06
NNW	8.4E-05	1.3E-06	9.1E-07
NW	7.8E-05	1.3E-06	9.5E-07
WNW	7.4E-05	1.5E-06	1.0E-06
W	6.4E-05	1.3E-06	9.2E-07
WSW	5.3E-05	9.5E-07	7.8E-07
SW	4.8E-05	1.1E-06	8.3E-07
SSW	4.9E-05	1.2E-06	8.8E-07
S	4.8E-05	1.1E-06	8.5E-07
SSE	4.9E-05	9.8E-07	7.9E-07
SE	6.1E-05	1.1E-06	8.6E-07
ESE	8.2E-05	1.5E-06	1.0E-06
E	9.4E-05	1.7E-06	1.1E-06
ENE	8.7E-05	1.5E-06	1.0E-06
NE	7.4E-05	1.2E-06	8.8E-07
NNE	7.7E-05	1.1E-06	8.5E-07

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Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 17, 2001 08:21 pm

Facility: VP-38
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Evaluation VP-38 Excavation Emissions

Dataset Name: VP-38 Emissions
Dataset Date: Mar 17, 2001 08:21 pm
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	1.45E+00
BREAST	1.35E+00
R MAR	1.75E+01
LUNGS	1.02E+02
THYROID	1.34E+00
ENDOST	2.06E+02
RMNDR	1.74E+00
EFFEC	2.16E+01

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	4.72E-01
INHALATION	2.01E+01
AIR IMMERSION	1.41E-04
GROUND SURFACE	1.01E+00
INTERNAL	2.06E+01
EXTERNAL	1.01E+00
TOTAL	2.16E+01

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	1.34E+00
TH-234	2.22E-01
PA-234M	1.72E-03
U-234	1.63E+00
TH-230	1.55E+01
RA-226	2.28E-02
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	9.01E-03
BI-214	4.77E-02
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	1.28E-04
TH-232	3.72E-01
RA-228	6.46E-01
AC-228	3.92E-01
TH-228	1.58E-01
RA-224	6.48E-03
RN-220	2.12E-04
PO-216	5.63E-06
PB-212	6.40E-02
BI-212	7.03E-02
TL-208	4.28E-01
TH-231	2.08E-04
U-235	6.76E-02
AC-227	3.45E-01
PA-231	2.63E-01
TOTAL	2.16E+01

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	1.71E-05
BONE	9.41E-06
THYROID	5.43E-07
BREAST	4.69E-06
LUNG	1.74E-04
STOMACH	3.07E-06
BOWEL	2.51E-06
LIVER	4.09E-06
PANCREAS	2.00E-06
URINARY	1.42E-06
OTHER	2.45E-06
TOTAL	2.21E-04

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	2.21E-04

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.17E-06
INHALATION	1.93E-04
AIR IMMERSION	3.34E-09
GROUND SURFACE	2.44E-05
INTERNAL	1.97E-04
EXTERNAL	2.44E-05
TOTAL	2.21E-04

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	2.21E-04

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.78E-05
TH-234	9.86E-06
PA-234M	4.13E-08
U-234	2.15E-05
TH-230	1.28E-04
RA-226	4.07E-07
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	2.13E-07
BI-214	1.15E-06
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	6.77E-10
TH-232	2.10E-06
RA-228	8.33E-06
AC-228	9.37E-06
TH-228	3.17E-06
RA-224	1.50E-07
RN-220	5.07E-09
PO-216	1.35E-10
PB-212	1.49E-06
BI-212	1.69E-06
TL-208	1.05E-05
TH-231	6.08E-09
U-235	9.07E-07
AC-227	2.99E-06
PA-231	1.47E-06
TOTAL	2.21E-04

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	2.21E-04

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	60	830	1950
N	1.8E+01	5.8E-01	4.1E-01
NNW	1.9E+01	4.7E-01	3.8E-01
NW	1.7E+01	4.9E-01	3.8E-01
WNW	1.7E+01	5.2E-01	3.9E-01
W	1.4E+01	4.8E-01	3.8E-01
WSW	1.1E+01	4.1E-01	3.7E-01
SW	1.0E+01	4.4E-01	3.7E-01
SSW	1.1E+01	4.6E-01	3.8E-01
S	1.1E+01	4.5E-01	3.7E-01
SSE	1.0E+01	4.2E-01	3.7E-01
SE	1.3E+01	4.5E-01	3.8E-01
ESE	1.9E+01	5.1E-01	3.9E-01
E	2.2E+01	5.6E-01	4.0E-01
ENE	1.9E+01	5.3E-01	3.9E-01
[illegible]	1.5E+01	4.6E-01	3.8E-01
[illegible]	1.7E+01	4.4E-01	3.7E-01

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	60	830	1950
N	1.8E-04	4.7E-06	2.9E-06
NNW	1.9E-04	3.6E-06	2.7E-06
NW	1.7E-04	3.8E-06	2.7E-06
WNW	1.8E-04	4.1E-06	2.8E-06
W	1.4E-04	3.7E-06	2.7E-06
WSW	1.1E-04	3.0E-06	2.5E-06
SW	1.0E-04	3.2E-06	2.6E-06
SSW	1.2E-04	3.5E-06	2.6E-06
S	1.1E-04	3.3E-06	2.6E-06
SSE	1.0E-04	3.1E-06	2.5E-06
SE	1.3E-04	3.4E-06	2.6E-06
ESE	1.9E-04	4.0E-06	2.8E-06
E	2.2E-04	4.5E-06	2.9E-06
ENE	2.0E-04	4.2E-06	2.8E-06
NE	1.5E-04	3.5E-06	2.6E-06
NNE	1.7E-04	3.3E-06	2.6E-06

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Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 17, 2001 08:28 am

Facility: USACE FUSRAP Radioanalytical Laboratory
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Stack
Source Type: Stack
Emission Year: 2000

Comments: Evaluation of CY00 Lab Radionuclide Emissions

Dataset Name: Lab2000
Dataset Date: Mar 17, 2001 08:27 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	6.78E-03
BREAST	4.25E-03
R MAR	1.52E-01
LUNGS	3.04E+00
THYROID	4.12E-03
ENDOST	1.87E+00
RMNDR	2.01E-02
EFFEC	4.48E-01

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	6.10E-03
INHALATION	4.39E-01
AIR IMMERSION	2.53E-08
GROUND SURFACE	3.14E-03
INTERNAL	4.45E-01
EXTERNAL	3.14E-03
TOTAL	4.48E-01

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	1.28E-01
TH-234	5.17E-05
PA-234M	4.37E-07
U-234	1.44E-01
TH-230	1.02E-01
RA-226	1.30E-03
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	3.95E-04
BI-214	2.09E-03
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	1.01E-05
TH-232	4.38E-03
RA-228	4.43E-05
AC-228	1.75E-04
TH-228	2.96E-03
RA-224	4.33E-05
RN-220	1.03E-07
PO-216	2.73E-09
PB-212	3.10E-05
BI-212	3.40E-05
TL-208	2.07E-04
TH-231	4.99E-08
U-235	6.23E-03
AC-227	3.18E-02
PA-231	2.42E-02
TOTAL	4.48E-01

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	1.35E-07
BONE	8.29E-08
THYROID	1.67E-09
BREAST	1.48E-08
LUNG	4.79E-06
STOMACH	9.09E-09
BOWEL	5.40E-09
LIVER	4.65E-08
PANCREAS	6.04E-09
URINARY	1.82E-08
OTHER	7.39E-09
TOTAL	5.12E-06

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	5.12E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.03E-08
INHALATION	5.01E-06
AIR IMMERSION	5.94E-13
GROUND SURFACE	7.54E-08
INTERNAL	5.04E-06
EXTERNAL	7.54E-08
TOTAL	5.12E-06

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	5.12E-06

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.70E-06
TH-234	2.38E-09
PA-234M	1.05E-11
U-234	1.90E-06
TH-230	8.45E-07
RA-226	2.39E-08
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	9.33E-09
BI-214	5.05E-08
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	5.38E-11
TH-232	2.47E-08
RA-228	5.89E-10
AC-228	4.21E-09
TH-228	5.94E-08
RA-224	9.81E-10
RN-220	2.45E-12
PO-216	6.55E-14
PB-212	7.21E-10
BI-212	8.19E-10
TL-208	5.05E-09
TH-231	1.46E-12
U-235	8.38E-08
AC-227	2.76E-07
PA-231	1.35E-07
TOTAL	5.12E-06

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	5.12E-06

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	60	830	1950
N	4.5E-01	1.4E-02	6.5E-03
NNW	2.6E-01	9.3E-03	5.4E-03
NW	2.3E-01	1.0E-02	5.6E-03
WNW	2.6E-01	1.1E-02	5.9E-03
W	2.3E-01	9.7E-03	5.4E-03
WSW	1.2E-01	6.8E-03	4.8E-03
SW	1.3E-01	7.9E-03	5.0E-03
SSW	1.5E-01	8.8E-03	5.2E-03
S	2.1E-01	8.3E-03	5.1E-03
SSE	1.6E-01	7.0E-03	4.9E-03
SE	2.1E-01	8.3E-03	5.1E-03
ESE	2.8E-01	1.1E-02	5.8E-03
E	2.9E-01	1.3E-02	6.3E-03
ENE	2.2E-01	1.2E-02	5.9E-03
[illegible]	1.9E-01	8.9E-03	5.3E-03
[illegible]	1.8E-01	8.1E-03	5.1E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 60	830	1950
N	5.1E-06	1.3E-07	4.7E-08
NNW	2.9E-06	7.9E-08	3.4E-08
NW	2.7E-06	9.0E-08	3.7E-08
WNW	2.9E-06	1.0E-07	4.0E-08
W	2.6E-06	8.4E-08	3.5E-08
WSW	1.3E-06	5.1E-08	2.8E-08
SW	1.5E-06	6.4E-08	3.1E-08
SSW	1.7E-06	7.4E-08	3.3E-08
S	2.4E-06	6.8E-08	3.2E-08
SSE	1.8E-06	5.4E-08	2.8E-08
SE	2.4E-06	6.9E-08	3.2E-08
ESE	3.2E-06	1.0E-07	3.9E-08
E	3.3E-06	1.3E-07	4.5E-08
ENE	2.5E-06	1.1E-07	4.1E-08
NE	2.2E-06	7.4E-08	3.3E-08
NNE	2.0E-06	6.6E-08	3.1E-08

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Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 27, 2001 08:07 am

Facility: SLDS
Address: Broadway Ave
City: St. Louis
State: MO Zip: 63120

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Excavation Emissions from Plant 1 by Air Sampling

Dataset Name: Plant 1
Dataset Date: Mar 27, 2001 08:07 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	2.10E-03
BREAST	1.60E-03
R MAR	6.90E-02
LUNGS	6.39E-01
THYROID	1.55E-03
ENDOST	8.53E-01
RMNDR	5.53E-03
EFFEC	1.13E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	3.81E-03
INHALATION	1.09E-01
AIR IMMERSION	2.79E-07
GROUND SURFACE	1.22E-04
INTERNAL	1.13E-01
EXTERNAL	1.22E-04
TOTAL	1.13E-01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	1.69E-02
U-234	1.90E-02
U-235	7.94E-04
TH-230	2.73E-02
TH-231	1.86E-07
TH-232	5.14E-03
TH-234	2.04E-04
TH-228	3.60E-03
RA-224	5.02E-05
RA-226	6.59E-03
RA-228	1.63E-03
PA-234M	1.86E-08
AC-228	3.56E-05
AC-227	2.91E-03
PA-231	2.88E-02
TOTAL	1.13E-01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	5.79E-08
BONE	3.67E-08
THYROID	3.01E-10
BREAST	2.73E-09
LUNG	1.03E-06
STOMACH	2.04E-09
BOWEL	2.24E-09
LIVER	1.03E-08
PANCREAS	1.44E-09
URINARY	3.04E-09
OTHER	1.77E-09
TOTAL	1.15E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.93E-08
INHALATION	1.13E-06
AIR IMMERSION	6.66E-12
GROUND SURFACE	2.83E-09
INTERNAL	1.15E-06
EXTERNAL	2.84E-09
TOTAL	1.15E-06

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	2.25E-07
U-234	2.51E-07
U-235	1.07E-08
TH-230	2.25E-07
TH-231	5.43E-12
TH-232	2.90E-08
TH-234	9.15E-09
TH-228	7.24E-08
RA-224	1.14E-09
RA-226	1.19E-07
RA-228	2.12E-08
PA-234M	4.74E-13
AC-228	7.18E-10
AC-227	2.53E-08
PA-231	1.61E-07
TOTAL	1.15E-06

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	267	970	4500
N	1.1E-01	1.2E-02	3.5E-03
NNW	5.9E-02	7.8E-03	3.2E-03
NW	6.9E-02	8.6E-03	3.2E-03
WNW	8.5E-02	9.8E-03	3.3E-03
W	6.4E-02	8.1E-03	3.2E-03
WSW	3.2E-02	5.3E-03	3.0E-03
SW	4.5E-02	6.3E-03	3.0E-03
SSW	5.5E-02	7.2E-03	3.1E-03
S	4.8E-02	6.7E-03	3.1E-03
SSE	3.4E-02	5.5E-03	3.0E-03
SE	4.9E-02	6.8E-03	3.1E-03
ESE	8.2E-02	9.6E-03	3.3E-03
E	1.1E-01	1.2E-02	3.4E-03
ENE	8.9E-02	1.0E-02	3.3E-03
NE	5.5E-02	7.3E-03	3.1E-03
NNE	4.6E-02	6.6E-03	3.1E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	267	970	4500
N	1.1E-06	1.1E-07	2.2E-08
NNW	5.9E-07	6.5E-08	1.8E-08
NW	7.0E-07	7.4E-08	1.9E-08
WNW	8.6E-07	8.6E-08	2.0E-08
W	6.5E-07	6.9E-08	1.8E-08
WSW	3.2E-07	4.0E-08	1.6E-08
SW	4.5E-07	5.1E-08	1.7E-08
SSW	5.5E-07	6.0E-08	1.8E-08
S	4.8E-07	5.5E-08	1.7E-08
SSE	3.4E-07	4.3E-08	1.6E-08
SE	4.9E-07	5.6E-08	1.7E-08
ESE	8.3E-07	8.5E-08	2.0E-08
E	1.1E-06	1.1E-07	2.1E-08
ENE	9.0E-07	9.0E-08	2.0E-08
[illegible]	5.5E-07	6.0E-08	1.8E-08
[illegible]	4.6E-07	5.3E-08	1.7E-08

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Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 27, 2001 08:06 am

Facility: SLAPS
Address: McDonnell Blvd
City: Hazelwood
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: SLAPS Transient

Dataset Name: SLAPS Transient
Dataset Date: Mar 27, 2001 08:05 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	8.37E-01
BREAST	7.10E-01
R MAR	1.61E+02
LUNGS	8.27E+02
THYROID	6.76E-01
ENDOST	2.00E+03
RMNDR	3.45E+00
EFFEC	1.80E+02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	3.75E+00
INHALATION	1.76E+02
AIR IMMERSION	1.16E-05
GROUND SURFACE	2.61E-02
INTERNAL	1.80E+02
EXTERNAL	2.61E-02
TOTAL	1.80E+02

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	7.63E+00
U-235	3.84E-01
U-234	8.79E+00
RA-226	1.03E+00
TH-232	1.59E+00
TH-230	1.56E+02
TH-228	6.60E-01
RA-224	9.27E-03
TH-234	3.01E-02
PA-234M	2.22E-06
TH-231	1.81E-05
RA-228	9.02E-02
AC-228	1.10E-03
AC-227	1.94E+00
PA-231	1.50E+00
TOTAL	1.80E+02

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	1.36E-04
BONE	8.92E-05
THYROID	1.17E-07
BREAST	1.09E-06
LUNG	1.32E-03
STOMACH	8.09E-07
BOWEL	9.82E-07
LIVER	6.48E-06
PANCREAS	5.70E-07
URINARY	3.06E-06
OTHER	6.97E-07
TOTAL	1.56E-03

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.53E-05
INHALATION	1.55E-03
AIR IMMERSION	2.75E-10
GROUND SURFACE	5.91E-07
INTERNAL	1.56E-03
EXTERNAL	5.92E-07
TOTAL	1.56E-03

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	9.91E-05
U-235	5.04E-06
U-234	1.13E-04
RA-226	1.40E-05
TH-232	8.98E-06
TH-230	1.28E-03
TH-228	1.32E-05
RA-224	2.08E-07
TH-234	9.91E-07
PA-234M	5.66E-11
TH-231	5.27E-10
RA-228	9.39E-07
AC-228	2.23E-08
AC-227	1.67E-05
PA-231	8.19E-06
TOTAL	1.56E-03

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)
Direction	169
N	1.6E+02
NNW	1.7E+02
NW	1.7E+02
WNW	1.4E+02
W	1.3E+02
WSW	1.2E+02
SW	1.1E+02
SSW	9.8E+01
S	1.0E+02
SSE	1.2E+02
SE	1.4E+02
ESE	1.7E+02
E	1.8E+02
ENE	1.8E+02
NE	1.8E+02
NNE	1.6E+02

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)
Direction	169
N	1.4E-03
NNW	1.5E-03
NW	1.5E-03
WNW	1.3E-03
W	1.2E-03
WSW	1.1E-03
SW	9.3E-04
SSW	8.5E-04
S	8.9E-04
SSE	1.0E-03
SE	1.2E-03
ESE	1.4E-03
E	1.6E-03
ENE	1.5E-03
[illegible]	1.6E-03
[illegible]	1.4E-03

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D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 27, 2001 08:05 am

Facility: SLAPS
Address: McDonnell Blvd
City: Hazelwood
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Evaluation of Radionuclide Emissions from SLAPS

Dataset Name: SLAP2000
Dataset Date: Mar 27, 2001 08:05 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	2.25E-01
BREAST	1.87E-01
R MAR	5.12E+01
LUNGS	2.71E+02
THYROID	1.76E-01
ENDOST	6.38E+02
RMNDR	7.35E-01
EFFEC	5.81E+01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	3.91E-01
INHALATION	5.77E+01
AIR IMMERSION	3.60E-06
GROUND SURFACE	8.75E-03
INTERNAL	5.81E+01
EXTERNAL	8.75E-03
TOTAL	5.81E+01

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
U-238	2.40E+00
U-235	1.21E-01
U-234	2.77E+00
RA-226	2.20E-01
TH-232	5.19E-01
TH-230	5.07E+01
TH-228	2.16E-01
RA-224	3.01E-03
TH-234	6.29E-03
PA-234M	4.26E-07
TH-231	5.91E-06
RA-228	1.63E-02
AC-228	3.60E-04
AC-227	6.17E-01
PA-231	4.71E-01
TOTAL	5.81E+01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	4.31E-05
BONE	2.84E-05
THYROID	3.04E-08
BREAST	2.92E-07
LUNG	4.33E-04
STOMACH	2.02E-07
BOWEL	1.77E-07
LIVER	1.98E-06
PANCREAS	1.46E-07
URINARY	3.81E-07
OTHER	1.78E-07
TOTAL	5.08E-04

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.59E-06
INHALATION	5.07E-04
AIR IMMERSION	8.50E-11
GROUND SURFACE	1.99E-07
INTERNAL	5.08E-04
EXTERNAL	1.99E-07
TOTAL	5.08E-04

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	3.19E-05
U-235	1.63E-06
U-234	3.66E-05
RA-226	3.99E-06
TH-232	2.93E-06
TH-230	4.18E-04
TH-228	4.33E-06
RA-224	6.80E-08
TH-234	2.84E-07
PA-234M	1.09E-11
TH-231	1.72E-10
RA-228	2.13E-07
AC-228	7.26E-09
AC-227	5.35E-06
PA-231	2.63E-06
TOTAL	5.08E-04

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)			
Direction	314	1400	1600	2300
N	4.8E+01	4.5E+00	3.7E+00	2.1E+00
NNW	4.8E+01	2.5E+00	2.0E+00	1.2E+00
NW	4.3E+01	2.8E+00	2.3E+00	1.4E+00
WNW	4.5E+01	3.4E+00	2.7E+00	1.6E+00
W	3.7E+01	2.6E+00	2.1E+00	1.3E+00
WSW	2.7E+01	1.4E+00	1.2E+00	7.5E-01
SW	2.6E+01	1.8E+00	1.5E+00	9.4E-01
SSW	3.0E+01	2.2E+00	1.8E+00	1.1E+00
S	2.7E+01	2.0E+00	1.7E+00	1.0E+00
SSE	2.5E+01	1.5E+00	1.2E+00	8.0E-01
SE	3.3E+01	2.0E+00	1.7E+00	1.0E+00
ESE	4.9E+01	3.3E+00	2.7E+00	1.6E+00
E	5.8E+01	4.1E+00	3.3E+00	1.9E+00
ENE	5.2E+01	3.5E+00	2.8E+00	1.6E+00
NE	3.8E+01	2.3E+00	1.8E+00	1.1E+00
NNE	4.2E+01	1.9E+00	1.6E+00	9.9E-01

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)			
Direction	314	1400	1600	2300
N	4.2E-04	3.8E-05	3.1E-05	1.7E-05
NNW	4.2E-04	2.0E-05	1.6E-05	9.4E-06
NW	3.8E-04	2.3E-05	1.9E-05	1.1E-05
WNW	4.0E-04	2.8E-05	2.3E-05	1.3E-05
W	3.2E-04	2.1E-05	1.7E-05	9.8E-06
SW	2.4E-04	1.1E-05	8.8E-06	5.3E-06
SW	2.3E-04	1.5E-05	1.2E-05	6.9E-06
SSW	2.6E-04	1.8E-05	1.5E-05	8.3E-06
S	2.4E-04	1.6E-05	1.3E-05	7.6E-06
SE	2.2E-04	1.2E-05	9.6E-06	5.7E-06
SE	2.9E-04	1.7E-05	1.3E-05	7.8E-06
SE	4.3E-04	2.7E-05	2.2E-05	1.2E-05
E	5.1E-04	3.5E-05	2.8E-05	1.5E-05
ENE	4.5E-04	2.9E-05	2.3E-05	1.3E-05
NE	3.3E-04	1.8E-05	1.5E-05	8.5E-06
[illegible]	3.7E-04	1.6E-05	1.3E-05	7.4E-06

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D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 17, 2001 08:21 am

Facility: Hazelwood Interim Storage Site (HISS)
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: CY00 Insitu Emissions Outside of Piles

Dataset Name: HISS Insitu
Dataset Date: Mar 17, 2001 08:20 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	4.15E-02
BREAST	3.29E-02
R MAR	5.11E-01
LUNGS	9.14E+00
THYROID	3.27E-02
ENDOST	6.13E+00
RMNDR	7.77E-02
EFFEC	1.38E+00

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	2.28E-02
INHALATION	1.33E+00
AIR IMMERSION	4.77E-07
GROUND SURFACE	2.63E-02
INTERNAL	1.36E+00
EXTERNAL	2.63E-02
TOTAL	1.38E+00

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	3.49E-01
TH-234	1.47E-04
PA-234M	1.15E-06
U-234	3.92E-01
TH-230	3.00E-01
RA-226	8.73E-03
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	2.41E-03
BI-214	1.27E-02
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	3.30E-05
TH-232	7.58E-02
RA-228	2.93E-03
AC-228	4.21E-03
TH-228	5.32E-02
RA-224	7.90E-04
RN-220	2.41E-06
PO-216	6.41E-08
PB-212	7.28E-04
BI-212	7.99E-04
TL-208	4.86E-03
U-235	1.74E-02
TH-231	1.39E-07
AC-227	8.87E-02
PA-231	6.77E-02
TOTAL	1.38E+00

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	4.90E-07
BONE	2.76E-07
THYROID	1.38E-08
BREAST	1.19E-07
LUNG	1.46E-05
STOMACH	7.47E-08
BOWEL	4.07E-08
LIVER	1.87E-07
PANCREAS	4.97E-08
URINARY	7.75E-08
OTHER	6.08E-08
TOTAL	1.60E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	1.60E-05

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.15E-07
INHALATION	1.52E-05
AIR IMMERSION	1.14E-11
GROUND SURFACE	6.35E-07
INTERNAL	1.54E-05
EXTERNAL	6.35E-07
TOTAL	1.60E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	1.60E-05

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	4.63E-06
TH-234	6.56E-09
PA-234M	2.76E-11
U-234	5.17E-06
TH-230	2.47E-06
RA-226	1.56E-07
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	5.69E-08
BI-214	3.08E-07
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	1.75E-10
TH-232	4.28E-07
RA-228	3.78E-08
AC-228	1.01E-07
TH-228	1.07E-06
RA-224	1.79E-08
RN-220	5.76E-11
PO-216	1.54E-12
PB-212	1.69E-08
BI-212	1.92E-08
TL-208	1.19E-07
U-235	2.34E-07
TH-231	4.05E-12
AC-227	7.69E-07
PA-231	3.78E-07
TOTAL	1.60E-05

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	1.60E-05

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	110	1300	2100
N	1.1E+00	3.4E-02	2.4E-02
NNW	1.1E+00	2.6E-02	2.1E-02
NW	1.0E+00	2.7E-02	2.1E-02
WNW	1.1E+00	2.9E-02	2.2E-02
W	8.8E-01	2.6E-02	2.1E-02
WSW	6.5E-01	2.1E-02	1.9E-02
SW	6.3E-01	2.3E-02	2.0E-02
SSW	7.2E-01	2.5E-02	2.0E-02
S	6.6E-01	2.4E-02	2.0E-02
SSE	6.0E-01	2.2E-02	1.9E-02
SE	7.8E-01	2.4E-02	2.0E-02
ESE	1.2E+00	2.9E-02	2.2E-02
E	1.4E+00	3.2E-02	2.4E-02
ENE	1.2E+00	3.0E-02	2.3E-02
NE	9.0E-01	2.5E-02	2.0E-02
[illegible]	9.9E-01	2.4E-02	2.0E-02

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 110	1300	2100
N	1.3E-05	2.8E-07	1.7E-07
NNW	1.3E-05	1.9E-07	1.3E-07
NW	1.2E-05	2.0E-07	1.4E-07
WNW	1.2E-05	2.3E-07	1.5E-07
W	1.0E-05	1.9E-07	1.3E-07
WSW	7.4E-06	1.4E-07	1.1E-07
SW	7.2E-06	1.6E-07	1.2E-07
SSW	8.3E-06	1.8E-07	1.3E-07
S	7.6E-06	1.7E-07	1.2E-07
SSE	6.9E-06	1.4E-07	1.1E-07
SE	9.0E-06	1.7E-07	1.2E-07
ESE	1.3E-05	2.3E-07	1.5E-07
E	1.6E-05	2.6E-07	1.6E-07
ENE	1.4E-05	2.3E-07	1.5E-07
NE	1.0E-05	1.8E-07	1.3E-07
NNE	1.1E-05	1.6E-07	1.2E-07

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Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 16, 2001 02:45 pm

Facility: Hazelwood Interim Storage Site (HISS)
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Excavation and InSitu Emissions South Spoils

Dataset Name: HISS S Spoils
Dataset Date: Mar 16, 2001 02:45 pm
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	2.58E-03
BREAST	2.25E-03
R MAR	2.39E-02
LUNGS	3.23E-01
THYROID	2.26E-03
ENDOST	2.79E-01
RMNDR	3.30E-03
EFFEC	5.20E-02

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	7.50E-04
INHALATION	4.94E-02
AIR IMMERSION	3.04E-08
GROUND SURFACE	1.86E-03
INTERNAL	5.02E-02
EXTERNAL	1.86E-03
TOTAL	5.20E-02

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	9.35E-03
TH-234	3.89E-06
PA-234M	3.07E-08
U-234	1.05E-02
TH-230	1.33E-02
RA-226	5.78E-04
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	1.59E-04
BI-214	8.42E-04
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	8.37E-07
TH-232	6.70E-03
RA-228	1.93E-04
AC-228	3.33E-04
TH-228	4.70E-03
RA-224	6.94E-05
RN-220	1.92E-07
PO-216	5.10E-09
PB-212	5.79E-05
BI-212	6.36E-05
TL-208	3.87E-04
U-235	4.80E-04
TH-231	3.83E-09
AC-227	2.45E-03
PA-231	1.87E-03
TOTAL	5.20E-02

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	2.43E-08
BONE	1.28E-08
THYROID	9.64E-10
BREAST	8.29E-09
LUNG	5.28E-07
STOMACH	5.22E-09
BOWEL	2.75E-09
LIVER	8.86E-09
PANCREAS	3.47E-09
URINARY	3.35E-09
OTHER	4.25E-09
TOTAL	6.02E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	6.02E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	3.81E-09
INHALATION	5.53E-07
AIR IMMERSION	7.29E-13
GROUND SURFACE	4.50E-08
INTERNAL	5.57E-07
EXTERNAL	4.50E-08
TOTAL	6.02E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	6.02E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.24E-07
TH-234	1.75E-10
PA-234M	7.38E-13
U-234	1.39E-07
TH-230	1.10E-07
RA-226	1.04E-08
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	3.77E-09
BI-214	2.04E-08
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	4.43E-12
TH-232	3.79E-08
RA-228	2.51E-09
AC-228	7.98E-09
TH-228	9.45E-08
RA-224	1.57E-09
RN-220	4.58E-12
PO-216	1.22E-13
PB-212	1.35E-09
BI-212	1.53E-09
TL-208	9.45E-09
U-235	6.45E-09
TH-231	1.12E-13
AC-227	2.12E-08
PA-231	1.04E-08
TOTAL	6.02E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	6.02E-07

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	65	1300	2100
N	5.1E-02	8.1E-04	6.7E-04
NNW	3.5E-02	6.9E-04	6.1E-04
NW	3.6E-02	7.1E-04	6.2E-04
WNW	4.1E-02	7.4E-04	6.3E-04
W	3.2E-02	6.9E-04	6.1E-04
WSW	1.9E-02	6.2E-04	5.8E-04
SW	2.2E-02	6.5E-04	5.9E-04
SSW	2.7E-02	6.7E-04	6.0E-04
S	2.4E-02	6.6E-04	6.0E-04
SSE	2.0E-02	6.3E-04	5.8E-04
SE	2.7E-02	6.6E-04	6.0E-04
ESE	4.2E-02	7.4E-04	6.3E-04
E	5.2E-02	7.9E-04	6.6E-04
ENE	4.4E-02	7.5E-04	6.4E-04
[illegible]	3.0E-02	6.7E-04	6.0E-04
[illegible]	2.9E-02	6.5E-04	6.0E-04

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 65	1300	2100
N	5.9E-07	5.9E-09	4.2E-09
NNW	4.1E-07	4.4E-09	3.5E-09
NW	4.2E-07	4.6E-09	3.6E-09
WNW	4.8E-07	5.0E-09	3.8E-09
W	3.7E-07	4.5E-09	3.5E-09
WSW	2.2E-07	3.6E-09	3.2E-09
SW	2.6E-07	3.9E-09	3.3E-09
SSW	3.1E-07	4.2E-09	3.4E-09
S	2.8E-07	4.1E-09	3.4E-09
SSE	2.2E-07	3.7E-09	3.2E-09
SE	3.1E-07	4.1E-09	3.4E-09
ESE	4.8E-07	5.0E-09	3.8E-09
E	6.0E-07	5.6E-09	4.0E-09
ENE	5.1E-07	5.1E-09	3.8E-09
NE	3.5E-07	4.2E-09	3.4E-09
NNE	3.4E-07	4.0E-09	3.3E-09

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D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 16, 2001 02:49 pm

Facility: Hazelwood Interim Storage Site (HISS)
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Excavation and Insitu Emissions from East Piles

Dataset Name: HISSEast
Dataset Date: Mar 16, 2001 02:49 pm
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	3.25E-03
BREAST	2.91E-03
R MAR	5.18E-02
LUNGS	4.25E-01
THYROID	2.91E-03
ENDOST	6.21E-01
RMNDR	3.80E-03
EFFEC	7.83E-02

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	8.48E-04
INHALATION	7.51E-02
AIR IMMERSION	3.80E-08
GROUND SURFACE	2.37E-03
INTERNAL	7.59E-02
EXTERNAL	2.37E-03
TOTAL	7.83E-02

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	8.10E-03
TH-234	3.35E-06
PA-234M	2.73E-08
U-234	9.10E-03
TH-230	4.12E-02
RA-226	7.31E-04
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	2.14E-04
BI-214	1.13E-03
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	7.07E-07
TH-232	7.29E-03
RA-228	2.42E-04
AC-228	3.96E-04
TH-228	5.12E-03
RA-224	7.59E-05
RN-220	2.28E-07
PO-216	6.05E-09
PB-212	6.87E-05
BI-212	7.54E-05
TL-208	4.59E-04
U-235	4.15E-04
TH-231	3.31E-09
AC-227	2.12E-03
PA-231	1.61E-03
TOTAL	7.83E-02

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	4.89E-08
BONE	2.81E-08
THYROID	1.23E-09
BREAST	1.06E-08
LUNG	6.96E-07
STOMACH	6.68E-09
BOWEL	3.50E-09
LIVER	1.07E-08
PANCREAS	4.45E-09
URINARY	3.77E-09
OTHER	5.44E-09
TOTAL	8.19E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	8.19E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	4.12E-09
INHALATION	7.58E-07
AIR IMMERSION	9.13E-13
GROUND SURFACE	5.71E-08
INTERNAL	7.62E-07
EXTERNAL	5.71E-08
TOTAL	8.19E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	8.19E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.08E-07
TH-234	1.52E-10
PA-234M	6.55E-13
U-234	1.20E-07
TH-230	3.40E-07
RA-226	1.33E-08
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	5.06E-09
BI-214	2.74E-08
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	3.75E-12
TH-232	4.12E-08
RA-228	3.17E-09
AC-228	9.50E-09
TH-228	1.03E-07
RA-224	1.72E-09
RN-220	5.44E-12
PO-216	1.45E-13
PB-212	1.60E-09
BI-212	1.82E-09
TL-208	1.12E-08
U-235	5.57E-09
TH-231	9.67E-14
AC-227	1.83E-08
PA-231	9.00E-09
TOTAL	8.19E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	8.19E-07

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	214	1300	2100
N	7.8E-02	3.4E-03	1.8E-03
NNW	4.0E-02	2.0E-03	1.2E-03
NW	4.8E-02	2.2E-03	1.3E-03
WNW	5.8E-02	2.6E-03	1.5E-03
W	4.4E-02	2.1E-03	1.3E-03
WSW	2.1E-02	1.3E-03	9.2E-04
SW	3.0E-02	1.6E-03	1.0E-03
SSW	3.7E-02	1.9E-03	1.2E-03
S	3.2E-02	1.7E-03	1.1E-03
SSE	2.3E-02	1.4E-03	9.6E-04
SE	3.3E-02	1.8E-03	1.1E-03
ESE	5.6E-02	2.6E-03	1.5E-03
E	7.4E-02	3.1E-03	1.7E-03
ENE	6.2E-02	2.7E-03	1.5E-03
NE	3.7E-02	1.9E-03	1.2E-03
[illegible]	3.1E-02	1.7E-03	1.1E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 214	1300	2100
N	8.2E-07	3.2E-08	1.6E-08
NNW	4.2E-07	1.8E-08	9.6E-09
NW	5.0E-07	2.0E-08	1.1E-08
WNW	6.1E-07	2.4E-08	1.2E-08
W	4.6E-07	1.9E-08	9.9E-09
WSW	2.2E-07	1.1E-08	6.3E-09
SW	3.1E-07	1.4E-08	7.6E-09
SSW	3.9E-07	1.6E-08	8.7E-09
S	3.4E-07	1.5E-08	8.2E-09
SSE	2.4E-07	1.1E-08	6.6E-09
SE	3.4E-07	1.5E-08	8.3E-09
ESE	5.9E-07	2.3E-08	1.2E-08
E	7.8E-07	2.9E-08	1.5E-08
ENE	6.4E-07	2.5E-08	1.3E-08
NE	3.9E-07	1.6E-08	8.9E-09
NNE	3.3E-07	1.4E-08	8.0E-09

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D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Mar 27, 2001 08:12 am

Facility: Hazelwood Interim Storage Site (HISS)
Address: Latty Avenue
City: Berkeley
State: MO Zip: 63134

Source Category: Area
Source Type: Area
Emission Year: 2000

Comments: Excavation and InSitu Emissions for North Spoils

Dataset Name: HISSNorth
Dataset Date: Mar 27, 2001 08:12 am
Wind File: C:\CAP88PC2\WNDFILES\13994.WND

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)
GONADS	1.41E-03
BREAST	1.06E-03
R MAR	1.94E-02
LUNGS	2.54E-01
THYROID	1.05E-03
ENDOST	2.33E-01
RMNDR	2.56E-03
EFFEC	4.11E-02

Radon Decay Product Concentration (working level)

0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)
INGESTION	5.80E-04
INHALATION	3.96E-02
AIR IMMERSION	1.60E-08
GROUND SURFACE	8.51E-04
INTERNAL	4.02E-02
EXTERNAL	8.51E-04
TOTAL	4.11E-02

Radon Decay Product Concentration (working level)

0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclide	Selected Individual (mrem/y)
U-238	1.52E-02
TH-234	6.26E-06
PA-234M	5.09E-08
U-234	1.71E-03
TH-230	1.19E-02
RA-226	2.78E-04
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	8.03E-05
BI-214	4.25E-04
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	1.30E-06
TH-232	2.13E-03
RA-228	9.18E-05
AC-228	1.28E-04
TH-228	1.50E-03
RA-224	2.23E-05
RN-220	7.33E-08
PO-216	1.95E-09
PB-212	2.21E-05
BI-212	2.43E-05
TL-208	1.48E-04
U-235	7.46E-04
TH-231	5.96E-09
AC-227	3.81E-03
PA-231	2.90E-03
TOTAL	4.11E-02

Radon Decay Product Concentration (working level)

0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	1.82E-08
BONE	1.04E-08
THYROID	4.44E-10
BREAST	3.84E-09
LUNG	4.02E-07
STOMACH	2.41E-09
BOWEL	1.31E-09
LIVER	7.07E-09
PANCREAS	1.60E-09
URINARY	1.99E-09
OTHER	1.96E-09
TOTAL	4.51E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	4.51E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	2.93E-09
INHALATION	4.27E-07
AIR IMMERSION	3.82E-13
GROUND SURFACE	2.05E-08
INTERNAL	4.30E-07
EXTERNAL	2.05E-08
TOTAL	4.51E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	4.51E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	2.02E-07
TH-234	2.84E-10
PA-234M	1.22E-12
U-234	2.25E-08
TH-230	9.78E-08
RA-226	5.06E-09
RN-222	0.00E+00
PO-218	0.00E+00
PB-214	1.90E-09
BI-214	1.03E-08
PO-214	0.00E+00
PB-210	0.00E+00
BI-210	0.00E+00
PO-210	6.88E-12
TH-232	1.21E-08
RA-228	1.21E-09
AC-228	3.08E-09
TH-228	3.01E-08
RA-224	5.07E-10
RN-220	1.75E-12
PO-216	4.67E-14
PB-212	5.15E-10
BI-212	5.84E-10
TL-208	3.61E-09
U-235	1.00E-08
TH-231	1.74E-13
AC-227	3.30E-08
PA-231	1.62E-08
TOTAL	4.51E-07

	Selected Individual Cancer Risk
Radon Decay Product Lung Exposure	0.00E+00
Total Fatal Risk All Exposures	4.51E-07

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	168	1300	2100
N	4.1E-02	1.3E-03	8.2E-04
NNW	2.1E-02	8.9E-04	6.2E-04
NW	2.5E-02	9.6E-04	6.6E-04
WNW	3.1E-02	1.1E-03	7.1E-04
W	2.3E-02	9.2E-04	6.3E-04
WSW	1.1E-02	6.5E-04	5.2E-04
SW	1.6E-02	7.5E-04	5.6E-04
SSW	2.0E-02	8.3E-04	6.0E-04
S	1.7E-02	7.9E-04	5.8E-04
SSE	1.2E-02	6.8E-04	5.3E-04
SE	1.7E-02	8.0E-04	5.8E-04
ESE	3.0E-02	1.1E-03	7.0E-04
E	3.9E-02	1.3E-03	7.8E-04
ENE	3.2E-02	1.1E-03	7.2E-04
NE	2.0E-02	8.4E-04	6.0E-04
[illegible]	1.7E-02	7.8E-04	5.7E-04

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)		
Direction	168	1300	2100
N	4.5E-07	1.2E-08	6.6E-09
NNW	2.3E-07	7.4E-09	4.4E-09
NW	2.7E-07	8.2E-09	4.8E-09
WNW	3.4E-07	9.5E-09	5.4E-09
W	2.5E-07	7.6E-09	4.5E-09
WSW	1.2E-07	4.8E-09	3.3E-09
SW	1.7E-07	5.8E-09	3.7E-09
SSW	2.1E-07	6.7E-09	4.1E-09
S	1.9E-07	6.3E-09	3.9E-09
SSE	1.3E-07	5.0E-09	3.4E-09
SE	1.9E-07	6.4E-09	4.0E-09
ESE	3.2E-07	9.3E-09	5.3E-09
E	4.3E-07	1.1E-08	6.2E-09
ENE	3.5E-07	9.8E-09	5.5E-09
NE	2.1E-07	6.8E-09	4.2E-09
NNE	1.8E-07	6.1E-09	3.9E-09