DRAFT FINAL RI ADDENDA:

REMEDIAL INVESTIGATION SUMMARY,
REMOVAL ACTION REPORT,
RESIDUAL RISK ASSESSMENT,
COMPARISON OF GROUNDWATER INORGANIC CONCENTRATIONS IN ON-SITE AND BACKGROUND MONITORING WELLS,
AND
IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

FOR

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

PESTICIDE STORAGE FACILITY

FORT RILEY MILITARY INSTALLATION

FORT RILEY, KANSAS

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BLRA	Baseline Risk Assessment
CAL	Corrective Action Level
CEMRD	Corps of Engineers - Missouri River Division
CEMRK	Corps of Engineers - Missouri River Division, Kansas City District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CMP	corrugated metal pipe
cm/sec	centimeters per second
COC	Chemical of Concern
CSF	cancer slope factor
CWA	Clean Water Act
DEH	Directorate of Engineering and Housing
ECAO	Environmental Criteria and Assessment Office
EE/CA	Engineering Evaluation/Cost Analysis
ERA	Ecological Risk Assessment
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreement
FS	Feasibility Study
FID	Flame Ionization Detector

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

ft/min	feet per minute
gpd	gallons per day
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HRS	Hazard Ranking System
IAG	Interagency Agreement
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
KDHE	Kansas Department of Health and Environment
kg	kilogram
KGS	Kansas Geological Survey
L	liter
LAW	Law Environmental, Inc., Government Services Division
LENL	Law Environmental National Laboratory
m	meter
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
mg	milligram
mgd	million gallons per day
mg/kg	milligram per kilogram

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

mg/L	milligram per liter
ML	Clayey silts - classification of soil under United Soil Classification System
MSL	mean sea level
MW	monitoring well
NA	not analyzed or not applicable
NAAQS	National Ambient Air Quality Standard
NCP	National Contingency Plan
ND	not detected
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List (Superfund List)
O&M	Operation and Maintenance
OHM	OHM Remediation Services Corp.
OSHA	Occupational Safety and Health Administration
OSR	on-site representative
OUs	Operable Units
PAHs	polynuclear aromatic hydrocarbons
PC	Permeability Constant
PCB	Polychlorinated Biphenyl
PSF	Pesticide Storage Facility
QA	Quality Assurance
QCSR	Quality Control Summary Report
RAO	remedial action objective

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RG	remediation goal
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
ROD/RD/RA	Record of Decision/Remedial Design/Remedial Action
RRA	Residual Risk Assessment
SC	Clayey sands - classification of soil under United Soil Classification System
SFL	Southwest Funston Landfill
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
TBC	To Be Considered
TCE	trichloroethylene
UCL	upper confidence limit
μg/L	microgram per liter
USACE	United States Army Corp of Engineers
USAEHA	United States Army Environmental Hygiene Agency
USDASCS	United States Department of Agriculture - Soil Conservation Service
USEPA	United States Environmental Protection Agency

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

USFWS	U.S. Fish & Wildlife Service
USGS	United States Geological Survey
VOC	volatile organic compound

EXECUTIVE SUMMARY

This report documents the site activities conducted at the Pesticide Storage Facility site since completion of the initial Remedial Investigation (RI) which was initially submitted in December 1993 and became final in April 1994. The Department of the Army - Fort Riley, the U.S. Environmental Protection Agency (USEPA) Region VII, and the State of Kansas Department of Health and Environment (KDHE), negotiated a Federal Facility Agreement (FFA) for Fort Riley, Docket No. VII-90-F-0015. This agreement, also referred to as the Interagency Agreement (IAG), was signed by the Army in August 1990 and by USEPA Region VII and KDHE in February 1991, and became effective on June 28, 1991. Under Section IX.A., paragraph 2 of the Agreement, the PSF was specifically addressed as a potential contaminant source, and a schedule for a site RI/FS and Remedial Action was established. Two pesticide monitoring studies and a closure at the site were completed between 1974 and 1990. Remedial Investigation/Feasibility Study (RI/FS) planning activities were conducted from 1990 to 1992. An RI/FS was initiated in 1992, and while the RI/FS was under development in 1993, Fort Riley conducted an Engineering Evaluation/Cost Analysis (EE/CA) which considered a non-time-critical Removal Action at the PSF. Subsequently, a Removal Action Memorandum was completed in December 1993. Results from the RI, which included a Baseline Risk Assessment (BLRA), are summarized in this report.

The non-time-critical Removal Action was initiated at the site in January 1994 to excavate and remove contaminated soils from the site. The removal of 2,600 tons of contaminated soils was completed in June 1994. During the Removal Action, it was discovered that the site conditions differed significantly from the interpretations presented in the RI report (LAW, 1993a), and contaminated areas and the vertical distribution of contaminants exceeded original estimates. The report presents the revised descriptions of the Pre-Removal Action site characterization incorporating Removal Action and RI data. The report also documents the Removal Action activities. The Removal Action substantially removed contaminated soils from the site, and clean fill material was replaced into the excavations.

A description of site conditions following the Removal Action is provided in the report. Following the Removal Action, surface and subsurface soil samples exceeding Removal Action goal concentrations were limited. Polynuclear aromatic hydrocarbons (PAHs) represented less than 2 percent of estimated risks in the BLRA, and have mostly been removed during the Removal Action further reducing exposure risks, and are not a concern. None of the soil samples analyzed for pesticides at the lateral and vertical limits of the Removal Action sampling exceeded preliminary remedial goals and it was concluded that the site characterization data is adequate.

An additional groundwater monitoring round was completed in September 1994 which included the PSF wells and two additional background wells at Building 354. This study provided additional data to confirm previous results and provided more background well information for comparison. From a review of the available data and based on professional judgement, it was concluded that the metals, including antimony, beryllium, cadmium, manganese, and thallium were indicative of background, because they were detected at concentrations and frequencies similar to the background wells. It was also concluded that the second round nitrate data were an anomaly, because these samples were significantly higher than the other rounds which had consistent concentrations, and a discrepancy was noted in a quality assurance sample from the second round. Initially, nitrate was considered a contaminant of concern because the on-site concentrations frequently exceeded the MCL. Inorganic chloride and sulfate concentrations exceeded background levels in some on-site wells. Although inorganic chloride and sulfate "may" indicate breakdown products, pesticides have not been detected above reporting limits in the groundwater and the data do not support this conclusion. Inorganic chloride and sulfate were not identified as contaminants of concern in the Baseline Risk Assessment in the RI report and are not regulated for health-based concerns. Inorganic chloride and sulfate were consistently detected at similar concentrations in past samples and further confirmation monitoring is unnecessary.

An additional round of groundwater samples was again collected from the PSF wells and background wells in December 1995. Using this additional data and the previous sampling data collected from these wells, a statistical comparison of the groundwater samples collected from the on-site and off-site (background) wells was completed in June 1996. The purpose of the study was to statistically determine whether the inorganic constituents detected in the on-site wells and previously considered as potential site contaminants were indicative of background concentrations. The constituents evaluated in the statistical study included: antimony, arsenic, beryllium, cadmium, manganese, nitrate, and thallium. From the study, it was concluded with a high level of confidence that, except for beryllium in a single on-site well, the concentrations of these inorganics were consistent with background concentrations. The study further concluded that the statistically determined average concentrations of these constituents in every on-site well was below its maximum contaminant level (MCL).

The risks in the BLRA previously presented in the RI report (December 1993) were based on-site conditions which no longer exist. Therefore, a residual risk assessment (RRA) was completed to address the risk that remains at the site following the Removal Action. The RRA was a "streamlined" version of the BLRA in that risks were recalculated only for the pathways with risks estimated to exceed 1 x 10^{-6} for carcinogens or 1 for noncarcinogens in the previous BLRA. Soils, sediment, and groundwater exposures were reevaluated in the RRA. Surface-water risks were not reevaluated in the RRA. The RRA considered revisions to the dermal absorption factors for soils and sediment since the BLRA was completed.

The groundwater at the site is not currently being used as a source of potable water and its future use for this purpose is unlikely, because an existing water system serves the PSF. However, risk estimates for hypothetical exposure to the groundwater were calculated in the BLRA in the RI, and were reevaluated in the RRA for information only as groundwater exposure is not part of the Reasonable Maximum Exposure (RME) scenarios for this site. The RRA also incorporated the additional groundwater data collected since the RI report (LAW, 1993a), in September 1994 and December 1995. The statistical comparison results were also incorporated in the RRA. For soil media, none of the exposure pathways reassessed in the RRA had a cancer risk exceeding 1 x 10^{-5} or 1 x 10^{-6}.

Similarly, none of the exposure pathways evaluated had a hazard index exceeding 1, the standard point of departure below which adverse health effects are not expected. Risks from soil exposure at the site are considered to be within acceptable limits.

For surface-water and sediment exposures at the PSF, risk estimates were calculated to be below 1 x 10^{-6} and 1 for carcinogenic and noncarcinogenic risks, respectively. Ecological risks were also determined to be minimal. Since the human health and ecological risks were not unacceptable for these media, they were not considered further. The resulting noncarcinogenic risk estimates for the hypothetical use of the groundwater were less than 1. The cancer-risk estimate was 1 x 10^{-4} with beryllium being the only COC contributing to the carcinogenic risk estimate.

Soils and sediment media exposure pathways were reevaluated in the RRA, and the carcinogenic risk estimates did not exceed 1 x 10^{-6}, and HI estimates for noncarcinogenic effects did not exceed 1. From the evaluation it is concluded that soil and sediment media do not present unacceptable risks at this site. RAOs addressing the sediment media are not needed, because protectiveness goals are being achieved at the site for the exposure scenarios considered. Similarly, soil exposure risks following the Removal Action do not exceed protectiveness goals at this site, and the identification of RAOs addressing soil media is not necessary. Although remedial action is not necessary, risk-based preliminary remediation goals (PRGs) concentrations were calculated and presented as an informational comparison to post-Remedial Action site conditions (since the RRA did not indicate unacceptable risk and therefore did not trigger remedial action requirements).

In the groundwater, beryllium was the only contaminant of concern identified which contributed to a significant risk under the groundwater use scenario evaluated for information only. Beryllium concentrations in the on-site wells were compared to the MCLG and MCL for information only. At the site, a single sample in one on-site well slightly exceeded the MCL concentration. The 95 percent UCL concentration for beryllium in the on-site wells was 0.0027 mg/L, which is less than the MCLG and the MCL. It was further concluded that the beryllium concentrations in the on-site wells were statistically below the MCL. From this evaluation it is concluded that the inorganics in the on-site wells are indicative of background or are not likely to exceed the MCL.

In conclusion, the RRA, based on post-Removal Action site conditions, indicates that the conditions at the Pesticide Storage Facility site pose no current or potential threat to human health or the environment. Consequently, the statutory cleanup standards of CERCLA Section 121 do not apply. No additional remedial action is necessary to ensure protection of human health and the environment. The groundwater exposure pathway is currently incomplete and the future use of groundwater as a potable water supply is very unlikely. An existing potable water supply system with adequate future capacity serves the site. The on-site wells have a low yield, making their use for a water supply impractical. Continued groundwater monitoring or remediation is not warranted.

REPORT SUMMARY

This Report Summary is a synopsis of the Draft Final Remedial Investigation Addenda: Remedial Investigation Summary, Removal Action Report, Residual Risk Assessment (RRA), Comparison of Groundwater Inorganic Concentrations in On-site And Background Monitoring Wells, and Identification of Applicable or Relevant and Appropriate Requirements (ARARs) for the Pesticide Storage Facility (PSF). This report, and consequently this report summary, is divided into seven main sections. The first section provides the site history, summarizes previous studies performed at the PSF, and presents the site characterization from the Remedial Investigation (RI). The second section provides a revised description of the nature and extent of soil contamination at the site, prior to the Removal Action. The third section provides a description of the Removal Action activities. The fourth section characterizes the current site conditions, following the Removal Action, and provides additional groundwater sampling data and evaluations completed following the completion of the RI. The fifth section presents a (RRA) which reevaluates site risks based on current conditions. The sixth section identifies ARARs and evaluates the need for remedial action. The seventh section provides the summary and conclusions. The reader is encouraged to review all sections of this report to gain a better understanding of the site.

The Department of the Army - Fort Riley, the U.S. Environmental Protection Agency (USEPA) Region VII, and the State of Kansas Department of Health and Environment (KDHE), negotiated a Federal Facility Agreement (FFA) for Fort Riley, Docket No. VII-90-F-0015 (FFA, 1991). This agreement, also referred to as the Interagency Agreement (IAG), was signed by the Army in August 1990 and by USEPA Region VII and KDHE in February 1991, and became effective on June 28, 1991. Under Section IX.A., paragraph 2 of the Agreement, the PSF was specifically addressed as a potential contaminant source, and a schedule for a site RI/FS and Remedial Action was established. Two pesticide monitoring studies and a closure at the site were completed between 1974 and 1990. Remedial Investigation/Feasibility Study (RI/FS) planning activities were conducted from 1990 to 1992. An RI/FS was initiated in 1992, and while the RI/FS was under development in 1993, Fort Riley conducted an Engineering Evaluation/Cost Analysis (EE/CA) which considered a non-time-critical Removal Action at the PSF (DEH, 1993a). Subsequently, a Removal Action Memorandum was completed in December 1993 (DEH, 1993b). The RI report (LAW, 1993a) was submitted in December 1993. Following the completion of the RI, pesticide contaminated soils at the PSF site were excavated and removed, and replaced with clean fill. These excavations and additional sampling revealed that the contaminated soil areas differed from those predicted in the RI. Two additional rounds of groundwater sampling were completed in September 1994 and December 1995, and a statistical comparison of selected inorganics in on-site and background wells was performed in 1996. To complete the RI/FS reporting requirements at this site, this report was prepared to document these activities which have provided a better understanding of the site, and altered conditions (e.g., removed soil contaminants) after the RI report (LAW, 1993a) was submitted. The purpose of this RI Addenda is to present a revised (using both RI and Removal Action data) description of the site prior to the Removal Action, provide a description of the post-removal action site characterization, complete a RRA to estimate site risks remaining following the Removal Action, incorporate the results of two additional rounds of groundwater sampling and provide a statistical comparison of selected inorganics in groundwater at the PSF. This RI Addenda also evaluates the need for additional remedial action at the site. The PRGs and ARARs developed for the PSF site are compared with residual contaminant concentrations to identify the need for additional remedial action.

Introduction and Background

The Fort Riley Military Installation was established in 1852 as an outpost near the confluence of the Smoky Hill and Republican Rivers in Geary and Riley Counties, Kansas (LAW, 1993a). Since its inception, Fort Riley has continuously served as a center of military education and readiness. Fort Riley has functioned as a small municipality and light industrial complex, at times having an installation population, including military and civilian residents, of over 20,000. Municipal activities on the installation include solid waste disposal (land filling), wastewater treatment, wastewater discharge and general infrastructure maintenance. Specific tasks associated with maintenance duties would include general construction activities, pesticide and herbicide application, fleet maintenance and general storage and repair services (LAW, 1993a).

Fort Riley serves in a military capacity as a training, equipment supply, and military maintenance center and, therefore, has historically required management and disposal of wastes associated with these activities. Pesticides (including insecticides and rodenticides), herbicides, fungicides, insect repellents, and soil fumigants have been used at Fort Riley for a variety of applications, and are referred to herein collectively as "pesticides and herbicides" (LAW, 1993a). Historically, the types of pesticides and herbicides used at Fort Riley have also been generally available to the public at the time of use.

The PSF area of investigation is located in the Main Post cantonment area. The site is an area around Building 348 of about 2/3 of an acre in size. Building 348 was constructed in 1941 as a general purpose warehouse and has since stored pesticides and herbicides and other products used at the base. Fort Riley records do not state when pesticides were first stored in Building 348. However, discussions with Fort Riley personnel indicate that Building 348 has been used for pesticide storage since at least 1973.

Prior to the late 1970s, the maintenance yard area east of and adjacent to Building 348 was used to wash down vehicles and spray equipment used for pesticide applications. Spills of pesticides and dumping of excess formulations may have also occurred and, due to the topography at the site, would tend to flow toward the east. Furthermore, electrical transformers containing polychlorinated biphenyls (PCBs) were once stored outside the southeast corner of Building 348. Other items previously stored at the site include paint, pesticides/herbicides, pressure-treated lumber, and various general improvement materials and equipment. Since at least 1976, the majority of pesticide application has been performed by outside contractors not allowed to use the PSF for formulation or mixing of pesticides.

Discussions with Army employees familiar with past operations at the PSF confirmed that grading and trenching activities had been carried out across the site over the years. Grading activities included the use of fill material to maintain suitable PSF topography and restore areas eroded from run-off over the years. Additional inquiry into the site history revealed that two trenches were constructed and backfilled during different time periods within the area of investigation to the east of the chain link fence at the site. These trenches were unlined and uncovered during the times they were operational, and because they impounded surface-water run-off, they probably served as accumulation points for contaminants. A floor drain inside Building 348 reportedly emptied into the sanitary sewer, and pesticide spills or use of this drain for disposal was not witnessed. The sewer lateral from this drain was found during the Removal Action.

The PSF has been investigated on several different occasions, and a closure and Removal Action have been completed at the site. Previous investigations and actions at the PSF site are as follows:

- Pesticide Monitoring Study, 1974
- Pesticide Monitoring Study, 1986
- Conex Closure Plan Wipe Samples, 1987
- Finalization on the National Priorities List (Superfund List) (NPL), August 30, 1990
- Closure of two CONEX containers, and a portion of Building 292 (now Building 348), finalized on December 3, 1990
- Fort Riley and U.S. Army Corps of Engineers RI/FS Planning Activities 1990 to 1992
- Development of Work Plan for the RI/FS, 1991 to 1992
- Initial Remedial Investigation, 1992 to 1993
- Draft Feasibility Study (FS), under development in 1993
- Removal Action Engineering Evaluation/Cost Analysis, 1993
- Removal Action Memorandum signed, December 1993
- Pesticide-contaminated soils excavated and disposed off site during the Removal Action, March to June 1994

- Statistical comparison of groundwater inorganic concentrations in on-site and background wells in 1996, following the December 1995 groundwater sampling event

- RI Addenda (1997) documenting prior investigations, Removal Action report, RRA, statistical analysis, and discontinuance of the FS.

- Six rounds of groundwater samples collected from the PSF monitoring wells: July 1992, November 1992, February 1993, May 1993, and September 1994, and December 1995. Note additional samples from background wells in the Building 354 area were collected during the September 1994 and December 1995 rounds.

- RI Addendum and Feasibility Study under development (following Removal Action and September 1994 groundwater sampling) in 1994 to 1995

Brief descriptions of these activities are presented in this report. The previous RI activities resulted in a site characterization and interpretation of the nature and extent of contamination, based on the available data at the time, and are documented in the RI Report (LAW, 1993a). In general, the results of the RI field activities and baseline risk assessment (BLRA) are summarized in this report.

Summary of RI Results

Results of analyses from the RI soil samples collected at the site indicated that three distinct areas of pesticide contamination were present. Several pesticides were detected in soil samples, including DDT and its metabolites (DDD and DDE), alpha- and gamma-chlordane, heptachlor, dieldrin, methoxychlor, endrin, Ronnel (Fenchlorphos), and malathion. Of the metals analyzed, arsenic, barium, chromium, and lead were routinely found in detectable concentrations in both background and PSF site samples. These metals are naturally occurring components of the earth's crust that are found in most soils and waters. Elevated concentrations of lead were detected in two soil samples and elevated levels of arsenic were detected in two samples. Several polyaromatic hydrocarbons (PAHs) were detected in some samples. PAHs detected include acenaphthene, anthracene, chrysene, fluoranthene, naphthalene, phenanthrene, and pyrene. The patterns of PAH concentrations followed surface run-off patterns. Constituents of asphalt paving activities, treated lumber, and asphalt stored in areas around the PSF are potential sources. Toluene and benzene were detected in some of the soil samples and are present in gasoline.

Four rounds of groundwater sampling were performed as part of the initial RI activities and are discussed in the following paragraphs. The first round (July 1992) served as the baseline, and the first through third quarter samples (November 1992, February 1993, and May 1993) were part of a site sampling program. Analytical results of the samples collected to establish baseline data showed metals and inorganics as the main constituents of the groundwater around the PSF, with the alkali earth metals (calcium, magnesium, potassium and sodium) exhibiting the highest concentrations. Antimony was not detected in the baseline samples. Concentrations (total and dissolved) of five metals (barium, beryllium, chromium, manganese, and selenium) were determined to be consistent with background conditions based on professional judgement. Only the total concentrations of metals aluminum, iron and zinc occurred slightly above background concentrations. Manganese exceeded the secondary Maximum Contaminant Level (MCL) in two samples but was detected at concentrations consistent with background levels.

Concentrations (total and dissolved) of eight metals (barium, beryllium, calcium, iron, magnesium, manganese, selenium and zinc) detected in first, second and third quarter groundwater samples were consistent with the baseline concentrations. Total antimony was only detected in two wells in the second quarter sampling event: at 0.022 mg/L in the upgradient well and at 0.032 mg/L in one downgradient well. Antimony was analyzed using USEPA Method 6010 with a detection limit of 0.022 mg/L in the baseline through second quarter. Arsenic was detected in one downgradient well during all quarters and in another downgradient well only during the second quarter. Arsenic did not exceed the MCL (0.050 mg/L). Total cadmium was detected only during the third quarter sampling event in the background well at 0.004 mg/L, and in two downgradient wells at 0.004 mg/L and 0.006 mg/L. The federal MCL for cadmium (0.005 mg/L) was exceeded once in a downgradient sample. Total chromium was detected in two baseline samples and again during the third quarter at 0.014 mg/L. The chromium MCL was never exceeded. Dissolved copper and total copper were detected in both background and downgradient wells at concentrations not exceeding 0.012 mg/L. During the second and third quarters, dissolved and/or total copper were detected in each well. Total lead was detected in two downgradient wells, PSF92-03 (0.0021 mg/L) and PSF92-04 (0.002 mg/L), only during the third quarter sampling event. In one downgradient well, both aluminum and iron increased during the first quarter, then showed large decreases in the second quarter, and were below detection in the third quarter.

Thallium was analyzed for during all sampling events and was not detected during the baseline, first quarter, and second quarter sampling events. During these sampling events, USEPA Method 6010 (USEPA, 1986), with a detection limit from 0.063 to 0.100 mg/L, was used in the analysis. After the second quarter event, the MCL for thallium was lowered to 0.002 mg/L, and USEPA Method 6010 no longer produced a detection limit below the MCL. The third quarter samples were analyzed and reanalyzed using USEPA Method 7841 with a detection limit of 0.001 mg/L. Thallium was reported in two downgradient wells during this quarter at concentrations of between nondetect and 0.0029 mg/L in well PSF92-02, and between 0.0013 and 0.0025 mg/L in well PSF92-03. Thallium was not detected in the background well. Considerable uncertainty pertaining to these reported thallium concentrations near the detection limit was due to interferences from high levels of calcium, magnesium, and sodium present at Fort Riley, which may positively bias the results. The federal MCL for thallium was exceeded by the maximum reported concentrations in both samples.

Of the inorganic constituents analyzed in the RI sampling program, first quarter and third quarter concentrations of nitrate were consistent with the baseline concentrations. During the second quarter, nitrate showed an increase from two to five times in all samples with the exception of the background well. During this sampling quarter, nitrate exceeded the MCL (10 mg/L as N) in all site wells with the exception of the background well (PSF92-01). The nitrate results for a quality assurance sample were not confirmed by the CEMRD Quality Assurance (QA) lab (CEMRD, 1993), which reported, "The extremely large discrepancy for nitrate analysis seems anomalous." Thus, uncertainty pertaining to these elevated second quarter results exists.

Volatile organic compounds were not detected in the groundwater samples, with the exception of 0.003 mg/L of trichloroethylene in one downgradient sample detected once during the baseline sampling event. Pesticides and semi-volatile organics were analyzed for but not detected in the groundwater during these sampling events.

Analytical results of surface-water samples indicated that only total metals and inorganic constituents commonly found in surface waters and soils were detected in the surface-water samples upstream and downstream from the PSF site. Total concentrations of aluminum, iron, and zinc increased immediately downstream of the PSF. Sulfates were observed to increase immediately downstream from the site.

Analytical results of sediment samples indicated that samples collected in the lined drainage ditch east of the PSF contained pesticides, volatile organic compounds, PAHs and metals. Pesticide concentrations increased immediately downstream of the PSF facility, and then gradually decreased further downstream.

Several volatile organic compounds were detected in the sediments, including toluene, carbon disulfide, 1,2-dichloropropane and 1,1,2,2-tetrachloroethane. Carbon disulfide, 1,2-dichloropropane and 1,1,2,2-tetrachlorethane were only found in one sample each.

The metals arsenic, barium, cadmium, chromium and lead were found in the sediments both upstream and downstream. Of these, only lead showed an increase downstream from the PSF.

A BLRA and ecological risk assessment were completed in the RI. The BLRA concluded that exposure to site soils, sediment, and hypothetical groundwater ingestion evaluated for information only may present potentially unacceptable risks to on-site workers and future residents. The potential for risks to occur is limited because of the relatively few complete exposure pathways at the site. Tables RS-1 and RS-2 summarize cancer risks and hazard indices from the BLRA, respectively. The primary chemicals of concern evaluated in soils and sediment were chlorinated pesticides, and in the groundwater were arsenic, beryllium, manganese, nitrate, and thallium. The ecological risk assessment concluded that negative impact to fauna and flora was not readily apparent. More favorable habitat is locally available and species are more likely to select these higher quality habitat areas, minimizing the impacts from past site activities. Also, downstream impacts from contaminated surface water and sediments would be minimized due to the intermittent nature of the surface flow in the lined channel adjacent to the PSF site.

Pesticides were not detected in downstream surface water (Kansas River) at the Southwest Funston Landfill site.

Removal Action, Feasibility Study Developments, and Additional Groundwater Sampling Activities

While the RI, BLRA, and an FS were under development in 1993, Fort Riley completed an Engineering Evaluation/Cost Analysis (EE/CA) which considered a non-time-critical Removal Action at the site to address pesticide-contaminated soils. The public comment period for the EE/CA was August 17 to September 16, 1993. A public meeting was held at Fort Riley on September 7, 1993, and no members of the public attended. Subsequently, the Removal Action Memorandum (DEH, 1993b) was signed in December 1993.

The Removal Action Memorandum specified excavation and off-site disposal of pesticide-contaminated soils, based on the extent of contamination interpreted from the RI field sampling results. Additional PSF soil sampling was then performed as a part of Removal Action planning activities to better define the extent of contamination and to establish the initial limits of excavation. These Removal Action sampling results identified a larger area of contamination at the PSF site than interpreted from the RI field sampling, and the initial limits of the Removal Action excavation were expanded.

During the Removal Action, site areas were excavated based on established soil contaminant concentrations (action levels) for pesticides with areas exceeding these contaminant levels removed. Excavated soils were not listed hazardous wastes and did not exhibit a characteristic of hazardous waste and were classified as nonhazardous. The excavated soils were disposed by direct burial in a Subtitle C landfill because several discrete samples had elevated concentrations of pesticides. Disposal in a Subtitle C landfill was used, because availability of Subtitle D landfills which could take these soils, which while not RCRA hazardous waste, considered the waste "special wastes" or otherwise classified in various states. The excavations were backfilled with fill material obtained locally to approximately their original elevations, and the Removal Action activities were completed in June 1994. The planning and completion of the Removal Action resulted in a revised understanding of the nature and extent of soil contamination at the PSF, as the observed conditions differed from those anticipated from the RI field investigation. The revised pre-removal action nature and extent of soil contamination, based on data from both the RI report (LAW, 1993a) and Removal Action activities are presented in Section 2.

Two additional rounds of groundwater samples were collected from the PSF monitoring wells and two additional background wells at Building 354 in September 1994 and December 1995, respectively. In 1996 the Corps of Engineers - Kansas City District (CEMRK) completed a statistical comparison of the selected inorganic constituents in the PSF wells with background wells. These groundwater sampling results and the previous RI sampling data, and a summary of the statistical comparison are presented in Section 4.

TABLE RS−1

SUMMARY OF CANCER RISKS
FROM THE BASELINE RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	CANCER RISK
SOIL MEDIA		
Current Site Worker	Incidental ingestion of surface soil	1E−06
Current Site Worker	Dermal contact with surface soil	8E−04
Future Site Worker	Incidental ingestion of surface soil	6E−06
Future Site Worker	Dermal contact with surface soil	4E−03
Future Site Worker	Inhalation of fugitive dust	1E−06
Future Site Worker	Dermal contact with sediments	2E−06
Current Utility Worker	Dermal contact with surface soil	4E−06
Current Utility Worker	Dermal contact with subsurface soil	2E−06
Future Utility Worker	Dermal contact with surface soil	2E−05
Future Utility Worker	Dermal contact with subsurface soil	8E−06
Current Landscaper	Dermal contact with surface soil	1E−06
Current Landscaper	Dermal contact with subsurface soil	2E−06
Future Landscaper	Dermal contact with surface soil	2E−05
Future Landscaper	Dermal contact with subsurface soil	7E−06
Future Construction Worker	Incidental ingestion of surface soil	1E−06
Future Construction Worker	Dermal contact with surface soil	7E−05
Future Construction Worker	Dermal contact with subsurface soil	4E−05
Current/Future Recreational Child	Dermal contact with surface soil	NA
SEDIMENT MEDIA		
Future Site Worker	Dermal contact	2E−06
GROUNDWATER MEDIA (For Information Only)		
Future Site Resident (Adult)	Ingestion of ground water	2E−04
Future Site Resident (Adult)	Dermal contact	4E−07
Future Site Resident (Child)	Ingestion of ground water	NA
Future Site Resident (Child)	Dermal contact	NA

NA − Not assessed because cancer risks are not estimated for children.

TABLE RS-2

SUMMARY OF HAZARD INDICES FROM THE BASELINE RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX
SOIL MEDIA		
Current Site Worker	Incidental Ingestion of surface soil	2E-02
Current Site Worker	Dermal contact with surface soil	9E+00
Future Site Worker	Incidental ingestion of surface soil	6E-02
Future Site Worker	Dermal contact with surface soil	3E+01
Future Site Worker	Inhalation of fugitive dust	4E-07
Future Site Worker	Dermal contact with sediments	2E-02
Current Utility Worker	Dermal contact with surface soil	4E-02
Current Utility Worker	Dermal contact with subsurface soil	2E-02
Future Utility Worker	Dermal contact with surface soil	1E-01
Future Utility Worker	Dermal contact with subsurface soil	7E-02
Current Landscaper	Dermal contact with surface soil	1E-02
Current Landscaper	Dermal contact with subsurface soil	2E-02
Future Landscaper	Dermal contact with surface soil	1E-01
Future Landscaper	Dermal contact with subsurface soil	1E-01
Future Construction Worker	Incidental ingestion of surface soil	3E-01
Future Construction Worker	Dermal contact with surface soil	2E+02
Future Construction Worker	Dermal contact with subsurface soil	7E+00
Current/Future Recreational Child	Dermal contact with surface soil	2E+00
SEDIMENT MEDIA		
Future Site Worker	Dermal contact	2E-02
GROUNDWATER MEDIA (For Information Only)		
Future Site Resident (Adult)	Ingestion of ground water	4.6E+00
Future Site Resident (Adult)	Dermal contact	9.0E-03
Future Site Resident (Child)	Ingestion of ground water	2.2E+01
Future Site Resident (Child)	Dermal contact	1.0E-02

Revised Nature and Extent of Soil Contamination

A limited background soil sampling effort was completed during the Removal Action. Twenty-two soil samples were collected and analyzed for arsenic, barium, beryllium, lead, thallium, and nitrate (CEMRK, 1994). These samples were collected from locations believed representative of three specific geologic and hydrogeologic regimes at Fort Riley. The three regimes were the river valley alluvium, the river valley terrace deposits and the upland areas. Six of these samples collected from the terrace deposits are believed to approximate the natural background levels at the PSF site and provided additional information for comparison.

As part of the RI activities, the surface soils (less than 2-foot depth) and subsurface soils (2 feet and greater) were sampled at the PSF site. Extensive additional sampling of the PSF soils was performed during Removal Action activities to further define the areas of pesticide contamination for the excavation. Following the soil excavation and disposal activities, confirmatory sampling was performed for the soils remaining at the site following completion of the soil excavation and disposal activities. Analytical results of soil samples collected during the RI and the Removal Action were evaluated in order to characterize the site. The additional information obtained from these Removal Action activities indicated that site conditions differed significantly from the interpretations presented previously in the RI report (LAW, 1993a).

The revised pre-Removal Action nature and extent of soil contamination is based on data collected during the RI and Removal Action. In surface soils, four distinct areas of chlordane concentrations above 1.0 mg/kg were indicated from the sampling results, and seven surface soil samples exceeded the Removal Action remediation goal (RG) concentration of 1.58 mg/kg. Five areas of surface soil with DDT and metabolites above 1.0 mg/kg were identified which generally were located in the same areas as the chlordane contamination, and four soil samples exceeded the Removal Action RG (1.73 mg/kg). Dieldrin was detected in four surface soil samples at concentrations exceeding the Removal Action RG concentration of 0.127 mg/kg in areas which generally followed patterns similar to the DDT and chlordane contamination. Heptachlor was detected infrequently in surface soils at or below 0.031 mg/kg, which was below the Removal Action RG of 0.05 mg/kg for this constituent.

In subsurface soils, chlordane distributions exceeding 1.0 mg/kg were identified at depths of 2 to 3 feet, 4 to 5 feet, and 6 to 7 feet. At depths from 2 to 6 feet, 22 soil samples exceeded the Removal Action RG of 1.58 mg/kg. No samples collected at depths of 6 feet and greater exceeded the RG. From the sampling data, three areas of subsurface contamination were predicted. An area of contamination east of the fence may have identified the location of a former trench at the site reported to have been approximately 4 feet deep and running the length of Building 348. Areas of DDT and metabolite concentrations exceeding 1.0 mg/kg were generally located in the same areas as the chlordane contamination and were detected at a greater depth within the area that may identify a former trench than the chlordane contamination. At depths from 2 to 7 feet, 15 samples exceeded the RG concentration (1.73 mg/kg). At depths exceeding 8 feet, no samples exceeded the RG. In some areas, detected concentrations increased with depth, confirming the irregular pattern of contamination believed due to site grading activities over the years. Dieldrin and heptachlor contamination were only detected at the 2- to 3-foot depth each in one sample exceeding the Removal Action RG concentrations near the northeast corner of Building 348. Dieldrin and heptachlor were detected infrequently at concentrations less than the RG in other areas of the site. Arsenic in subsurface soils exceeded the maximum background concentration in four samples in separate areas of the site.

Post-Removal Action Soil Data Evaluation

The site characterization for the PSF in its current, post-Removal Action state is based on analytical data for soils left remaining in place after the Removal Action excavation activities. Only soils were addressed by the Removal Action. Therefore, surface-water and sediment site characterizations presented in the RI report (LAW, 1993a) are still relevant. Surface-water and sediment characterization data fully described in the RI report (LAW, 1993a) are not repeated in this report.

Following the Removal Action, chlordane levels in surface soil did not exceed the Removal Action RG (1.58 mg/kg). DDT and metabolites and dieldrin in surface soil each exceeded their Removal Action RGs in one sample (DDT metabolites - 1.73 mg/kg, dieldrin - 0.127 mg/kg). Heptachlor concentrations were less than the Removal Action RG concentration (0.050 mg/kg).

In subsurface soils after completion of the Removal Action, nine chlordane samples, one DDT sample, and two heptachlor samples exceeded the Removal Action RG concentrations which were based on surface soil exposure. Of the metals, lead was found to occur in subsurface samples at elevated concentrations at two locations. For each subsurface soil sample analyzed for metals, arsenic was detected, typically at low concentrations. Arsenic, chromium, and lead were found to exceed the high-end Fort Riley background soil concentrations in some PSF soil samples. However, none of these metals were found individually to cause excessive risk as determined by the RRA discussed in Section 5.

PAHs were detected in a small number of subsurface samples. The greatest number and highest concentrations of these compounds were found in two subsurface soil samples. PAHs accounted for less than 2 percent of the risks calculated in the BLRA and therefore were not considered contaminants of concern during the Removal Action or in the RRA. The PAHs detected in subsurface soils during the RI field investigation occurred mostly in the areas where soil has been removed and replaced by clean fill during the Removal Action, reducing exposure risks at the site below the levels estimated in the BLRA.

None of the soil samples collected and analyzed for pesticides at the lateral and vertical limits of the Removal Action exceeded the Removal Action RGs at the 10^{-6} risk levels in surface and subsurface soils. No data gaps were, therefore, identified for pesticides.

Arsenic samples in surface soils not under pavement collected during the RI did not exceed the maximum background arsenic concentration detected during the Removal Action background sampling effort. Additional surface soil samples were not analyzed for arsenic during the

Removal Action because elevated levels of arsenic were not detected during the RI in the area where pesticide contamination was found. Since arsenic levels were not elevated in these areas as would be expected, the limited arsenic data is not considered a significant data gap. In subsurface soils, a single sample under existing pavement was significantly below the RG at the 10^{-5} level for arsenic and slightly exceeded the RG at the 10^{-6} risk level.

Groundwater Data Evaluation

This report provides a summary of the groundwater sampling and evaluations that have been performed at the PSF site since the RI report (LAW, 1993a) was completed in 1993. As part of the RI activities, four rounds of groundwater samples were collected from the five PSF site wells (LAW, 1993a). A fifth round of samples was collected in September 1994, and was evaluated with the five previous rounds of sampling in the RI Addendum under development in May 1995. From the evaluation of the data it was concluded that the inorganic constituents of concern detected infrequently at low concentrations in the on-site wells except for nitrate represented background conditions. The May 1995 conclusions were subjective and based on professional judgement; therefore, it was decided that further confirmation of these conclusions was necessary. Therefore, a sixth round of samples was collected in December 1995, and the results are added to the evaluation in this section. This sixth round was collected to further confirm the previous sampling results, and to provide the additional data set needed for a statistical comparison of the concentrations in the on-site and background wells. Results of all the sampling rounds are discussed in Section 4.2.1. The statistical evaluation is summarized in Section 4.2.2.

Groundwater analytical results indicated that inorganics and metals were the main constituents detected during these sampling events. As discussed in Section 4.2, twelve constituents of potential concern (COPCs) were identified in the BLRA. These constituents were aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, manganese, nitrate, selenium, thallium, and vanadium. In general, in comparing the September 1994 analytical results to the previous results, the results were consistent with the low concentrations of these constituents of concern previously detected. Reported total and dissolved concentrations were comparable and exhibited variations within expected differences (plus or minus 10 percent). Aluminum and selenium were minor contributors to noncarcinogenic risk in the BLRA and the 1994 sampling results for these metals were consistent with previous results. These constituents were therefore not included in the following discussion. In downgradient wells, arsenic, barium, and chromium did not exceed the MCL in any samples, and vanadium did not exceed its RG in any sample (note that no MCL has been established for vanadium); antimony (PSF92-05), beryllium (PSF92-02), and cadmium (PSF92-05) exceeded the respective MCLs on one occasion over the five sampling rounds; thallium equaled or exceeded its MCL two times; manganese exceeded the secondary MCL five times out of the 20 samples obtained during the five sampling events; and nitrate exceeded the MCL on 17 out of 20 occasions.

Consistent with the September 1994 data, arsenic was not detected in the December 1995 PSF samples above the detection limit of 0.005 mg/L. Arsenic was detected in a background well at 0.049 mg/L.

Total cadmium was not detected during the September 1994 sampling round. The December 1995 samples were consistent with the 1994 results, that is, cadmium was not detected in any PSF wells or background wells above the method detection limit of 0.001 mg/L. In soils, cadmium was detected infrequently at low levels.

Total chromium was detected once in the background well and twice in downgradient wells during the first four sampling rounds. Total chromium was not detected during the September 1994 sampling round. In December 1995 total chromium was detected in well PSF92-03 at 0.005 mg/L. Total chromium was not detected in any other on-site wells in December 1995 but was detected in the background wells at Building 354 at comparable concentrations.

Antimony was detected in the upgradient well and one downgradient well only during the second round at comparable concentrations and was not detected above the 0.005 mg/L detection limit in any wells in September 1994 and is likely naturally occurring. Antimony was not detected in any PSF or background wells in 1995. Antimony was not sampled in site soils.

Beryllium was detected at comparable concentrations in upgradient and downgradient wells and the detections consistently occurred at the same time in upgradient and downgradient wells, and reflects likely naturally occurring background. In December 1995, beryllium was not detected in any PSF or background wells above the detection limit (0.001 mg/L). Beryllium was not analyzed in site soils.

Manganese was detected consistently in background and downgradient wells during the first four sampling events, but was not detected in the upgradient well or two downgradient wells during the September 1994 event. Manganese levels were variable but consistent with background conditions and reflect naturally occurring conditions. Manganese was not analyzed for in the December 1995 samples. Manganese was not sampled in soils at the site.

First quarter, third quarter, and September 1994 nitrate concentrations were consistent with baseline concentrations. During the second quarter, nitrate showed an increase from two and one-half to five times in all samples except PSF92-01, and the second quarter nitrate results were not confirmed by the Corps of Engineers - Missouri River Division (CEMRD) QA lab (CEMRD, 1993). Thus, uncertainty pertaining to these elevated second quarter results exists. The September 1994 results for nitrate confirmed that the high levels of nitrates observed during the second quarter (February 1993) are not consistently present in the PSF aquifer. Nitrate concentrations measured in the December 1995 samples were consistent with the previous sampling round (excluding the February 1993 data), except a lower concentration was recorded in PSF92-02 than from the previous samples. Nitrate concentrations were not analyzed in site soils.

Inorganic chloride exceeded the maximum detected background concentrations of 147 mg/L in three of the five samples collected from well PSF92-02 during the five sampling rounds. The maximum detected background concentration for inorganic chloride was not exceeded by samples collected from wells PSF92-03, PSF92-04, and PSF92-05 during the five sampling rounds. The maximum detected background concentration for sulfate was 160 mg/L collected from PSF92-01 during the September 1994 sampling round. This background concentration was not exceeded by samples collected from PSF92-04 or PSF92-05 during the five sampling rounds, but was exceeded by five of five samples from PSF92-02 and four of five samples from PSF92-03. Inorganic chloride and sulfate were not analyzed in site soil samples. These species were not analyzed in the December 1995 samples.

Thallium was not detected during the baseline, first quarter, and second quarter sampling rounds. After the second quarter samples were collected, the method of analysis for the third quarter and September 1994 sampling rounds was changed to USEPA Method 7841, and total thallium was observed in two downgradient wells during the third quarter sampling event at maximum reported concentrations of 0.0029 mg/L and 0.0025 mg/L). Interferences and variable analysis results during reanalyses of these samples was noted previously. During September 1994, total thallium was detected in only the upgradient well at a concentration of 0.0024 mg/L. Similar concentrations of thallium near the detection limit were observed in background wells at Building 354 and the Southwest Funston Landfill area. These results indicated that thallium is likely naturally occurring background in the area. Thallium was not detected in any background or on-site wells in December 1995. Thallium was not sampled in PSF soils.

Total vanadium has been detected at concentrations ranging from nondetect to 0.027 mg/L in downgradient wells, and vanadium remained consistent with background conditions. This metal was not analyzed for in the December 1995 samples.

Pesticides were analyzed but not detected in groundwater above the detection limits during any sampling rounds. Final breakdown (mineralization) of pesticides could result in increased inorganic chloride and sulfate concentrations in the groundwater. Since pesticides have not been detected in groundwater at this site, however, the data do not support this conclusion. Furthermore, the source of pesticides in the soil has been removed with the completion of the Removal Action.

The data available through the September 1994 groundwater sampling event strongly suggested that the inorganics considered as contaminants of concern in the BLRA were indicative of background conditions. To test this hypothesis further, the additional round of samples collected in December 1995 and the data was statistically evaluated.

The statistical evaluation was performed by CEMRK, the results of which are provided in Section 4.2.2 in the report. The purpose of the evaluation was to provide statistical evidence as to whether on-site concentrations of the specified compounds are equivalent to the detected background concentrations. The results of the statistical evaluation were that, for the seven inorganic compounds evaluated, only beryllium in well PSF92-02 was present in a single on-site well (PSF92-02) at concentrations not considered equivalent to background concentrations. The following briefly summarizes the results of the statistical evaluation for each of the seven inorganics:

- **Antimony** - Antimony was only detected in well PSF92-05. Using one-half the detection limit as a proxy concentration for all non-detect results, the results for well PSF92-05 were shown to be part of the same distribution as background (i.e., no statistical difference).

- **Arsenic** - The statistical evaluation showed that the distribution of arsenic concentrations in on-site wells was equivalent to that in the background wells.

- **Beryllium** - The statistical evaluation showed that the distribution of beryllium concentrations in on-site wells, with the exception of well PSF92-02, was equivalent to that in the background wells. The beryllium concentrations in PSF92-02 were shown to be outside the statistically-derived distribution for the background well. However, the beryllium concentrations in PSF92-02 were shown to be statistically less than the MCL of .004 mg/L.

- **Cadmium** - Cadmium was only detected in well PSF92-05. The statistical evaluation showed that the distribution of cadmium concentrations in on-site wells was equivalent to that in the background wells, assuming a proxy concentration of one-half the detection limit for all non-detected results.

- **Manganese** - The statistical evaluation showed that the distribution of manganese concentrations in on-site wells was equivalent to that in the background wells.

- **Nitrate** - The statistical evaluation showed that the distribution of nitrate concentrations in on-site wells was equivalent to that in the background wells.

- **Thallium** - The statistical evaluation showed that the distribution of thallium concentrations in on-site wells was equivalent to that in the background wells.

Residual Risk Assessment

The RRA addresses the risk that remains at the site after completion of the Removal Action. This RRA includes a human health risk assessment and consideration of ecological risks due to potential exposures at the PSF site. Because the RI contains an extensive risk assessment, the

RRA was conducted as a streamlined version of a BLRA. Residual risks to human health were recalculated only for pathways for which risks were estimated to be equal to or greater than 1 x 10^{-6} (for carcinogens) or 1.0 (for noncarcinogens) in the RI. Hypothetical risks to human health due to potential use of the uppermost aquifer beneath the site as a source of potable water are considered separately from the risks due to residual soil and sediment contaminants. The groundwater exposure scenarios and associated risks are presented for information purposes only.

The objective of this residual human health risk assessment is to examine the effects on exposed and potentially exposed populations following the soil Removal Action. The risk assessment approach used is consistent with the BLRA and with the approach presented in the USEPA "Risk Assessment Guidance for Superfund" document (USEPA, 1989a).

The human health risk assessment consists of four steps, listed below. These four elements of the risk assessment are conducted in the following sections.

1. Identification of Chemicals of Concern
2. Exposure Assessment
3. Toxicity Assessment
4. Risk Characterization

For the purpose of the RRA, the chemicals remaining in the soil and sediment at the site have been retained as COCs (Table RS-3). These constituents were initially evaluated to identify contaminants of concern. As detailed in the RRA, the evaluation for the PSF site presents scenarios which include exposure to soil by future site workers.

Risks for each of the following receptors and exposure pathways have been quantified for the appropriate media (i.e., soil or sediment). These exposure scenarios are those for which risks were estimated to be equal to or greater than 1 x 10^{-6} (for carcinogens) or 1 (for noncarcinogens) in the RI report (LAW, 1993a).

A summary of the HI estimates, by pathway, is presented in Table RS-4. None of the exposure pathways evaluated had a HI estimate greater than 1, the standard point of departure below which adverse health effects are not expected. The chemical-specific hazard quotient and hazard index calculations are presented, by pathway, in Appendix A. Also presented in Table RS-4 are the pathway-specific HI estimates calculated in the BLRA. A comparison of the two sets of HI estimates shows that the residual risks that were calculated range from approximately 1 to 4 orders of magnitude less than the baseline risks.

A summary of the cancer risk estimates, by pathway, is presented in Table RS-5. None of the exposure pathways evaluated had a risk greater than 1 x 10^{-6}, the most conservative (i.e., health-protective) point-of-departure typically used to assess unacceptable risk. Chemical-specific risk calculations are presented by pathway in Appendix A. Also presented in Table RS-5 are the pathway-specific cancer risk estimates calculated in the BLRA. A comparison of the two sets

TABLE RS–3

CHEMICALS DETECTED IN SOIL SAMPLES DETECTION FREQUENCIES AND CONCENTRATION RANGES

Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
SURFACE SOIL SAMPLES:			
Chlorinated Pesticides:			
Chlordane	17/52	0.0207	1.12
DDD	7/18	0.0237	0.454
DDE	12/18	0.0356	0.847
DDT	35/52	0.012	1.29
Dieldrin	20/52	0.007	0.158
Heptachlor	2/52	0.004	0.0093
SUBSURFACE SOIL SAMPLES:			
Metals:			
Arsenic	31/31	0.4	20
Barium	29/29	35	190
Chromium	29/29	4.6	20
Lead	25/29	4.7	770
Mercury	1/29	--	0.1
Silver	3/29	0.9	1.2
Chlorinated Pesticides:			
Chlordane	41/126	0.0051	10.2
DDD	16/100	0.0013	0.925
DDE	31/101	0.0104	0.666
DDT	42/126	0.011	1.95
Dieldrin	12/126	0.007	0.077
Heptachlor	8/126	0.0012	0.3
Volatile Organics:			
Benzene	2/29	0.0059	0.0066
Methylene chloride	13/29	0.011	0.031
Toluene	7/29	0.0059	0.038
Semi–Volatile Organics:			
Benzo(a)anthracene	3/29	0.11	0.33
bis(2–Ethylhexyl)phthalate	3/29	0.41	1.2
Chrysene	3/29	0.11	0.29
Diethylphthalate	1/29	--	0.43
Fluoranthene	3/29	0.18	0.53
Phenanthrene	2/29	0.23	0.25
Pyrene	5/29	0.11	0.57

Note: Information presented is based on site conditions following the removal action. Values reported are for total chlordane which includes the sum of alpha–chlordane and gamma–chlordane.

TABLE RS-4

SUMMARY OF HAZARD INDICES
SOIL RESIDUAL RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX[a]	BASELINE HAZARD INDEX[b]
Current Site Worker	Incidental Ingestion of surface soil	0.002	0.02
Current Site Worker	Dermal contact with surface soil	0.01	9
Future Site Worker	Incidental ingestion of surface soil	0.003	0.06
Future Site Worker	Dermal contact with surface soil	0.02	30.0
Future Site Worker	Inhalation of fugitive dust	NA	0.0000004
Future Site Worker	Dermal contact with sediments	0.00003	0.02
Current Utility Worker	Dermal contact with surface soil	0.00002	0.04
Current Utility Worker	Dermal contact with subsurface soil	0.00001	0.02
Future Utility Worker	Dermal contact with surface soil	0.00007	0.2
Future Utility Worker	Dermal contact with subsurface soil	0.00004	0.07
Current Landscaper	Dermal contact with surface soil	0.00005	0.01
Current Landscaper	Dermal contact with subsurface soil	0.000009	0.02
Future Landscaper	Dermal contact with surface soil	0.00006	0.1
Future Landscaper	Dermal contact with subsurface soil	0.00004	0.1
Future Construction Worker	Incidental ingestion of surface soil	0.01	0.3
Future Construction Worker	Dermal contact with surface soil	0.007	20.0
Future Construction Worker	Dermal contact with subsurface soil	0.004	7
Current/Future Recreational Child	Dermal contact with surface soil	0.0009	2

NA – Not assessed because toxicity data for inhalation of the chemicals of concern (RfCs) were not available.

[a] Estimates based on post-removal site data and revised absorption factors for pesticides.

[b] Hazard Index estimates from the Baseline Risk Assessment (prior to the Removal Action).

TABLE RS-5

SUMMARY OF CANCER RISKS
SOIL RESIDUAL RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDI	CANCER RISK(a)	BASELINE CANCER RISK(
Current Site Worker	Incidental ingestion of surface soil	2E-07	1E-06
Current Site Worker	Dermal contact with surface soil	1E-06	8E-04
Future Site Worker	Incidental ingestion of surface soil	3E-07	6E-06
Future Site Worker	Dermal contact with surface soil	1E-06	4E-03
Future Site Worker	Inhalation of fugitive dust	3E-10	1E-06
Future Site Worker	Dermal contact with sediments	8E-09	2E-06
Current Utility Worker	Dermal contact with surface soil	2E-09	4E-06
Current Utility Worker	Dermal contact with subsurface soil	1E-09	2E-06
Future Utility Worker	Dermal contact with surface soil	6E-09	2E-05
Future Utility Worker	Dermal contact with subsurface soil	5E-09	8E-06
Current Landscaper	Dermal contact with surface soil	1E-09	1E-06
Current Landscaper	Dermal contact with subsurface soil	1E-09	2E-06
Future Landscaper	Dermal contact with surface soil	6E-09	2E-05
Future Landscaper	Dermal contact with subsurface soil	5E-09	7E-06
Future Construction Worker	Incidental ingestion of surface soil	5E-08	1E-06
Future Construction Worker	Dermal contact with surface soil	3E-08	7E-05
Future Construction Worker	Dermal contact with subsurface soil	2E-08	4E-05
Current/Future Recreational Child	Dermal contact with surface soil	NA	NA

NA – Not assessed because cancer risks are not estimated for children.

(a) Estimates based on new site data and revised absorption factors for pesticides.

(b) Risk estimates from the Baseline Risk Assessment (prior to the Rapid Response Removal Action).

of cancer risk estimates shows that the residual risks that were calculated range from approximately 1 to 4 orders of magnitude less than the baseline risks.

PAHs represented less than 2 percent of the estimated risk or hazard indices in surface soil in the BLRA, and PAH-contaminated soils were substantially removed and replaced with clean fill during the Removal Action. Therefore, they were not reassessed in the RRA. For subsurface soil, data from samples from monitoring well borings that included PAH information used in the BLRA and not excavated during the Removal Action were added to the data set used for the RRA.

None of the exposure pathways for which risks were assessed in the RRA exceeded a cancer risk of 1 x 10^{-6}. Similarly, none exceeded a hazard index of 1. Risk estimates for two pathways, however, were approximately equivalent to 1 x 10^{-6}. These were potential dermal exposure to surface soil by current and future site workers. Because the potential increased risk at the site resulting from exposure to site-related constituents (including soil, surface-water, and sediment pathways not reevaluated in this RRA) is less than or equal to the most conservative point of departure used in risk assessment, risks at the site are considered to be within acceptable limits.

The risk assessment for hypothetical exposures to the groundwater in the uppermost aquifer at the site is being provided for information purposes only and these exposures are not considered to be part of the reasonable maximum exposure (RME) scenarios for this site. This is because the uppermost aquifer at the site is not currently being used as a source of potable water - and because its future use for this purpose is considered highly unlikely because an adequate existing water supply currently serves the area, the uppermost aquifer is not currently used as a water supply, and its low yield makes the uppermost aquifer an unlikely source of potable water in the future.

The risk assessment approach used to evaluate these potential impacts to human health from the hypothetical use of the upper most aquifer as a potable water supply is consistent with the approach presented in the USEPA "Risk Assessment Guidance for Superfund" document (USEPA, 1989a) and with the risk assessment conducted as part of the RI report (LAW, 1993a).

The groundwater data used for this RRA include the data reported in the RI report (LAW, 1993a), [i.e., baseline (July 1992) through third quarter (May 1993) sampling results], plus the results from the most recent sampling events (September 1994 and December 1995). Twelve inorganic compounds were included as COCs in the BLRA presented in the RI report (LAW, 1993a). However, based on the statistical evaluation and comparison to background concentrations summarized in Section 4.2.3 and presented in Appendix C, six of these inorganic compounds are not considered COCs for this risk assessment because they were statistically equivalent to background concentrations. These six compounds are antimony, arsenic, cadmium, manganese, nitrate, and thallium. The remaining compounds which have been selected as COCs in groundwater for the risk assessment are shown on Table RS-6. The elimination of inorganic chemicals which are present at the site at naturally occurring levels (i.e., background levels) from the quantitative risk assessment is consistent with USEPA guidance (USEPA, 1989a). It

TABLER RS–6

CHEMICALS OF CONCERN IN GROUNDWATER DETECTION FREQUENCIES AND CONCENTRATION RANGES

Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	Frequency of Detection	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)
Metals:			
Aluminum	10/20	0.11	0.8
Barium	20/20	0.042	0.130
Beryllium	15/24	0.001	0.005
Chromium	3/24	0.005	0.014
Selenium	16/24	0.011	0.0036
Vanadium	4/20	0.008	0.027

should be noted that pesticides were not detected in the groundwater during any previous sampling efforts at concentrations greater than above the laboratory reporting limit.

Noncarcinogenic Effects Characterization - The HI estimates for the hypothetical use of the groundwater in the uppermost aquifer at the site are 0.2 and 0.8 for adults and children, respectively (Table RS-7). Of the two exposure routes that make up these scenarios (i.e., ingestion and dermal contact), ingestion comprises approximately 99.8 percent of the HI estimates.

Carcinogenic Risk Characterization - The cancer risk estimates for the hypothetical use of the groundwater in the uppermost aquifer at the site are 1 x 10^{-4} and 3 x 10^{-7} for the ingestion and dermal contact exposure routes, respectively (Table RS-8). Beryllium is the only carcinogenic COC identified in the groundwater at PSF.

At the present time, risks due to exposure to the groundwater beneath the site do not exist because a complete exposure pathway does not exist. This is because potable water supply wells do not exist at the site for either residential or occupational uses. However, if residential water supply wells were installed at the site in the future, the possibility of adverse human health effects is indicated due to the presence of beryllium. However, it should be noted that the exposure point concentration for beryllium (0.0028 mg/L) is below the MCL for drinking water of 0.004 mg/L. The statistical evaluation showed that the beryllium concentration in one well (PSF92-05) was different than background; however, the concentration was shown to be statistically less than the MCL.

Prior to the soil Removal Action, the ecological risks due to potential exposures at the site were judged to be minimal. The soil Removal Action replaced contaminated surface and subsurface soil with clean backfill and included the removal of soil from the area where stressed vegetation had been observed. Therefore, based on current site conditions, it is expected that ecological risks are not a concern at the PSF site.

Identification of Remedial Action Objectives (RAOs) - To establish the need for remedial action, an evaluation of current site conditions to identify remedial action objectives (RAOs) consistent with NCP Section 300.430(e)(2)(i) is performed in this section. RAOs specify the contaminants and media of concern, potential exposure pathways, and remediation goals (RGs) to be addressed by remedial actions at the site. No RAOs were identified for any media as presented below. Continued monitoring or additional remedial action is not warranted at this site.

Soils and Sediment - Soils and sediment media exposure pathways were reevaluated in the RRA, and the carcinogenic risk estimates did not exceed 1 x 10^{-6}, and HI estimates for noncarcinogenic effects did not exceed 1. From the evaluations it is concluded that soil and sediment media do not present unacceptable risks at this site. RAOs addressing the sediment media are not needed, because protectiveness goals established under the NCP are being achieved at the site for the exposure scenarios considered. Similarly, soil exposure risks following the Removal Action do not exceed NCP protectiveness goals at this site, and the identification of RAOs addressing soil

TABLE RS-7

SUMMARY OF HAZARD INDICES
HYPOTHETICAL GROUNDWATER USE
(For Information Only)
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX	BASELINE HAZARD INDEX[a]
Hypothetical Site Resident (Adult)	Ingestion of ground water	0.2	5
Hypothetical Site Resident (Adult)	Dermal contact	0.0003	0.009
Hypothetical Site Resident (Child)	Ingestion of ground water	0.8	20
Hypothetical Site Resident (Child)	Dermal contact	0.001	0.02

(a) Estimates from the Baseline Risk Assessment (using the four quarters of data available at that time).

TABLE RS-8

SUMMARY OF CANCER RISKS
HYPOTHETICAL GROUNDWATER USE
(For Information Only)
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	CANCER RISK	BASELINE CANCER RISK[a]
Hypothetical Site Resident (Adult)	Ingestion of ground water	1E-04	2E-04
Hypothetical Site Resident (Adult)	Dermal contact	3E-07	4E-07
Hypothetical Site Resident (Child)	Ingestion of ground water	NA	NA
Hypothetical Site Resident (Child)	Dermal contact	NA	NA

NA – Not assessed because cancer risks are not estimated for children.

[a] Estimates from the Baseline Risk Assessment (using the four quarters of data available at that time).

media is not necessary. Although remedial action is not necessary, informational risk-based preliminary remediation goals (PRGs) concentrations are developed for the receptors which represented the exposure pathways with the highest risks in the BLRA, and are compared to residual soil concentrations to identify individual exceedances at the site. Risk-based PRGs are calculated for the COCs in the soils and are presented in Section 6.1.2.1.

Surface water - Potential exposure pathways for surface water and associated risk estimates were evaluated previously in the December 1993 RI BLRA and are not reevaluated in the RRA. Calculated risk estimates did not exceed 1 x 10^{-6} for carcinogens nor did the HI exceed 1 for noncarcinogenic effects for any exposure pathway. Surface-water media do not present unacceptable risks at this site and it is unnecessary to identify RAOs addressing surface water, because protectiveness goals established under the NCP are being achieved at the site.

Air - Volatile organics were not detected at levels of concern at this site, and were not identified as COCs, and the metals and pesticides do not readily volatilize. Therefore, RAOs/RGs pertaining to air media are not developed.

Groundwater - The groundwater exposure pathway is currently incomplete at this site, and the future use of groundwater is very unlikely. An existing water supply system with adequate future capacity serves the site, and the on-site wells have a low yield, making their use for a water supply impractical. The groundwater exposure scenarios and associated risks were evaluated for information only in the RRA because the calculated risks will not be realized at this site. Chemical constituents which were statistically evaluated (Section 4.2.2) and equivalent to background are not considered as COCs nor are they included in the risk estimates. The calculated noncarcinogenic hazard index for the hypothetical exposure scenario was less than 1. Therefore the COCs included in the noncarcinogenic risk calculation (presented in Section 5.2.5) are not of concern under a groundwater use scenario. The carcinogenic risk estimate was calculated to be 1 x 10^{-4}, due to beryllium which is the only COC included in the carcinogenic risk evaluation.

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED (TBC) CRITERIA

CERCLA remedial response actions must address the requirements of the environmental laws which are determined to be "applicable" or "relevant and appropriate." The identification of ARARs involves the comparison of a number of factors, including the physical nature of the site (location-specific), the type of hazardous substances present (chemical-specific), and the types of remedial actions considered (action-specific), to the statutory or regulatory requirements of the relevant environmental laws. Two types of ARARs are addressed in the following sections: location-specific and chemical-specific.

In addition to the ARARs, to be considered criteria (TBCs) may be identified during the process of determining remedial response objectives, in accordance with the NCP Section 300.400 (g)(3). The TBCs are nonpromulgated advisories or guidance criteria issued by the state or federal government that are not legally binding and thus do not have the status of potential ARARs. TBCs are used, however, in conjunction with ARARs to aid in the determination of cleanup levels necessary to protect human health and the environment. Examples of TBCs include health advisories, guidance policy documents developed to implement regulations, and calculated risk-based levels such as contaminant-specific risk-based remediation goals. Potential ARARs and TBCs are presented and discussed in Section 6.1 of the report.

K.A.R. 28-16-28c, titled: General provisions, implements K.S.A. 65-165 and K.S.A. 65-171d. The provisions in K.A.R. 28-16-28c(a) require that levels of water quality be maintained in surface waters of the state to protect existing and designated uses. Water in the lined channel adjacent to the site has been tested and shown to exhibit levels of water quality necessary to protect existing uses and not result in pollution causing harmful effects on populations of any threatened or endangered species. The groundwater quality at the site, if considered to fall within the K.A.R. 28-16-28b(c) definition of an alluvial aquifer, is also protective of existing and designated uses in that all chemicals of concern are statistically equivalent to background or statistically below the MCL. This criterion is not applicable nor relevant and appropriate.

Surface-water quality criteria are presented in K.A.R. 28-16-28e. In K.A.R. 28-16-28e(b) the general criteria for surface waters are stated. Surface waters are to remain free from artificial polluting substances, such as toxic chemicals, infectious microorganisms from livestock, rubbish, debris, oil and grease, or other pollutants from direct discharges and from nonpoint sources that jeopardize public health, terrestrial or aquatic wildlife. These general criteria may be applicable to the lined channel, since the channel is defined as "surface water," as these criteria apply to all surface waters, regardless of classification. These general criteria also apply to the groundwater if considered to fall within the K.A.R. 28-16-28b(c) definition of an alluvial aquifer. The groundwater is considered free of pollutants in that all chemicals of concern are statistically equivalent to background or statistically below the MCL. The criteria for designated uses of surface waters are presented in K.A.R. 28-16-28e(c). These criteria are not applicable nor relevant and appropriate to the lined channel since the channel is not classified and a designated use cannot be applied.

K.S.A. 65-164 is titled: Sewage; definition; complaints; investigations, orders; judicial review. "Sewage" as defined in K.S.A. 65-164(b) has a broad definition which includes "chemical or other wastes from domestic, manufacturing or other forms of industry." The Statute also sets out in K.S.A. 65-164(c) the Secretary of Health and Environment's role in investigating "the pollution or the polluted condition" of any waters of the state whenever the secretary "has reason to believe that any waters of the state are being polluted in a manner prejudicial to the health of any of the inhabitants of the state." These investigative requirements were satisfied by this investigation, and it was concluded from the investigation that the surface and groundwater at the PSF site are not prejudicial to the health of any inhabitants of the state.

Remediation goals (RGs) shall establish acceptable exposure levels that are protective of human health and the environment [NCP 300.430 (e)(2)(i)]. Appropriate RGs for a site are determined by identifying chemical concentrations available in ARARs and from the consideration of risk-based RGs for the site when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure [NCP 300.430 (e)(2)(i)(A)(2)]. This report presents the preliminary remediation goals (PRGs) for consideration at this site. Final remediation goals will be determined when the remedy is selected.

PRGs are concentrations defining allowable residual contamination that can remain at the site for individual COCs for specific medium contaminants and land use combinations. The NCP allows risk levels of between 10^{-4} and 10^{-6} to be considered for establishing remedial goals to be attained by alternatives which consider multiple contaminants and pathways of exposure at the site. The 10^{-5} risk level is considered appropriate for this industrial area, as discussed in the report. The exposure variable values used for calculating the PRGs for the PSF site are consistent with the values used in the RRA presented in Section 6.1 of this report. For surface soil, PRGs have been developed for future workers at the site. For subsurface soil, PRGs have been developed for future construction workers at the site. For soils, both the 10^{-5} and 10^{-6} point of departure levels are presented for information and comparison. The selection of risk level has a very minor impact on the evaluation and results. Risk-based PRGs were not calculated for the hypothetical future groundwater use because an MCLG and an MCL under the Safe Drinking Water Act are available for beryllium and were used for comparison with on-site groundwater for information only.

Tables RS-9 and RS-10 present summaries of the current detections of COCs in surface soils and subsurface soils, respectively, and comparisons of the detected concentrations of these contaminants to the calculated PRG concentrations to identify exceedances at the PSF.

At the 10^{-5} risk level, no surface or subsurface soil samples exceeded the PRG concentrations. A single surface soil sample exceeded the PRG for dieldrin at the 10^{-6} risk level. One subsurface soil sample under existing pavement exceeded the arsenic PRG concentration at the 10^{-6} risk level. Exposure point concentrations in surface and subsurface soils were less than the PRGs at the 10^{-5} and 10^{-6} risk levels. From these evaluations it is concluded that the Removal Action achieved the primary goal to adequately protect human health. Further remedial actions addressing soils are, therefore, unnecessary.

In the groundwater, beryllium was the only COC identified which contributed to a significant risk under the groundwater use scenario evaluated for information only. Beryllium concentrations in the on-site wells were compared to the MCLG and MCL for information only. From the six rounds of samples conducted at the site, a single sample in one on-site well slightly exceeded the MCL concentration. The 95 percent UCL concentration for beryllium in the on-site wells was less than the MCLG and the MCL. It was further concluded that the beryllium concentrations in the on-site wells were statistically below the MCL. From this evaluation it is concluded that the inorganics in the on-site wells are indicative of background or are not likely to exceed the MCL. Furthermore, the on-site groundwater will not be used as a drinking water source. Neither continued groundwater monitoring nor remediation can be justified under the present conditions.

TABLE RS-9

CONTAMINANTS OF CONCERN DETECTION SUMMARY - SURFACE SOILS AND COMPARISON TO RISK-BASED PRELIMINARY REMEDIATION GOALS

Pesticide Storage Facility
Fort Riley, Kansas

Pesticide Constituent	Detection Frequency[a]	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	10^{-5} Risk-Based Preliminary Remediation Goal (mg/kg)	10^{-6} Risk-Based Preliminary Remediation Goal (mg/kg)	10^{-5} Risk Exceedance Frequency[b]	10^{-6} Risk Exceedance Frequency
Chlordane	17/52	1.12	0.12	12.3	1.23	0/52	0/52
4,4'-DDD	7/18	0.454	0.45	24.0	2.4	0/18	0/18
4,4'-DDE	12/18	0.847	0.37	16.9	1.69	0/18	0/18
4,4'-DDT	35/52	1.29	1.29	16.9	1.69	0/52	0/52
Dieldrin	20/52	0.158	0.04	1.27	0.127	0/52	1/52
Heptachlor	2/52	0.0093	0.0022	3.56	0.356	0/52	0/52

a Number of times the analyte was detected/number of times the analyte was sampled.
b Number of times the analyte concentration exceeded the remediation goal concentration/number of times the analyte was sampled.

TABLE RS-10

CONTAMINANTS OF CONCERN DETECTION SUMMARY – SUBSURFACE SOILS AND COMPARISON TO GOVERNING RISK-BASED PRELIMINARY REMEDIATION GOALS

Pesticide Storage Facility
Fort Riley, Kansas

Constituent	Detection Frequency [a]	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	10^{-5} Risk-Based Preliminary Remediation Goals (mg/kg)	10^{-6} Risk-Based Preliminary Remediation Goal (mg/kg)	10^{-5} Risk Exceedance Frequency [b]	10^{-6} Risk Exceedance Frequency
Pesticides:							
Chlordane	41/126	10.2	0.220	20.9	18.9 (d)	0/126	0/126
4,4'-DDD	16/100	0.925	0.017	669	66.9	0/100	0/100
4,4'-DDE	31/101	0.666	0.033	473	47.3	0/101	0/100
4,4'-DDT	42/126	1.95	0.150	114	47.3 (d)	0/126	0/126
Dieldrin	12/126	0.077	0.0048	16.4	1.64	0/126	0/126
Heptachlor	8/126	0.3	0.0029	54.6	5.46	0/126	0/126
Volatile Compounds:							
Benzene	2/29	0.0066	0.0023	3080	308	0/29	0/29
Methylene chloride	13/29	0.031	0.019	7610	1,190 (d)	0/29	0/29
Toluene	7/29	0.038	0.0067	25,400 (d)	25,400 (d)	0/29	0/29
Semi-Volatile Compounds:							
Benzo[a]anthracene	3/29	0.33	0.1	81.2	8.12	0/29	0/29
bis(2-Ethylhexyl)phthalate	3/29	1.2	0.33	2540	638 (d)	0/29	0/29
Chrysene	3/29	0.29	0.092	3080	308	0/29	0/29
Diethylphthalate	1/29	0.43	0.24	101,000	10,100	0/29	0/29
Fluoranthene	3/29	0.53	0.13	5,070	507	0/29	0/29
Pyrene	5/29	0.57	0.12	3,800	380	0/29	0/29
Metals:							
Arsenic	31/31	20	4.6	130	17.4 (d)	0/31	1/31
Barium	29/29	190	105	28,500	2,850	0/29	0/29
Chromium	29/29	20	8.4	2,160 (d)	2,160 (d)	0/29	0/29
Lead	25/29	770	99.5	1,000 (c)	1,000 (c)	0/29	0/29
Mercury	1/29	0.1	0.054	130 (d)	130 (d)	0/29	0/29
Silver	3/29	1.2	0.46	2,160 (d)	2,160 (d)	0/29	0/29

a – Number of times the analyte was detected / number of times the analyte was sampled.
b – Number of times the analyte concentration exceeded the remedial goal / number of times the analyte was sampled.
c – OSWER Directive #9355.4-02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, September 1989.
d – Preliminary remediation goal based on hazard index of 1.0.

1.0 INTRODUCTION AND BACKGROUND

In support of the Fort Riley Installation Restoration Program, the United States Army Corps of Engineers, Missouri River Division, Kansas City District (CEMRK) under Contract DACW41-92-D-9002, retained Law Engineering and Environmental Services, Inc., Government Services Division, (LAW) to perform a Remedial Investigation/Feasibility Study (RI/FS) at the Pesticide Storage Facility (PSF) at Fort Riley, Kansas. Since the initiation of the PSF project, several organizational changes have been made at Fort Riley, including the conversion of the Directorate of Engineering and Housing (DEH) to the Public Works (PW) directorate and the creation of the Directorate of Environment and Safety (DES) in 1994. The previous designations are used throughout this report to maintain consistency with previous documents.

Pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Fort Riley was proposed for inclusion on the National Priority List (NPL) on July 14, 1989. Two Operable Units (OUs) at Fort Riley, the PSF (OU002) and Southwest Funston Landfill (SFL) (OU001), were combined by the U.S. Environmental Protection Agency (USEPA) as one site for purposes of Hazard Ranking System (HRS) scoring. The USEPA reasoned that both contaminant sources potentially affect the same shallow aquifer and target populations. These two sites were finalized on the NPL on August 30, 1990, and were assigned a combined score of 33.79 on the HRS. (An HRS score of 28.5 is needed for inclusion on the NPL.) The two sites are the subjects of separate RI/FS efforts.

The Department of the Army - Fort Riley, the U.S. Environmental Protection Agency (USEPA) Region VII, and the State of Kansas Department of Health and Environment (KDHE), negotiated a Federal Facility Agreement (FFA) for Fort Riley, Docket No. VII-90-F-0015 (FFA, 1991), also referred to as the Interagency Agreement (IAG) which became effective on June 28, 1991.

The PSF has been previously investigated on several different occasions. Two pesticide monitoring studies and closure of a PCB storage container at the site were completed between 1974 and 1990. The RI/FS planning activities were conducted from 1990 to 1992. The initial RI Report (LAW, 1993a) was issued in December 1993, and became final in April 1994. While the RI/FS was under development in 1993, Fort Riley conducted an Engineering Evaluation/Cost Analysis (EE/CA) which considered a non-time-critical Removal Action at the PSF (DEH, 1993a). A Removal Action Memorandum was subsequently completed in December 1993 (DEH, 1993b). Removal Action activities, which included the excavation and off-site disposal of pesticide-contaminated soils, were completed in June 1994.

This RI Addenda report has been prepared to document the Removal Action and to present the additional site information collected and evaluated since the initial RI report (LAW, 1993a). The Removal Action excavations and additional soil sampling revealed that the contaminated soil areas differed from those predicted from the RI field data. This RI Addenda report presents a revised description of the soil contamination that existed at the PSF site, using the RI field data and the additional data obtained from the Removal Action. A description of the current (post Removal Action) site conditions is also included.

Two additional groundwater sampling rounds have been conducted since the initial RI report (LAW, 1993a) was completed in December 1993. The groundwater data sets for selected inorganics in the on-site and background monitoring wells were subjected to a statistical evaluation to determine whether the concentrations for these inorganics in the on-site wells were statistically different from the concentrations for these inorganics in background wells.

A residual risk assessment (RRA) is also presented in this RI Addenda report which provides revised estimates of site risks considering the current conditions at the site (i.e., following the Removal Action), and the additional conclusions from the statistical evaluation of the groundwater data. Site-specific, contaminant-specific remediation goal concentrations (RGs) and Applicable or Relevant and Appropriate Requirements (ARARs) are identified in this report. The ARARs and informational PRGs are compared to the residual contamination at the site (following the Removal Action), and to the groundwater concentrations found in the on-site wells to evaluate whether there is a need for additional remedial action at the PSF site. Continued groundwater monitoring or remediation is not warranted.

1.1 ORGANIZATION OF REPORT

The content and organization of this report is in general accordance with the USEPA's Guidance on Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9355.3-01, October 1988 and Superfund Removal Procedures, Removal Response Reporting: POLREPs and OSC Reports, June 1994. This RI addenda report is divided into eight sections.

- Section 1 presents a site description and summaries of the previous studies prior to and including the initial RI site characterization activities (LAW, 1993a).

- Section 2 presents a revised description of the nature and extent of soil contamination that existed at the site prior to the Removal Action activities using both the RI data and the additional data obtained during the Removal Action.

- Section 3 presents the Removal Action Report. It describes the excavation and sampling activities conducted during the Removal Action and documents the disposal of the excavated material.

- Section 4 describes the current site conditions following the Removal Action; presents the September 1994 and December 1995 groundwater sampling results; incorporates this groundwater data with the previous sampling results presented in the December 1993 RI; and presents the statistical evaluation of the concentrations of selected inorganics in groundwater from on-site wells versus background wells.

- Section 5 includes the residual risk assessment (RRA) which provides estimates of the current site risks remaining following the Removal Action and reevaluates hypothetical groundwater risks in light of the conclusions from the statistical evaluation of the concentrations of inorganics in on-site versus background wells.

- Section 6 presents the identification of applicable or relevant and appropriate requirements (ARARs), and an informational comparison of residual soil contaminants to the preliminary remediation goals (PRGs). There is no need for additional remedial action based on an analysis of removal action objectives (RAOs) for the applicable site media.

- Section 7 presents the summary and conclusions.

- Section 8 presents references.

1.2 SITE DESCRIPTION

1.2.1 Installation History

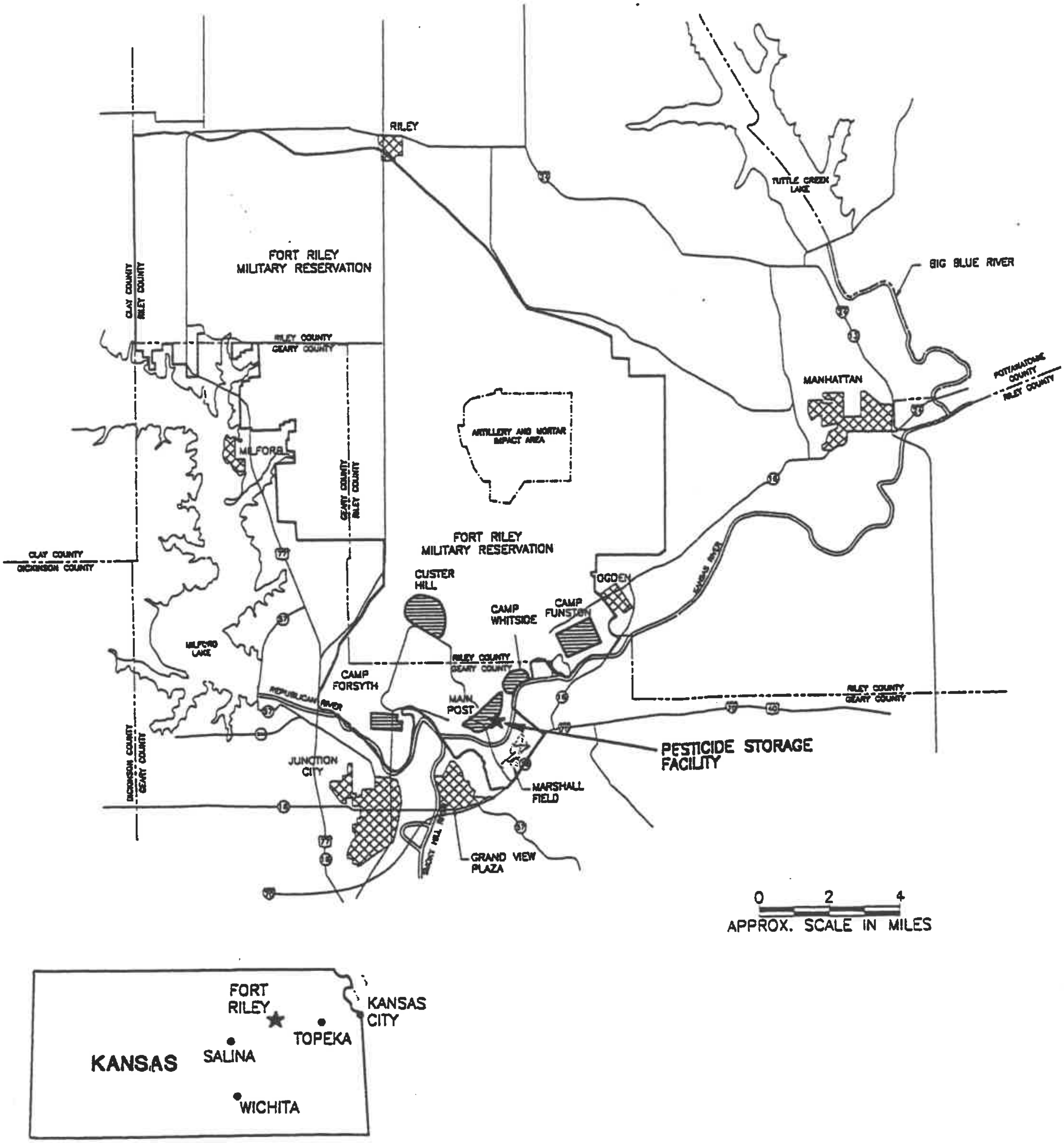
The Fort Riley Military Installation was established in 1852 as an outpost near the confluence of the Smoky Hill and Republican Rivers in Geary and Riley Counties, Kansas (LAW, 1993a), as shown in Figure 1-1. The development and growth of Fort Riley proceeded in response to the evolution of the American military mission, in response to the Indian conflicts of the last half of the 1800s, the Spanish American War, World Wars I and II, the Korean and Vietnamese conflicts, and the Persian Gulf War.

Since its inception, Fort Riley has continuously served as a center of military education and readiness. Fort Riley has functioned as a small municipality and light industrial complex, at times having an installation population, including military and civilian residents, of over 20,000. Municipal activities on the installation include solid waste disposal (landfilling), wastewater treatment, wastewater discharge, and general infrastructure maintenance. Specific tasks

FIGURE1 -1

PESTICIDE STORAGE FACILITY LOCATION MAP

FORT RILEY, KANSAS



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associated with maintenance duties would include general construction activities, pesticide and herbicide application, fleet maintenance and general storage and repair services.

Fort Riley serves in a military capacity as a training, equipment supply, and military maintenance center and, therefore, has historically required management and disposal of wastes associated with these activities. Pesticides (including insecticides and rodenticides), herbicides, fungicides, insect repellents, and soil fumigants have been used at Fort Riley for a variety of applications, and are referred to herein collectively as "pesticides and herbicides" (LAW, 1993a). Historically, the types of pesticides and herbicides used at Fort Riley have also been generally available to the public at the time of use.

1.2.2 Site Description, History, and Operations at the PSF

Figure 1-1 shows the location of the PSF at Fort Riley. Figure 1-2 shows the configuration of the Directorate of Engineering and Housing (DEH) yard within the vicinity of the PSF as it appeared in 1992, following the installation of the five monitoring wells which were part of the RI field work activities (LAW, 1993a). The DEH yard extends south of Dickman Avenue to the south-central edge of the Main Post cantonment area. Items stored within the DEH area include paint, pesticides/herbicides, pressure-treated lumber, electrical and plumbing materials, bulk asphalt, bulk aggregate, and fence materials. Vehicle maintenance and storage facilities are also located at the DEH yard. Stored items include heavy equipment, pick-up trucks, mowers, dump trucks, loaders, lift trucks and equipment, and tools used to perform maintenance activities.

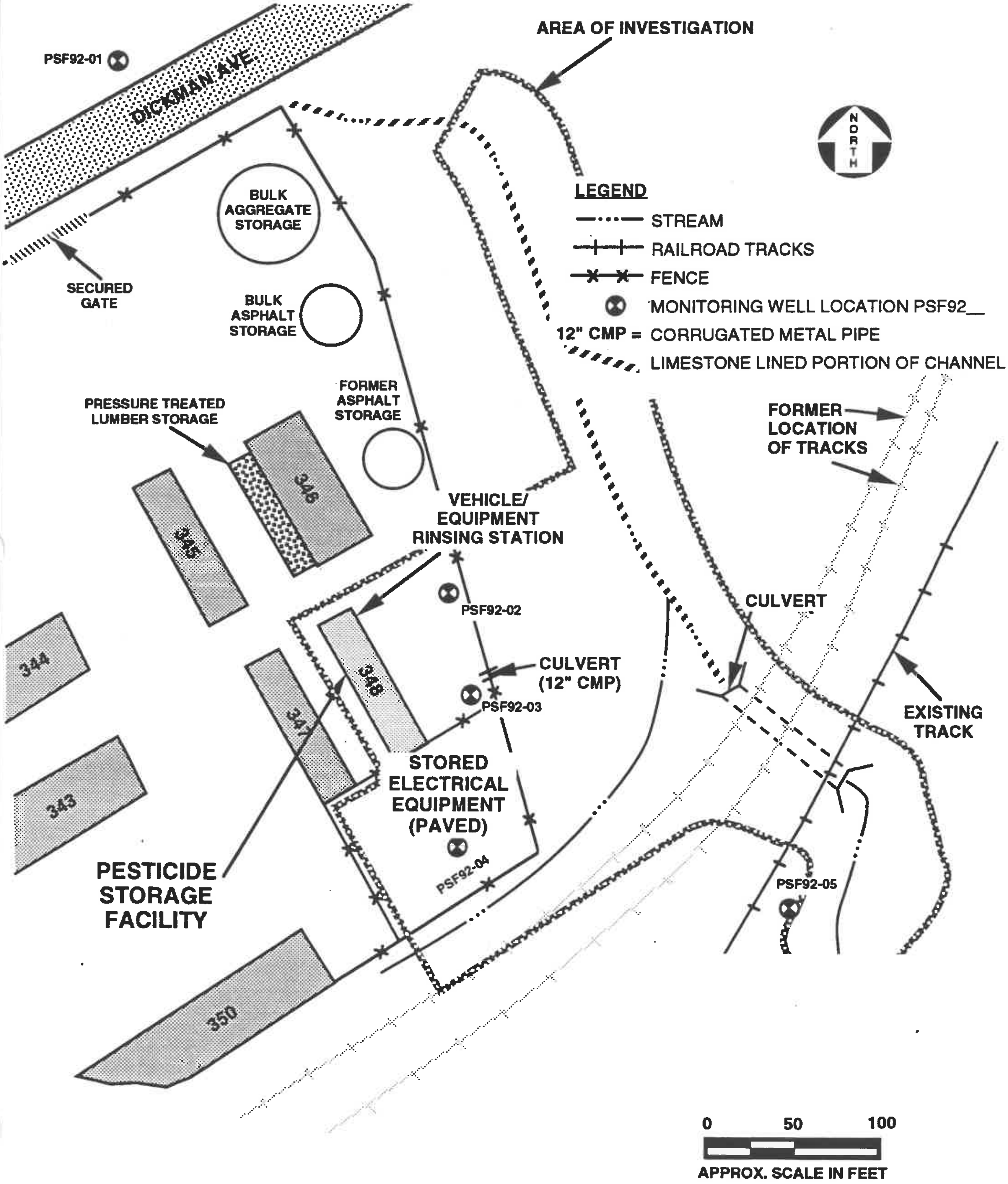
The area of investigation is approximately two-thirds of an acre and consists of the southeast portion of the DEH yard which is a fenced, secured storage and maintenance area that supports services necessary to maintain the buildings, grounds, and utility systems at Fort Riley. Items and materials that have been stored in "outside warehouse areas" have been relocated over time.

The Pesticide Storage Facility, Building No. 348 (formerly Building No. 292), was constructed in 1941, to serve as a general purpose warehouse. Fort Riley records do not state what was initially stored in Building 348. However, a personal interview with the Fort Riley Senior Pesticide and Herbicide Program Manager and the Exterior Works Branch Chief indicated that the building had been used for the storage of pesticides since at least 1973 (LAW, 1993a). Inventories of the chemicals commonly available (1971) to Fort Riley when formulation and mixing occurred at the PSF, and substances stored at the PSF after this practice was discontinued, (recorded in 1979 and 1983) are presented in the RI (LAW, 1993a). Chemicals previously stored at Building 348 included insecticides, herbicides, repellents, rodenticides, a fungicide, and a soil fumigant. The remainder of the building was used to store general improvement materials, equipment, and paint. Information derived from DEH files (dated pre-1990) indicated that pressure-treated lumber was stored along the eastern fence. DEH

FIGURE 1-2

PESTICIDE STORAGE FACILITY – 1992

FORT RILEY, KANSAS



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photographs from the spring and summer of 1991 also show that pressure-treated lumber storage occurred adjacent to the eastern fence at the site. Pressure-treated lumber was removed to allow access to these site areas for the 1992 RI field investigation.

In the past, spray vehicles were filled with water on the eastern side of Building 348. During this time, overfilling of spray tanks occurred, with water containing pesticides spilling onto the ground. Vehicles used to transport and spray the pesticide mixes were also washed in this area. Pesticide and herbicide wastewaters, rinse water, and concentrated spills were allowed to run onto the ground. Due to the topography at the site, water generated by overfilling and washing would tend to flow toward the east, down the slope leading to the limestone-lined drainage channel. Since at least 1976, the majority of pesticide application has been performed by outside contractors to Fort Riley. Contractors were not allowed to use the PSF for formulation or mixing of pesticides.

Discussions with Army employees familiar with past operations at the PSF confirmed that grading and possibly trenching activities had been carried out across the site over the years. Grading activities included the use of fill material from other areas of Fort Riley to maintain suitable PSF topography. Additional inquiry into the site history performed after completion of the RI report revealed that trenches were constructed and backfilled within the area of investigation (LAW, 1994a). Current and past DEH workers describe two trenches that were constructed during different time periods to the east of the chain link fence at the site. These trenches were reportedly constructed by excavating soil in the area, and were unlined and uncovered during the times they were operational. The reason for construction of these trenches was not known by the DEH workers interviewed. However, because the trenches impounded surface-water run-off, they probably served as accumulation points for contaminants.

The first trench was reportedly constructed between 1967 and 1974. Information about how the trench was constructed was not available. This excavation was oriented parallel to the fence, and is estimated to have measured approximately 6 feet in width and 18 feet in length. The depth of the excavation was unknown. The date that the excavation was filled in was also not known. The second trench excavated at the site is estimated to have been constructed between 1979 and 1982. This trench (called a "slit trench" by one DEH worker) was constructed using heavy earth-moving equipment. The width of this trench was reported to be approximately 6 feet, its depth approximately 4 feet, and its length reported to be the length of Building 348 (approximately 120 feet). The trench was reportedly backfilled with soil during the early to mid-1980s.

Interviews conducted with DEH employees indicated that a floor drain had been present inside Building 348 (LAW, 1994a). This floor drain reportedly emptied into the base sanitary sewer system. However, the available utility maps of the sewer system in the vicinity of the PSF site did not show laterals emanating from Building 348. Interviewees indicated that they did not witness pesticide spills in the interior of the building or the use of the drain for the disposal of pesticides or hazardous substances. The floor drain was eventually filled with concrete on an unknown date and is currently inactive. The sewer lateral from this drain was found during the Removal Action.

In 1982, general improvements were made to Building 348 consisting of the addition of insulation to the roof/ceiling spaces and installation of fire proofing to the vertical walls. In 1984, the interior portion of Building 348 was renovated to correct for deficiencies to meet federal standards for pesticide storage.

Aerial photographs and interviews indicated that several bins used for the collection of scrap metal had been located along the west side of the fence (i.e., inside the PSF site operational area). Items stored within the study area in 1992 at the time of the RI field investigation included paint, pesticides/herbicides, pressure treated lumber, electrical and plumbing materials, bulk asphalt, bulk aggregate, and fence materials. During the RI site visit, no visual evidence of surficial or below ground disposal of chemical wastes was detected. In August 1994, pesticide storage and handling operations were transferred to a new Pesticide Storage Building, located within the DEH yard area but outside the limits of this investigation. The southern portion of Building 348 is still used for material storage.

Another operational practice of note is the manner in which containers at the PSF site were disposed. Used pesticide containers were triple-rinsed and emptied into a spray tank; the containers were then punctured several times to prevent reuse. The containers were stored for short periods of time (approximately one to three days) inside of Building 348 prior to disposal in an off-site landfill (LAW, 1994a).

According to labeled photographs taken in December 1991 by DEH personnel, an underground water-line leak had occurred immediately east of Building 348, near the outdoor water faucet located at the northeast end of the building. Around December 1991, this piping was relocated to the west side of the building. The photographs showed moist water stains on the ground within the fenced area as a result of the water-line leak.

Also, in December 1991, a natural gas line leak developed in gas piping south of the railroad tracks (LAW, 1993a). Repairs of this leak occurred December 10, 1991, and resulted in the excavation of a portion of the gas line (to expose gas valving) east of Building 348. While the excavations were open, slide photographs were taken. Review of these slides reveal indications of several layers of gravel material being placed as surface cover. The excavated material was returned to the trench(es) when repairs were finished. Less than 1 foot of settlement had occurred where the excavations were developed as observed by field personnel during the field work (February 1992 through May 1993).

1.2.3 Surface Topography

The PSF is situated on an escarpment on the north side of the Kansas River Valley approximately 2,000 feet north and west of the Kansas River, on the southeast edge of the Main Post contonment area. Topographic elevations at the PSF are about 25 feet higher than the Kansas River (LAW, 1993a). The topographic survey performed as a part of RI field work confirmed the general observations of the site reconnaissance. The ground surface slopes downward towards the east-southeast with an average slope of approximately 1-foot fall for every 13 feet of run (1:13) or a grade of approximately 10 percent. There is an abrupt drop or slope change just east of the PSF fence line.

Surface run-off flows easterly, following the general topography of the site. Direct observation during a thunderstorm confirms that surface run-off follows the general topographic trends as seen in Figure 1-3 (IRP Manager, 1992). Surface run-off behaves as sheet flow in the unobstructed areas of the DEH yard. As the run-off follows the general slope it is, to a degree, interrupted by Buildings 345, 346, 347 and 348. Once the flow has "navigated" these obstacles, it then enters a 12-inch corrugated metal pipe culvert discharging via overland into the rock-lined drainage channel east of the yard area. The lined drainage ditch runs from Dickman Avenue to the railroad tracks southeast of the site. The sides of the drainage ditch are constructed of cemented limestone blocks. This channel proceeds southward under the railroad tracks and then flows into an unnamed tributary leading to the Kansas River.

DEH personnel have indicated during personal interviews that numerous heavy thunderstorms occurred between 1981 and 1983 (Chief, Env. & Nat. Res. Div., DEH, 1992). The resulting storm-water run-off eroded sizeable channels, ruts, and "wash outs" in areas along and underneath the fence and to the east and south of the PSF fence lines. Some of these erosional features were large enough for a man to crawl through (Chief, Env. & Nat. Res. Div., DEH, 1992). Estimates indicate that between 3 and 5 feet of material was eroded from underneath the train tracks adjacent to the PSF at one time. In each case, new "fill" material was emplaced, returning the site to existing grade. At the time of asphalt paving of the area south of the fence (August/September 1990), the blacktop area was built up anywhere from 1 to 1.5 feet, based on original fence height and surface of blacktop.

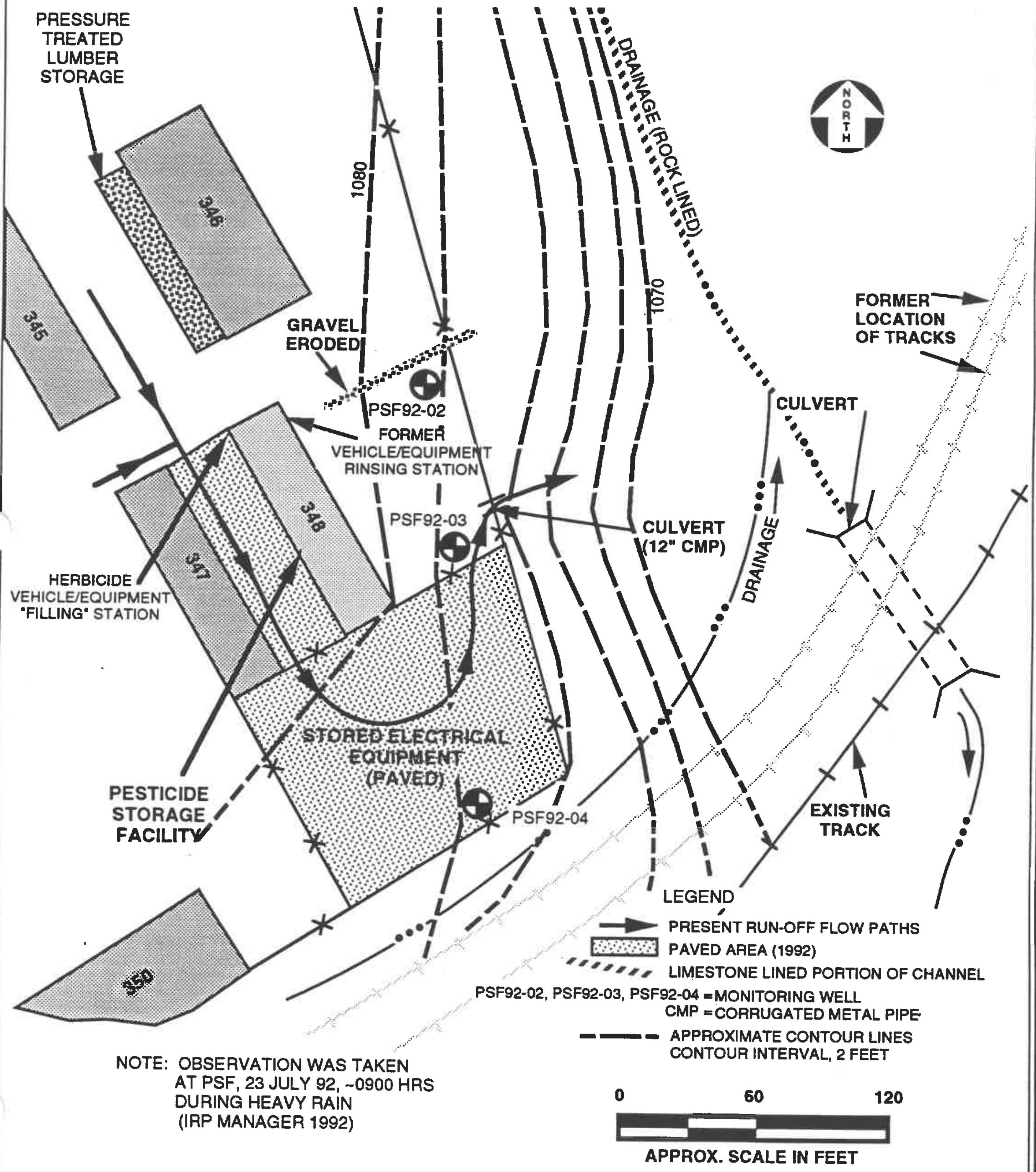
1.2.4 Surface-Water Hydrology

Surface-water features at Fort Riley can be characterized into three distinct categories: rivers, streams/drainages and impoundments (LAW, 1993a). Refer to Figure 1-4 for the locations of these features. The major rivers in the vicinity of the PSF are the Republican, Smoky Hill and Kansas Rivers. There is no levee between the PSF and the Kansas River (United States Geological Survey [USGS], 1992). The Kansas River flows at a mean annual discharge rate of 2,750 cubic feet per second (cfs), calculated as the combined flow from the Republican and

FIGURE 1-3

OBSERVED PATH OF SURFACE WATER RUNOFF – 1992

PESTICIDE STORAGE FACILITY – 1992
FORT RILEY, KANSAS



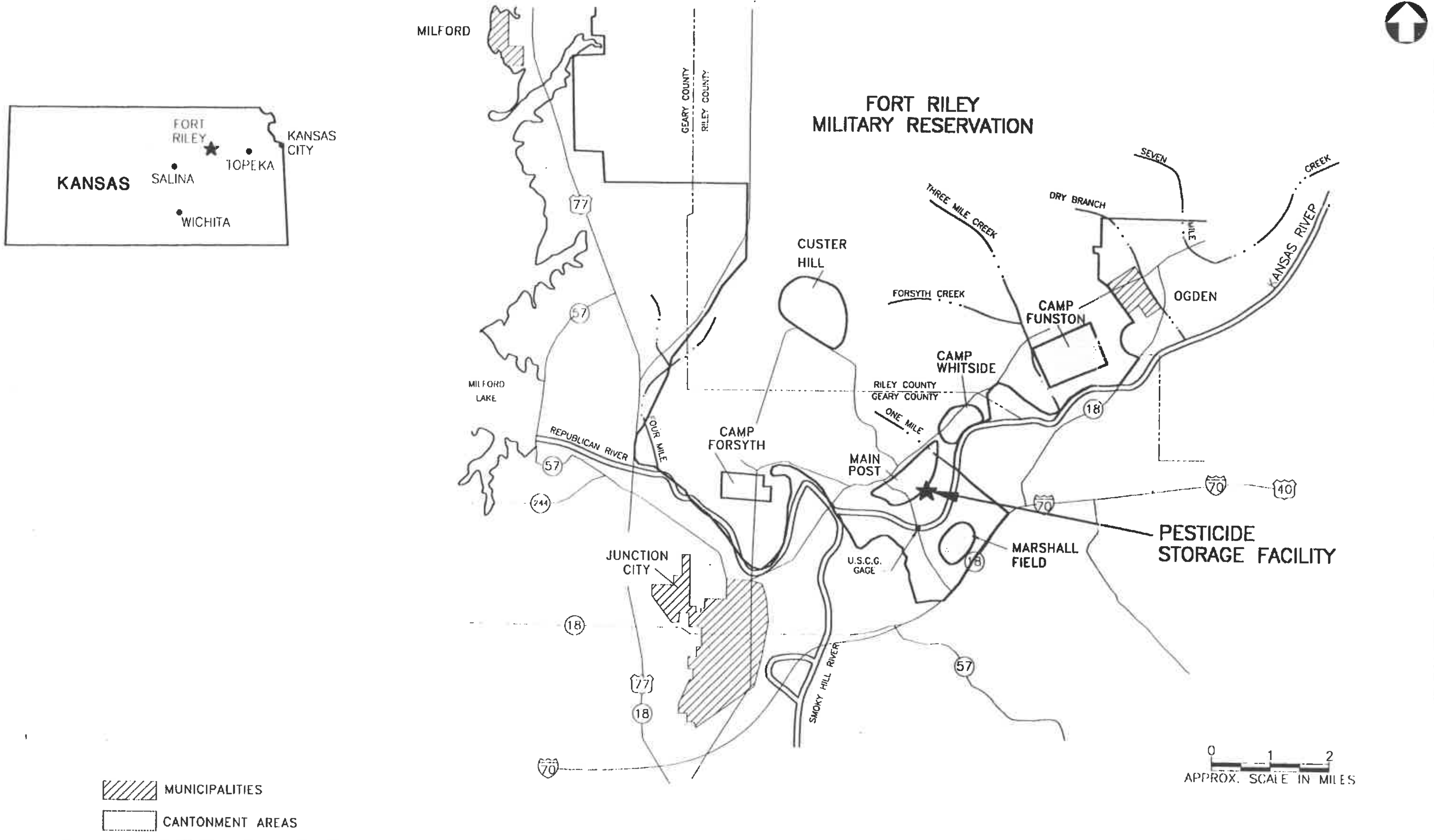
NOTE: OBSERVATION WAS TAKEN
AT PSF, 23 JULY 92, ~0900 HRS
DURING HEAVY RAIN
(IRP MANAGER 1992)

2563-0308.21

FIGURE 1–4

MAJOR DRAINAGES AND SURFACE WATER FEATURES

FORT RILEY, KANSAS



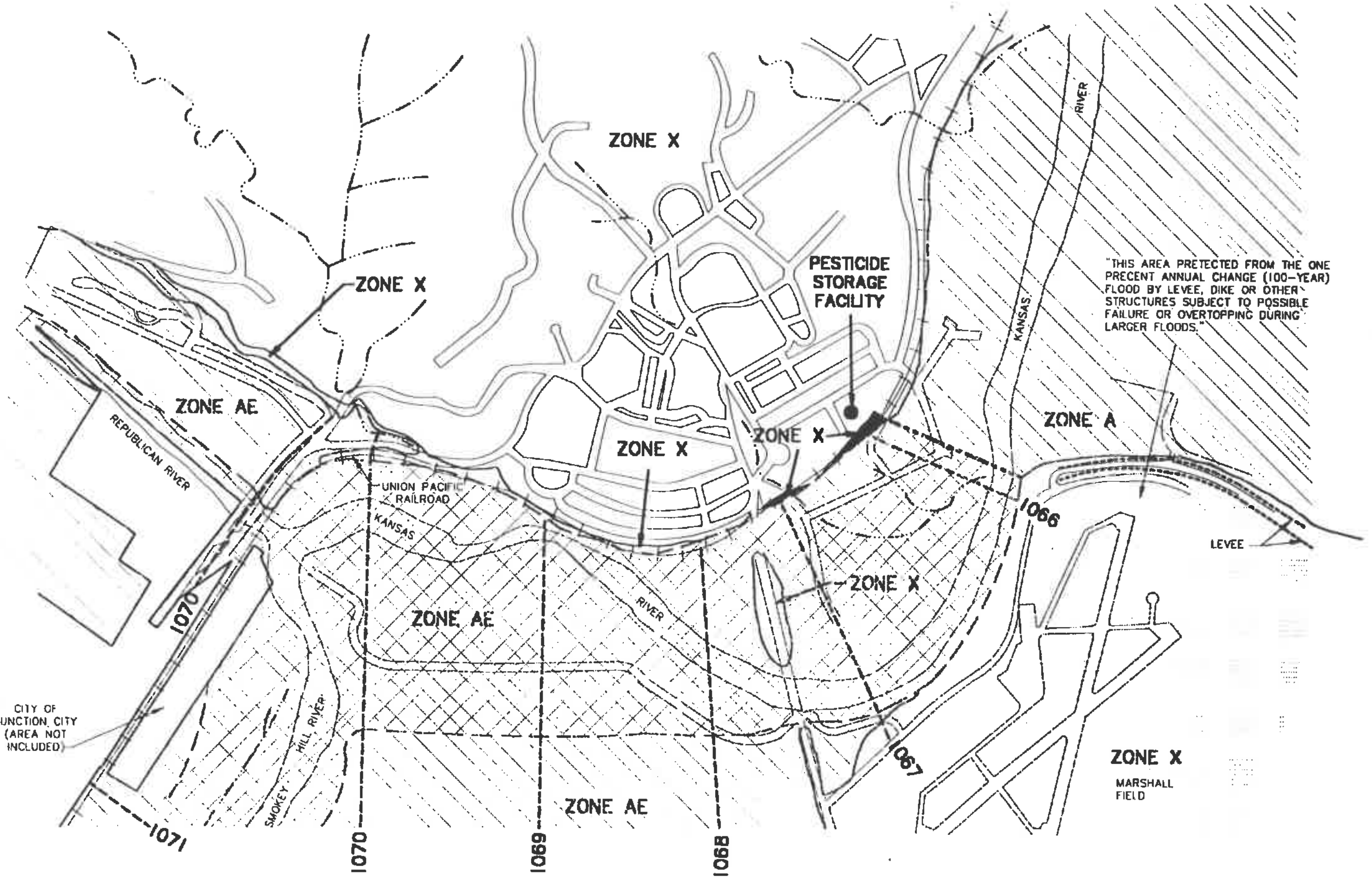
Smoky Hill Rivers (USGS, 1992) at the USGS gaging station on Henry Drive off Interstate 70. The Kansas River depth fluctuates between 1.5 and 12 feet. The Republican River flows at a mean annual discharge rate of 1,007 cfs. The lowest flow recorded was 50 cfs, and the highest flow recorded was 13,500 cfs (USGS, 1992). The Smoky Hill River discharges approximately 1760 cfs (USGS, 1992). General surface-water quality is considered moderate to poor especially during periods of lower flow (USGS, 1992). The waters are characterized as turbid, alkaline, moderately mineralized, buffered, with high dissolved oxygen content, low organic load, high nutrient levels, and high bacterial levels. The Kansas Department of Health and Environment has not issued restrictions on fish consumption and Class III recreation along the Kansas River near Fort Riley.

The Flood Insurance Study report ([FEMA], 1988), lists the following flood frequency elevations above mean sea level (msl) for the Kansas River: 10 year equals 1,059 feet; 50 year equals 1,067 feet; 100 year equals 1,070.5 feet; and 500 year equals 1,078 feet. Therefore, based on these data and the ground surface (1,088 feet to 1,062 feet msl) for the PSF, the southern portion of the area of investigation lies within the 50-year floodplain. Figure 1-5 shows the area of flood hazard around the PSF. Previous Kansas River flood events are not documented to have reached or inundated the PSF. However, DEH personnel stated that floods of the early 1950s reached and inundated the DEH yard in general and the PSF specifically. High water stages in the Kansas River occur from the last part of February through the first part of June. The lowest river stages occur from late October through January (USGS, 1992). Before the construction of Milford Reservoir, major flooding occurred approximately every eight to 10 years, with a three- to five-day duration (USGS, 1992).

Surface-water impoundments at or near Fort Riley include a man-made reservoir, several oxbow lakes (crescent shaped lake formed in an abandoned river meander which has become separated from the main stream by a change in the course of the river), and several large and smaller ponds. Milford Reservoir is located west of Fort Riley and is fed by the Republican River. There are no surface-water impoundments within the PSF drainage basin or immediately downstream of the Kansas River.

1.2.5 Geology

This section presents a summary discussion of the regional and site-specific geology as related to the PSF investigation. Additional information is available in the RI report. The primary reference for this section is the Kansas Geological Survey (KGS) Bulletin #189 titled "The Stratigraphic Succession in Kansas" (KGS, 1968).



N

NOTES

THIS MAP IS FOR USE IN ADMINISTERING THE NATIONAL FLOOD INSURANCE PROGRAM; IT DOES NOT NECESSARILY IDENTIFY ALL AREAS SUBJECT TO FLOODING PARTICULALY FROM LOCAL DRAINAGE SOURCES OF SMALL SIZES, OR ALL PLANIMETRIC FEATURES OUTSIDE SPECIAL FLOOD HAZARD AREAS.

CERTAIN AREAS NOT IN SPECIAL FLOOD HAZARD AREAS MAY BE PROTECTED BY FLOOD CONTROL STRUCTURES

BOUNDARIES OF THE FLOODWAYS WERE COMPUTED AT CROSS SECTIONS AND INTERPOLATED BETWEEN CROSS SECTIONS. THE FLOODWAYS WERE BASED ON HYDRAULIC CONSIDERATIONS WITH REGARD TO REQUIREMENTS OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY.

FLOODWAY WIDTHS IN SOME AREAS MAY BE TO NARROW TO SHOW TO SCALE. REFER TO FLOODWAY DATA TABLE WHERE FLOODWAY WIDTH IS SHOWN AT 1/20 INCH.

COASTAL BASE FLOOD ELEVATIONS APPLY ONLY LANDWARD OF THE SHORELINE

ELEVATION REFERENCE MARKS ARE DESCRIBED IN THE FLOOD INSURANCE STUDY REPORT.

CORPORATE LIMITS SHOWN ARE CURRENT AS OF THE DATE OF THIS MAP. THE USER SHOULD CONTACT APPROPRIATE COMMUNITY OFFICALS TO DETERMINE IF CORPORATE LIMITS HAVE CHANGED SUBSEQUENT TO THE ISSUANCE OF THIS MAP.

FOR ADJOINING PANELS, SEE SEPARATELY PRINTED MAP INDEX

MAP REPOSITORY

COUNTY COURTHOUSE ANNEX, JUNCTION CITY, KANSAS (MAPS AVAILABLE FOR REFERENCE ONLY, NOT FOR DISTRIBUTION)

INITIAL IDENTIFICATION:
OCTOBER 18, 1977

FLOOD HAZARD BOUNDARY MAP REVISIONS:
FEBRUARY 20, 1979

FLOOD INSURANCE RATE MAP EFFECTIVE:
FEBRUARY 4, 1988

FLOOD INSURANCE RATE MAP REVISIONS:

SOURCE

FEDERAL EMERGENCY MANAGEMENT AGENCY
PANEL NUMBER 200579-0055C
FEB. 4, 1988.

0 1600 3200
SCALE IN FEET

LEGEND

▨ SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD
ZONE A NO BASE FLOOD ELEV. DETERMINED
ZONE AE BASE FLOOD ELEV. DETERMINED

▦ FLOODWAY AREA IN ZONE AE

☐ OTHER FLOOD AREAS
ZONE X AREAS OF 500-YEAR FLOOD; AREAS OF 100 YEAR FLOOD WITH AVERAGE DEPTHS OF LESS THAN 1 FOOT OR DRAINAGE AREA LESS THAN 1 SQUARE MILE; AND AREAS PROTECTED BY LEVEES FROM 100-YEAR FLOOD

☐ OTHER AREAS
ZONE X AREAS DETERMINED TO BE OUTSIDE 500-YEAR FLOOD PLAIN
ZONE D AREAS IN WHICH FLOOD HAZARDS ARE UNDETERMINED

— — — BOUNDARY DIVIDING SPECIAL FLOOD HAZARD ZONES, AND BOUNDARY DIVIDING AREA OF DIFFENRENT COASTAL BASE FLOOD ELEVATIONS WITHIN SPECIAL FLOOD HAZARD ZONES

--1067-- BASE FLOOD ELEVATION LINE; ELEVATION IN FEET*

* REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

FLOOD HAZARD BOUNDARY MAP

PREPARED BY/DATE:	FIGURE NUMBER:	FILE DATE: 28.OCT.94
CHECKED BY/DATE:	1-5	PLOT DATE: 9.MAY.95
APPROVED BY/DATE:		FILE NAME: fldmap.dwg

1.2.5.1 Regional Geology - Fort Riley is situated in three distinct geomorphic areas (Figure 1-6). The first is the uplands area, which is underlain by flat-lying and gently-dipping (northwesterly), interbedded limestone and shale units (KGS, 1968). The shallowest rocks beneath the uplands area consist of various shale units. The deeper limestone are typically exposed along the escarpments. Small streams have dissected these thick shale units and eroded much of the area into a rolling plateau. Local relief ranges from 164 to 240 feet in the uplands area. The second is steep to hilly country which extends from the uplands down to the alluvial bottomlands. This second geomorphic area is occasionally mantled by loess deposits. The third is the alluvial bottomlands of the Republican and Kansas Rivers. Relief in this area ranges from 25 to 60 feet.

Stratigraphic units present at Fort Riley are Lower Permian in age and consist of alternating limestones and shales (Figure 1-7). The Chase Group and the Council Grove Group are the uppermost geologic units, with the Chase group being the uppermost of the two. Bedding planes dip gently to the northwest at approximately 15 feet per mile.

Geologic formations at Fort Riley within the Council Grove Group, include Stearns Shale, Bader Limestone, Easly Creek Shale, Crouse Limestone, Blue Rapids Shale, Funston Limestone, and Speiser Shale.

1.2.5.2 Site-Specific Geology - This section presents a summary of site-specific geology as related to the PSF evaluation. The PSF is located in the Buck Creek Terrace deposits north of the Kansas River alluvium (LAW, 1993a). These terrace deposits are part of the valley-fill deposits of the Kansas River valley and contain water-bearing sand and gravel (KGS, 1974). They are described as grading upward from brownish-yellow sand, sandy silt and fine gravel in the lower part to reddish-brown and reddish-tan silt in the upper part. The soils formed in this material are described as reddish-brown or reddish-tan silt and clay.

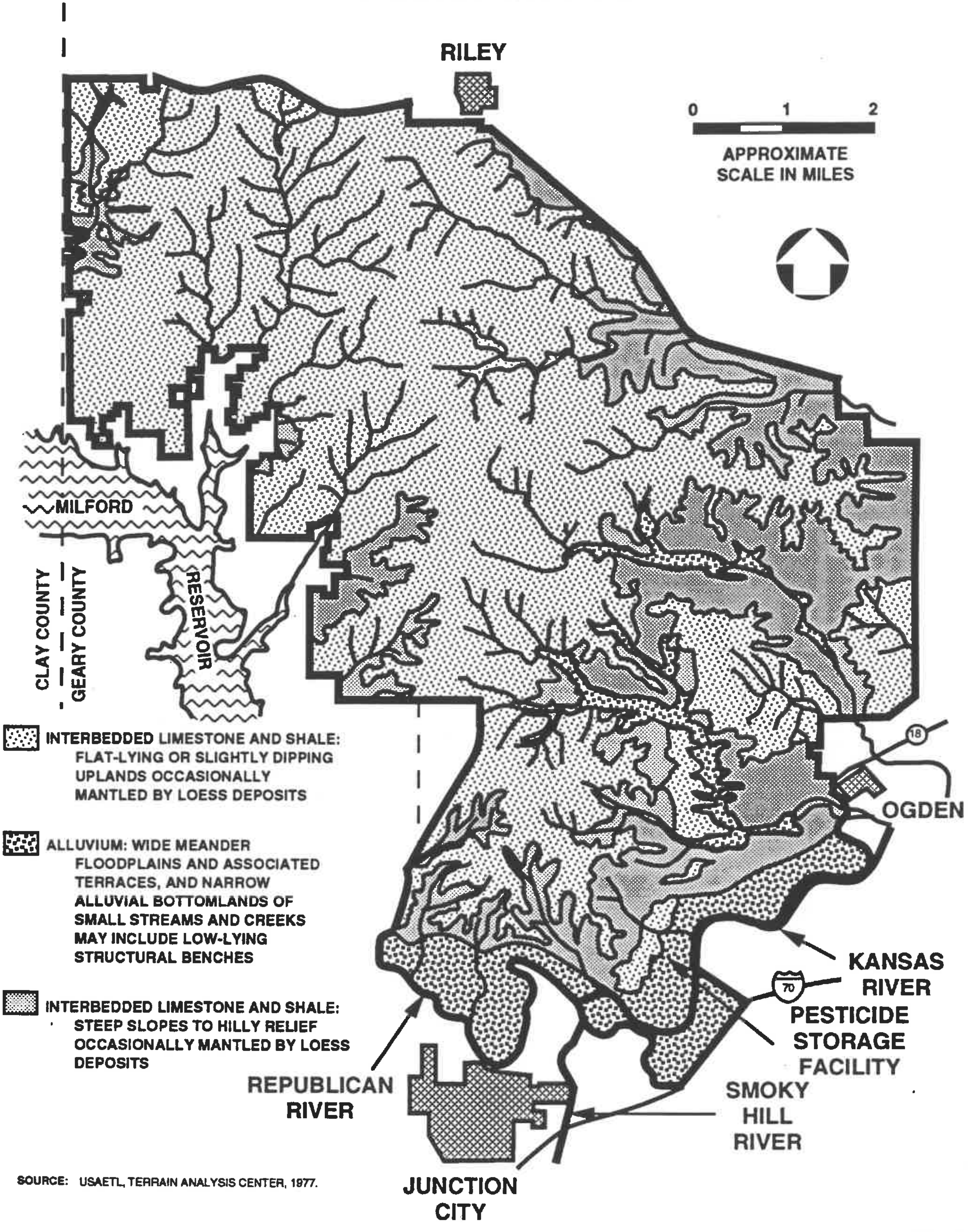
In general, the relative positions of the alluvium and terrace areas are described as follows. Geologically recent alluvium extended from the Kansas River to the first distinguishable escarpment. Older alluvial deposits underlie the Newman terrace that extends from the first escarpment to the next escarpment (or change in soil texture) towards the valley wall. Finally, still older alluvium underlies the second Buck Creek terrace, which extends to the valley wall. The alluvium beneath these two terraces are referred to as terrace deposits.

Field investigations revealed the depth to the competent shale and limestone bedrock is approximately 28 feet below ground surface (bgs). This corresponds to an elevation of approximately 1,034 msl. The unconsolidated materials alternate between brown and black silt or clayey silt and brown to yellow-brown fine to coarse sand or clayey sand. In the monitoring well borings (PSF92-02, -03, -04), asphalt or gravel was present at the surface. The bedrock encountered beneath the alluvial and terrace deposits is Lower Permian in age and believed to

FIGURE 1-6

GEOLOGIC MAP OF FORT RILEY

FORT RILEY, KANSAS

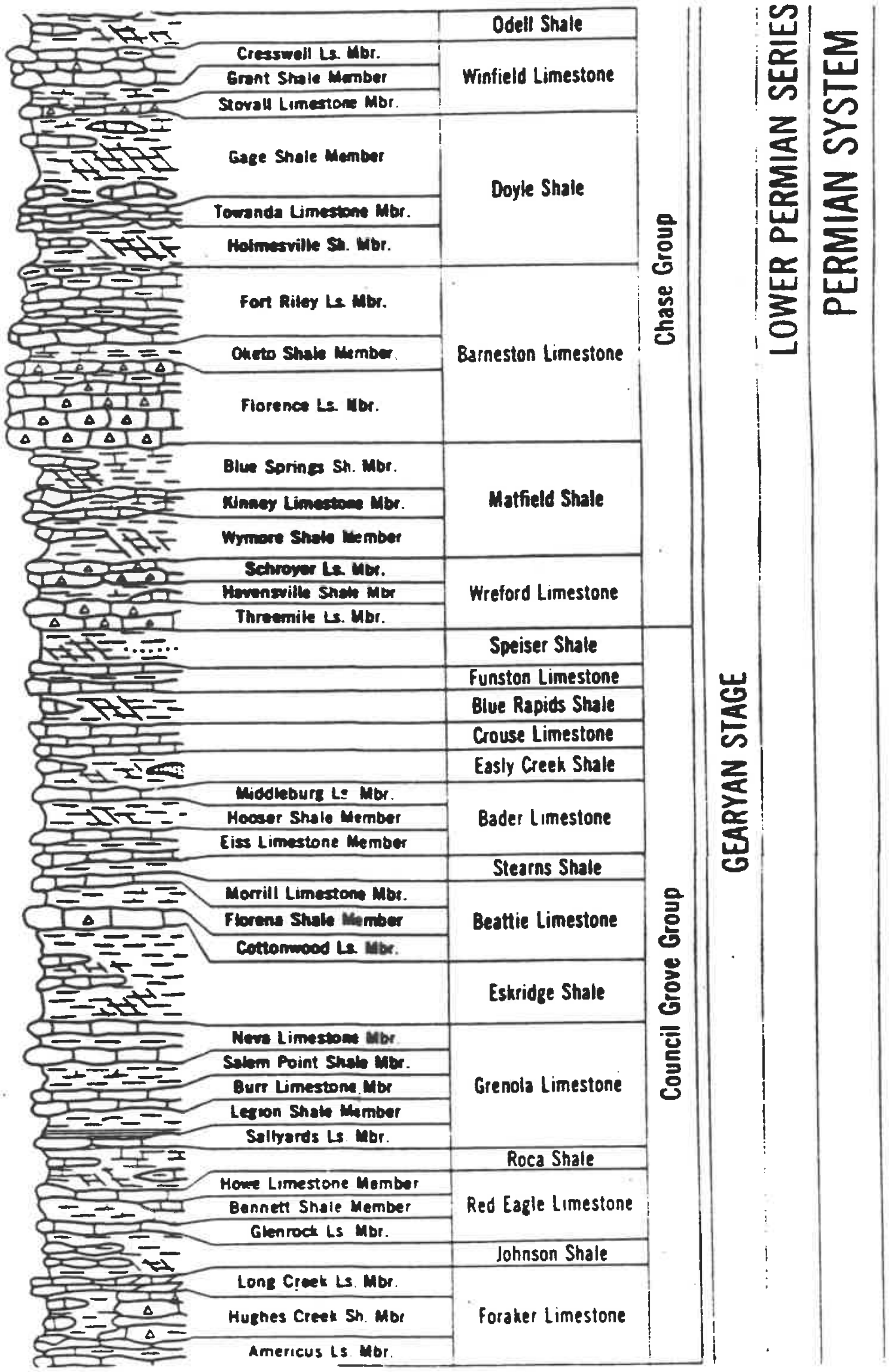


SOURCE: USAETL, TERRAIN ANALYSIS CENTER, 1977.

2563-0308.21

FIGURE 1-7

GENERAL STRATIGRAPHIC SEQUENCE-ROCK COLUMN
FORT RILEY, KANSAS



SOURCE: ZELLER, 1968

CP

be of the Council Grove Group, Gearyan Stage. Refer to Figures 1-8 and 1-9 for graphical representations of the site-specific geological conditions.

An area fill is interpreted to have been placed for site grading during the original site construction in 1941. Approximately 10 feet of fill was noted on the east side of Building 348 near PSF92-03. Schematic cross sections A-A' (Figures 1-8 and 1-9) illustrate approximate profiles north of and through Building 348. Substantially more fill was placed near Building 348, probably in an effort to extend the terrace surface southward. Fill at PSF92-02 and PSF92-04 is estimated to be at 7 and 3 feet, respectively.

1.2.6 Soils

Geotechnical analysis from the five borings completed during the RI has classified the soil as clayey sands (SC) and clayey silts (ML) under the Unified Soil Classification System (LAW, 1993a). Table 1-1 shows the classification of the soil at each boring together with parameters analyzed and the Unified Soil Classification System identification.

The Soil Survey of Riley County and Part of Geary County, Kansas by the United States Department of Agriculture Soil Conservation Service (USDASCS, 1975) has classified the soil at the PSF and its vicinity to be of the Kennesaw Series silt loam, with 6 to 10 percent slopes. The surface layer is about 12 inches thick consisting of dark gray to dark grayish-brown silt loam. The subsoil which extends to 36 inches deep is made up of brown to light brown silt loam. The Kennesaw soils are well drained and moderately permeable. Surface run-off is medium to rapid in some cultivated areas, and erosion is a severe hazard.

1.2.7 Hydrogeology

This section presents a summary of the general and site-specific hydrogeology of the region taken from the RI report (LAW, 1993a).

1.2.7.1 Regional Hydrogeology - The Fort Riley Military Installation covers a portion of the Republican and Kansas Rivers and Milford Reservoir watersheds (Figure 1-4). This area is characterized by poorly developed karst topography (KGS, 1968) and cyclothymic stratigraphic sequences of interbedded limestones and shales. The term "karst" refers to lithologic characteristics associated with dissolution of carbonate rock by groundwater movement through the rock column (LAW, 1993a). Karst is a type of topography that is characterized by sinkholes, caves, and underground drainage (Bates and Jackson, 1984).

FIGURE 1-8

LOCATION OF GEOLOGIC CROSS SECTION

PESTICIDE STORAGE FACILITY – 1992
FORT RILEY, KANSAS

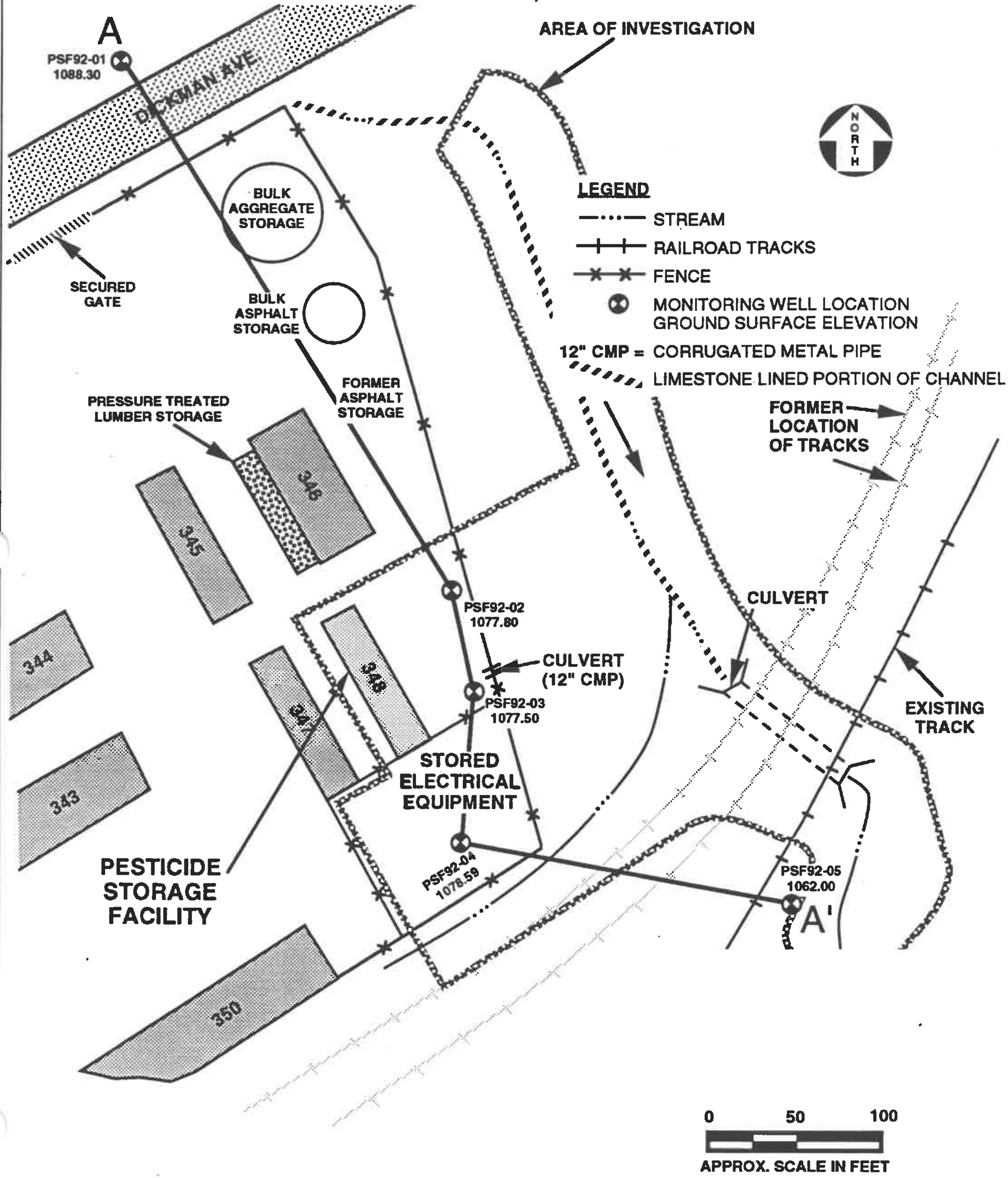


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FIGURE 1-9

GEOLOGIC CROSS SECTION A-A'

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

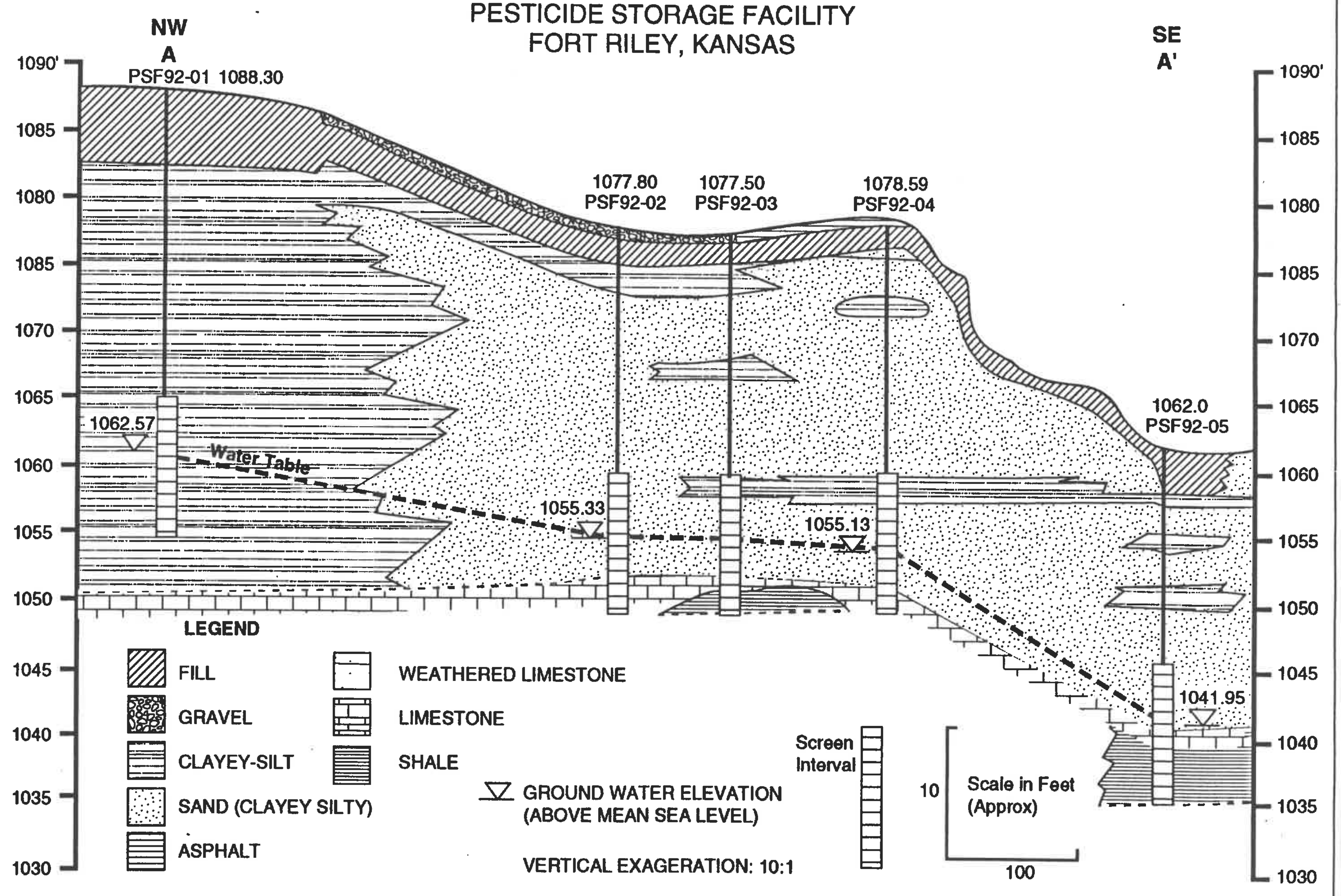

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TABLE 1–1

ANALYTICAL RESULTS
GEOTECHNICAL SAMPLES
Pesticide Storage Facility
Fort Riley, Kansas

WELL NO/ SAMPLE DEPTH	% SAND	% SILT	% CLAY	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	UNIFIED SOIL CLASSIFICATION
PSF92–01 GT/ 7' – 9'	46.0	46.0	8.0	26	18	8	CL
PSF92–01 GT/ 25' – 27'	27.0	62.0	11.0	27	18	9	CL
PSF92–02 GT/ 2' – 4'	19.5	60.0	20.5	19	19	N.P.	SC
PSF92–02 GT/ 22' – 24'	82.5	13.0	4.5	NR	NR	N.P.	SC
PSF92–03 GT/ 2' – 4'	12.5	67.5	20.0	35	22	13	CL
PSF92–03 GT/ 20' – 22'	17.0	69.5	13.5	24	18	6	CL
PSF92–04 GT/ 2' – 4'	69.5	25.0	5.5	15	15	N.P.	SC
PSF92–04 GT/ 22' – 24'	12.0	80.0	8.0	24	21	3	ML
PSF92–05 GT/ 3' – 5'	56.0	35.0	9.0	22	18	4	SC
PSF92–05 GT/ 17' – 19'	61.0	33.5	5.5	NR	NR	N.P.	SC

NOTES:
CL = Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
SC = Clayey sands, sand–clay mixtures.
ML = Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
GT = Geotechnical
NP = Nonplastic
NR = Not reported

Source: Unified Soil Classification System

The principal source of water for municipal, industrial and irrigation supplies is the combined river and valley fill deposits of the Kansas River Valley (KGS, 1974). Groundwater is also produced, to a lesser degree, from solution channels and joints in the Permian Age limestone bedrock aquifer which underlies the unconsolidated overburden (KGS, 1974).

The alluvium adjacent to the Kansas River and the Pleistocene Age Newman and Buck Creek terrace deposits are major geologic units in the Kansas River Valley (KGS, 1974). Within these deposits are zones of sands and gravels which are considered important water-bearing units.

Supplies adequate for local drinking water and moderate-scale agricultural activities can be derived from bedrock wells (KGS, 1974). Depth and presence of groundwater varies depending on local physiographic, geologic, and hydrologic conditions. The regional direction of groundwater flow is generally towards the Kansas River and is influenced by river stage.

The primary source of drinking water for Fort Riley, Junction City and Ogden is the valley fill alluvium (alluvial aquifer) of the Republican and Kansas Rivers (KGS, 1974). Junction City and Fort Riley water supply wells are within the Republican River floodplain. Wells completed in limestone at Fort Riley are producing from zones approximately 70 feet below the ground surface. The alluvial deposits are capable of yielding more than 1400 gallons per minute (gpm) from a single well (KGS, 1974). This aquifer is recharged through direct infiltration of rain and seepage from limestone and shales. The Kansas and Republican Rivers are also primary sources of recharge to the alluvial aquifer. Water levels in the Fort Riley water supply wells generally range from 15 to 25 feet below land surface.

1.2.7.2 Site-Specific Hydrogeology - This section summarizes the site-specific hydrogeologic conditions discussed in the RI (LAW, 1993a).

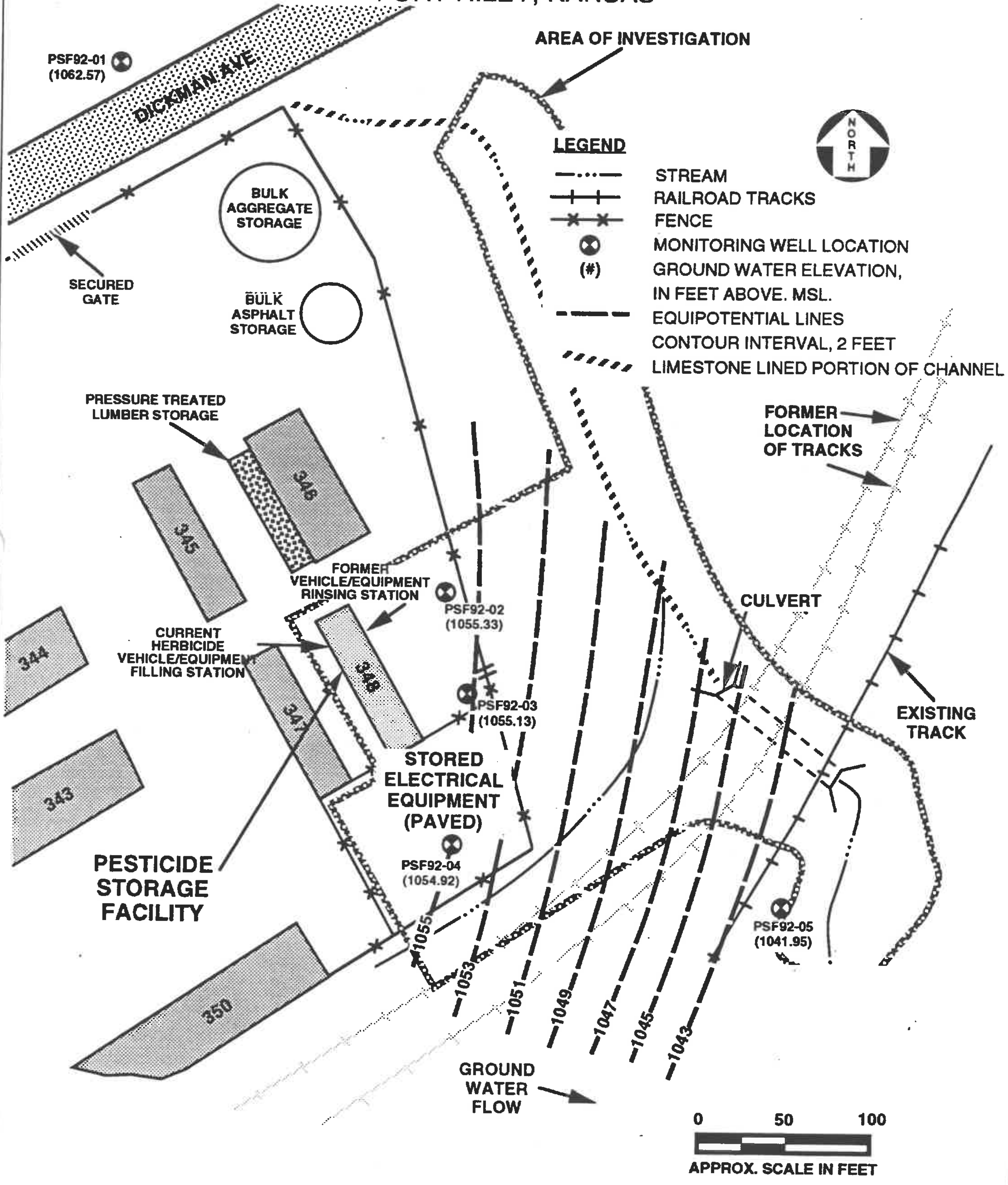
Five groundwater monitoring wells were installed in 1992 at the PSF. Analysis and reduction of the well slug test data resulted in calculated hydraulic conductivity (K) values for the PSF wells ranging from 1.171 x 10^{-4} ft/min (5.9 x 10^{-5} cm/sec) to 1.03 x 10^{-3} ft/min (5.21 x 10^{-4} cm/sec) (LAW, 1993a).

The calculated direction of flow at the PSF is east-southeast with an observed gradient of approximately 0.07 ft/ft toward the Kansas River and appears to follow the approximate slope of the bedrock surface and the general topographic trends. Figure 1-10 shows the groundwater potentiometric surface estimated in December 1992. Water levels recorded at the site are also presented on this figure, and the depth to groundwater was about 23 feet at the time. Based on the range of estimates for hydraulic conductivity and the estimated hydraulic gradient given above, and assuming an effective porosity value for the geologic media of 0.30, calculated groundwater flow velocities range from 2.7 x 10^{-5} ft/min to 2.4 x 10^{-4} ft/min (LAW, 1993a).

FIGURE 1-10

POTENTIOMETRIC SURFACE MAP, DEC. 1992

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



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The yield of the on-site aquifer was estimated to be 1 to 2 gpm, based on monitoring well pumping and recharge rates observed during the sampling events (LAW, 1993a). Water levels in PSF wells and background wells in the Building 348 area were measured in September 1994. The potentiometric surface at the PSF during this event and additional analyses to estimate a range of on-site aquifer yields are presented in Section 4.3.

1.2.8 Ecological Description

Land use in the undeveloped portions of Fort Riley consists primarily of grasslands or woodlands, with very little acreage devoted to crop production (LAW, 1993a). Cropland on the reservation is planted primarily as wildlife food plots or as a firebreak between private and federal lands. Grasslands may be comprised either of native prairie species, of cool-season tame grasses, or of naturally invaded grasses and forbs on old field or "go-back" acres where crops once grew (U.S. Fish and Wildlife Service [USFWS], 1992a).

A survey of threatened and endangered species on the Fort Riley Military Reservation was conducted by the U.S. Fish and Wildlife Service (USFWS, 1992a). The results of this survey indicate that eight federally-listed threatened and endangered species along with twelve federal category 2 candidate species could potentially occur on Fort Riley. Category 2 candidate species are those which the USFWS is seeking additional information regarding their biological status, in order to determine if listing of these species is warranted. Although the eastern hognose snake was included in this survey, the status of this species has changed from "state-listed endangered" to a species "in need of conservation" (LAW, 1993a).

A PSF site survey was conducted by CEMRK contractor personnel accompanied by the Fish and Wildlife Administrator at Fort Riley on August 5, 1992. The purpose of this survey was to determine if PSF activities had impacted any habitats suitable for threatened and endangered species. Due to the close proximity of the PSF to the floodplain of the Kansas River, the wooded area to the southeast of the PSF can be categorized as a riparian woodland; however, there are no documented sightings of wintering bald eagles in this area. The Fish and Wildlife Administrator mentioned that the confluence of the drainage ditch to the east of the PSF and the Kansas River provides a suitable habitat for the sturgeon chub, which is a federal Category 2 species. Although the confluence of the drainage ditch to the east of the PSF and the Kansas River provides a suitable habitat for the sturgeon chub (USFWS, 1992b), the summary report on threatened and endangered species states that the occurrence of the sturgeon chub at Fort Riley is very unlikely (USFWS, 1992a).

Based on a wetlands delineation report completed on March 8, 1993 by the Corps of Engineers, Kansas City District (CEMRK, 1993) and Section 404 of the Clean Water Act (CWA), there are no wetlands within the immediate vicinity of the PSF that meet jurisdictional requirements. A review of the National Wetlands inventory conducted by the USFWS did not identify wetlands within the immediate vicinity of the PSF. The Fort Riley Fish and Wildlife Administrator indicated that based on facultative plant types, soil types, and/or duration of inundation (annually) there could be nonjurisdictional wetlands. The Administrator further stated that these were likely associated with the drainages nearby. However, they would be small (less than 0.25 acre) and of low quality.

1.2.9 Climate

The Fort Riley area experiences four distinct seasons: summer, fall, winter, and spring. During the summer months (June, July, and August), the average daily high temperature is 89 degrees Fahrenheit while the average daily low temperature is 65 degrees Fahrenheit. The summer daily mean temperature is 77 degrees Fahrenheit.

During the winter months (December, January, and February), the average daily high and low temperatures are 47 degrees Fahrenheit and 27 degrees Fahrenheit, respectively. The winter daily mean temperature is 30 degrees Fahrenheit.

Extreme high and low summer temperatures are 110 degrees Fahrenheit and 42 degrees Fahrenheit, respectively, while the extreme high and low winter temperatures are 79 degrees Fahrenheit and -20 degrees Fahrenheit, respectively.

The average amount of precipitation for this area of Kansas is approximately 34 inches per year with 70 per cent of that occurring during the six month period between April and September. However, during the 1992 calendar year, when a majority of the field activities took place, the Fort Riley Marshall Army Air Field Weather Station recorded nearly 45 inches of precipitation. Equally unusual is that approximately one-half, or 24 inches, occurred during the summer months, which for Kansas are typically the drier months of the year. Thirteen inches of rain fell in the month of July 1992 alone.

The data presented above are averages over a 30-year period (1962-1992) as recorded by the First Weather Group, Detachment 8, Fort Riley Marshall Air Field. Table 1-2 presents these data in tabular form.

TABLE 1–2

AVERAGED CLIMATOLOGICAL DATA – 1962 THROUGH 1992
FORT RILEY AREA
Pesticide Storage Facility
Fort Riley, Kansas

		Extreme Maximum Temperature	Mean Temperature	Extreme Minimum Temperature	Rainfall (inches)	Snowfall (inches)
Winter	Jan	75°F	27°F	−26°F	0.90	5.00
	Feb	86°F	32°F	−21°F	1.00	4.00
Spring	Mar	90°F	42°F	−10°F	2.20	4.00
	Apr	94°F	55°F	7°F	3.00	1.00
	May	100°F	65°F	27°F	4.60	0.00
Summer	Jun	110°F	74°F	40°F	5.70	0.00
	Jul	112°F	80°F	43°F	3.80	0.00
	Aug	109°F	78°F	45°F	3.40	0.00
Fall	Sep	112°F	69°F	30°F	3.50	0.00
	Oct	100°F	56°F	20°F	2.90	0.00
	Nov	84°F	43°F	−9°F	1.40	1.00
Winter	Dec	77°F	32°F	−14°F	1.20	4.00

Source: First Weather Group, Detachment 8, Fort Riley Marshall Air Field

1.2.10 Demographics and Groundwater Use Near the PSF

Locations of existing residences and groundwater wells supplying potable water to the area relative to the PSF site were identified so that the estimated impacts from potential or actual releases from the PSF site could be evaluated in the risk assessment. The Fort Riley Military Installation is situated along the north bank of the Kansas River in Riley and Geary counties in north central Kansas, near the cities of Manhattan, Odgen, Junction City, and Grandview Plaza, Kansas (Figure 1-1). Respective populations of these cities and Fort Riley are as follows:

COMMUNITY	POPULATION	SOURCE
Fort Riley	17,164	(1990 Economic Impact Survey)
Manhattan	37,712	(Assistant Director of Planning, Manhattan, 1992)
Ogden	1,500	(City Clerk of Ogden, 1992)
Junction City	21,000	(Deputy City Clerk, Junction City, 1992)
Grandview Plaza	1,266	(City Clerk, Grandview Plaza, 1992)

Troop housing and support facilities are also located in the southern portion of Fort Riley and consist of the Main Post, Camp Forsyth, Custer Hill, Camp Whitside, Camp Funston, and Marshall Army Air Field. The remainder of the installation consists of troop/family housing, numerous training areas, gunnery complexes, small arms firing ranges, drop zones, tank trails, and an impact area used for live fire artillery. The closest residential area on post, Housing Area No. 5, is located approximately 0.3 miles northwest of the site, along Lowe Place, Carpenter Avenue, and Carpenter Place (Figure 1-11). A more detailed discussion of demographics and land use is presented in the RI (LAW, 1993a).

The primary source of drinking water for Fort Riley, Junction City, and Ogden is the valley fill alluvium (alluvial aquifer) of the Republican and Kansas Rivers (KGS, 1974). These alluvial deposits are capable of yielding more than 1,400 gpm from a single well. Junction City's and Fort Riley's water supply wells are within the Republican River floodplain (Figure 1-12), about 1.8 miles upstream from the PSF. Ogden's water supply wells are located downstream, approximately 3 miles from the site.

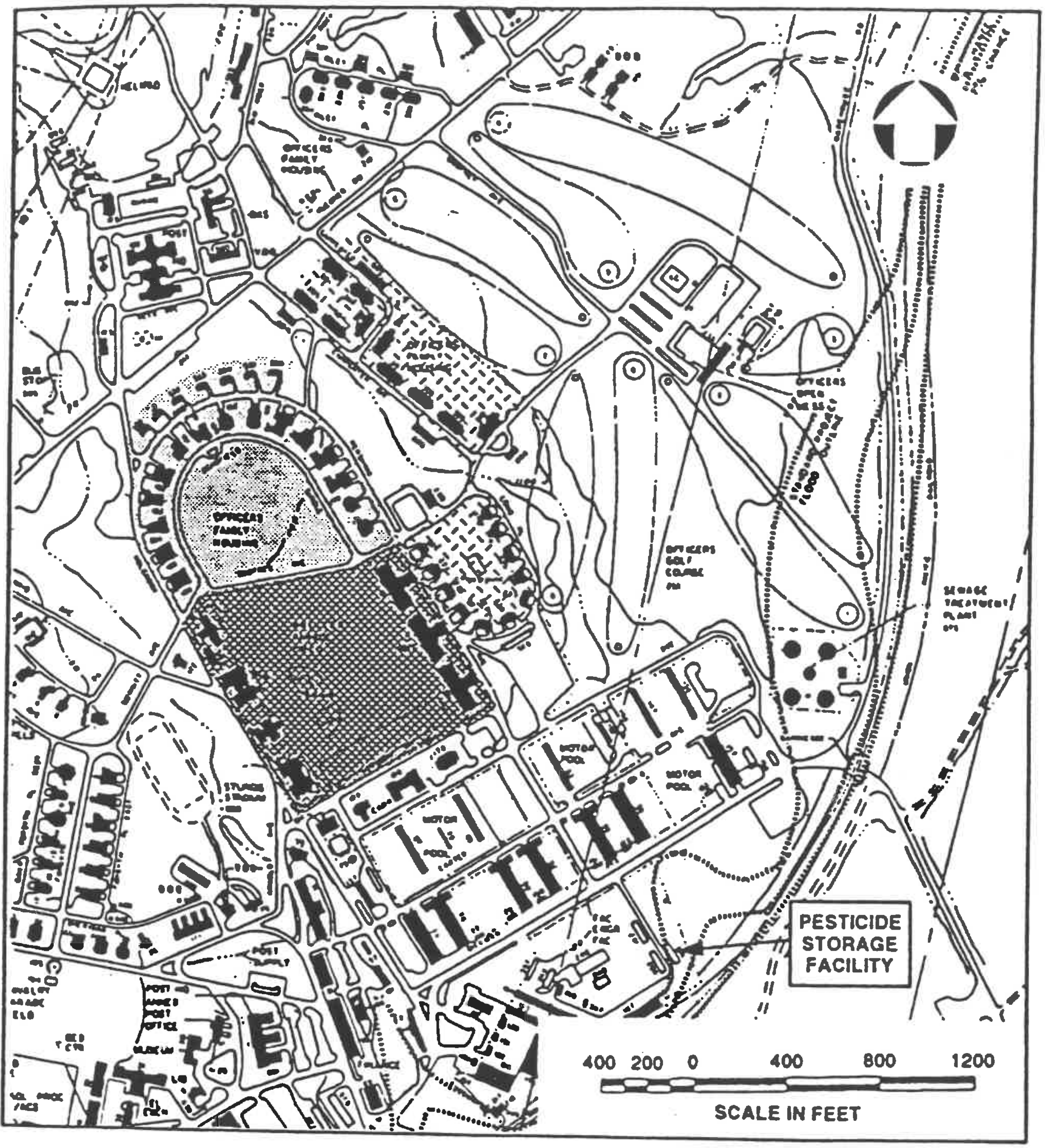
1.2.11 Cultural and Historical Description

Interest in the antiquities within Fort Riley and the region have been documented to extend back to the late 19th century. Since the 1930s, several institutions and individuals have conducted archaeological research in the region, and, within the Fort Riley complex. The Main Post

FIGURE 1-11

RESIDENTIAL AREAS LOCATED NEAR THE PESTICIDE STORAGE FACILITY

PESTICIDE STORAGE FACILITY – FORT RILEY, KANSAS



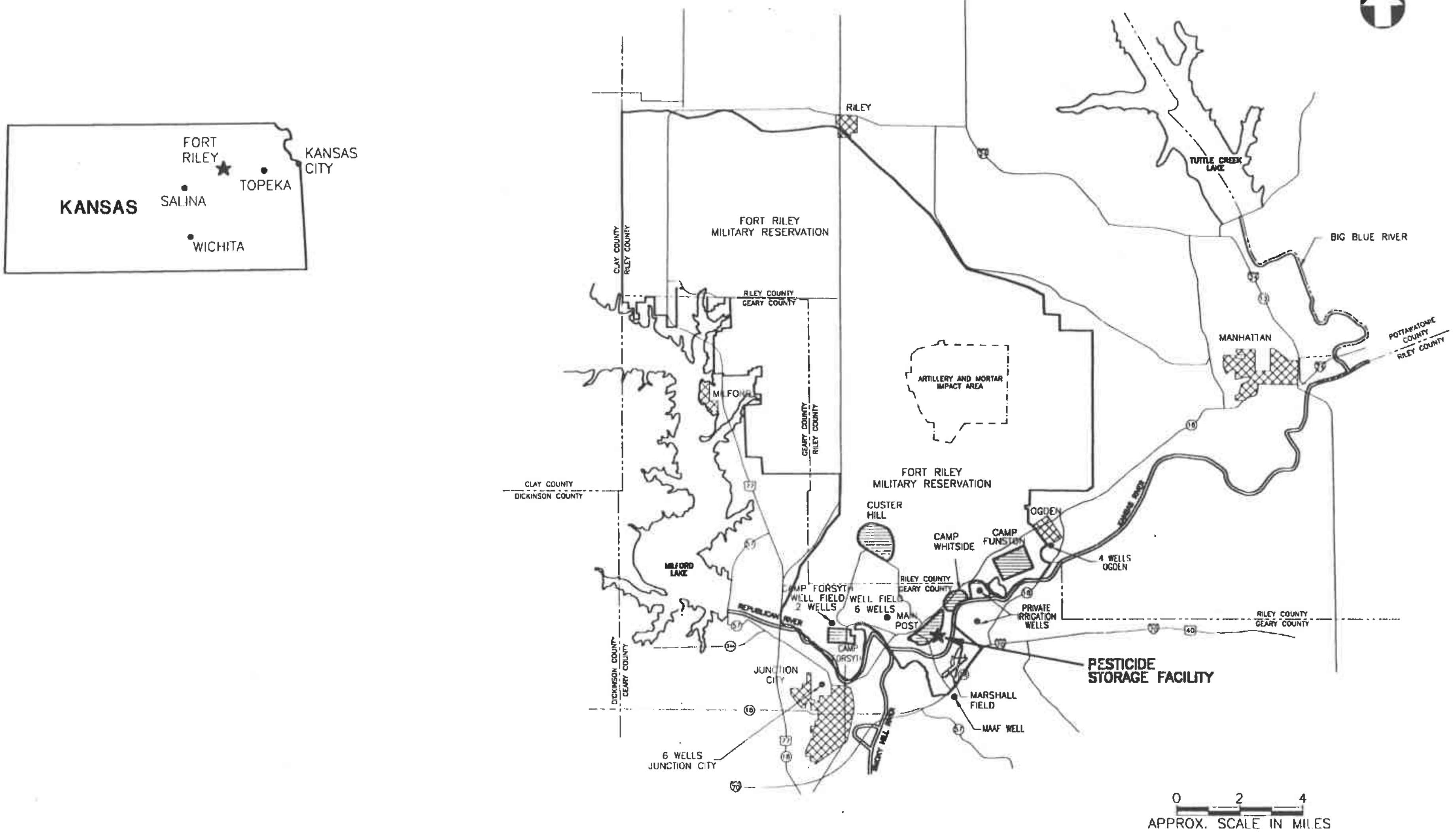
- ░ HOUSING AREA NO. 2
- ▨ HOUSING AREA NO. 5
- ▩ TROOP HOUSING (BARRACKS)

CP

FIGURE 1-12

SUPPLY WELL LOCATIONS NEAR PESTICIDE STORAGE FACILITY

FORT RILEY, KANSAS



filename: G:\FT-RILEY\FIG3-6.DWG

complex, comprising approximately 271 acres including the DEH yard area, was placed on the National Register of Historic Places in 1974 by the U.S. Department of Interior. These resources consist primarily of historic structures. Several archaeological resources are also contained within the historical district. The total Historic District encompasses an area of approximately 670 acres. Examination of recent cartography and records revealed that this part of Fort Riley has been an integral part of the main post at least since the early part of this century. Current cartography documents that parts of the study area have been urbanized.

The PSF study area lies within the boundaries of the Historical District; however, Building 348 was constructed in 1941 and is not designated to have historical significance. The study area has been extensively altered by filling, grading, and construction of the limestone-lined channel during the past 60 years. Considering these past activities, it is likely that any remaining historic or cultural resources present within the PSF site have been disturbed.

1.3 OVERVIEW OF PREVIOUS INVESTIGATIONS AND REMOVAL ACTION AT THE PSF

The PSF has been investigated on several different occasions, and a storage area closure and Removal Action have been completed at the site. Previous investigations and actions at the PSF site are as follows:

- Pesticide Monitoring Study, 1974
- Pesticide Monitoring Study, 1986
- CONEX Closure Plan Wipe Samples, 1987
- Finalization on the NPL, August 30, 1990
- Closure of two CONEX containers, and a portion of Building 292 (now Building 348), finalized on December 3, 1990
- Fort Riley and U.S. Army Corps of Engineers RI/FS Planning Activities, 1990 to 1992
- Development of Work Plan for the RI/FS, 1991 to 1992
- Initial Remedial Investigation, 1992 to 1993
- Draft Feasibility Study under development in 1993

- Removal Action Engineering Evaluation/Cost Analysis, 1993
- Removal Action Memorandum signed, December 1993
- Pesticide-contaminated soils excavated and disposed off site during the Removal Action, March to June 1994
- Six rounds of groundwater samples collected from the PSF monitoring wells: July 1992, November 1992, February 1993, May 1993, September 1994, and December 1995. Note additional samples from background wells in the Building 354 area were collected during the September 1994 and December 1995 rounds.
- RI Addendum and Feasibility Study under development (following Removal Action and September 1994 groundwater sampling) in 1994 to 1995
- Statistical comparison of groundwater inorganic concentrations in on-site and background wells in 1996, following the December 1995 groundwater sampling event
- RI Addenda (1997) documenting prior investigations, Removal Action report, residual risk assessment, statistical analysis, and discontinuance of the FS.

Brief descriptions of the activities conducted prior to the RI/FS (1974 to 1990) are presented in Section 1.4. The RI activities summarized in Section 1.5 resulted in a site characterization and interpretation of the nature and extent of contamination at the PSF site, based on the observed field investigation results. The RI investigation activities and the resulting site characterization are documented in the RI report (LAW, 1993a).

While the RI, baseline risk assessment (BLRA), and FS were under development, Fort Riley completed an EE/CA which considered a Removal Action at the site to address pesticide-contaminated soils. The public comment period for the EE/CA was August 17 to September 16, 1993, and a public meeting was held at Fort Riley on September 7, 1993. No public participants attended this meeting. Subsequently, the Removal Action Memorandum (DEH, 1993b) was signed in December 1993. The FS, which was under development at the time of initiation of the EE/CA and Removal Action in May 1993, was not finalized at that time because the Removal Action was implemented. Section 1.6 summarizes the initial FS development. The Removal Action report is presented in Section 3 of the report.

The Removal Action Memorandum specified excavation and off-site disposal of pesticide-contaminated soils, based on the extent of contamination interpreted from the RI field sampling results. Additional PSF soil sampling was then performed as a part of Removal Action planning activities to better define the extent of contamination and to establish the initial limits of excavation. These Removal Action sampling results identified a larger area of contamination at the PSF site than interpreted from the RI field sampling, and the initial limits of the Removal Action excavation were expanded, as discussed in Section 2. After the additional soil sampling, the risk-based remediation goals were analyzed and revised to account for new absorption factors for pesticides that would be retained in the skin.

During the Removal Action, site areas were excavated based on established soil contaminant concentrations (revised risk-based remediation goals) for pesticides with areas exceeding these contaminant levels removed, as discussed in Section 3. The excavations were backfilled with fill material obtained locally to approximately their original elevations, and the Removal Action activities were completed in June 1994. The planning and completion of the Removal Action resulted in a revised understanding of the nature and extent of soil contamination at the PSF, as the observed conditions differed from those anticipated from the RI field investigation. Additional discussion is presented in Sections 2, 3, and 4.

An additional round of groundwater samples was collected from the PSF monitoring wells in September 1994, and the sample analysis results were presented in a separate Quality Control Summary Report (QCSR) (LAW, 1994c). An additional round of PSF groundwater samples was collected in December 1995 and analyzed for selected inorganics. A statistical comparison of these inorganic constituents in PSF wells and background wells was completed and submitted for review in June 1996. The additional information obtained from these activities was incorporated into this RI Addenda report. These activities are discussed further in Section 1.8.

1.4 SUMMARY OF PREVIOUS SITE STUDIES PRIOR TO THE RI/FS

The PSF has been investigated on several different occasions, and the purpose of this section is to summarize the previous investigations and evaluations which led to the Removal Action. The following sections provide a chronological summary of previous investigations and evaluations conducted at the PSF site. The Removal Action is discussed in Section 3.

1.4.1 Pesticide Monitoring Study, 1974

The earliest site investigation of the PSF was conducted by the U.S. Army Environmental Hygiene Agency (USAEHA) in 1974, as part of the U.S. Army Pesticide Monitoring and Entomological Studies Program. A single soil sample was collected in July 1974, and four additional samples were taken in November 1974, in the immediate vicinity of the pesticide formulating and storage facility (Building 348, formerly Building 292), within the fenced area.

Pesticide concentrations ranged from 0.41 parts per million (ppm) diazinon to 544.6 ppm chlordane (USAEHA, 1975). The fenced area was devoid of ground cover which was thought possibly due to the pesticide levels in the soils. Lower levels of pesticides were found in the soils of the wooded area, located east and downslope from the building, beyond the fence. Pesticide residues were also found in the sediments of unlined portions of the drainage ditch, located east and downstream from the Building 348 area. Water samples taken from the ditch contained no detectable concentrations of pesticides. Recommendations in the report included re-establishment of a grass cover or placement of an impermeable surface within the fenced area, and a revision of pesticide handling practices so as to minimized spillage. This study report was included in the RI report (LAW, 1993a). Contaminated soils within the fenced area were covered by a compacted gravel layer about 6 inches thick following the conclusions of the study.

1.4.2 Pesticide Monitoring Study, 1986

The purpose of the study was to confirm the presence or absence of pesticides in the soil in the vicinity of the PSF Building 348, and to develop an installation restoration plan to address the pesticides if present at significant levels. During May 1986, two soil and four sediment samples were collected at an approximate depth of 2 inches in the vicinity of the PSF (Figure 1-13). Two of the sediment samples (86S3, 86S5) contained no pesticides. Sediment sample 86S6 contained only low levels of DDT metabolites, chlordane and dieldrin. Two soil samples (86S1, 86S2) and the remaining sediments sample (86S4) contained a mixture of pesticides, including DDT metabolites, chlordane, dieldrin, and methoxychlor. Recommendations in the study included limiting access within the fenced area east of Building 348 (USAEHA, 1986) and continuing a pesticide monitoring program at the site.

1.4.3 Closure of a Portion of Building 348 and Two CONEX Containers, 1987 to 1990

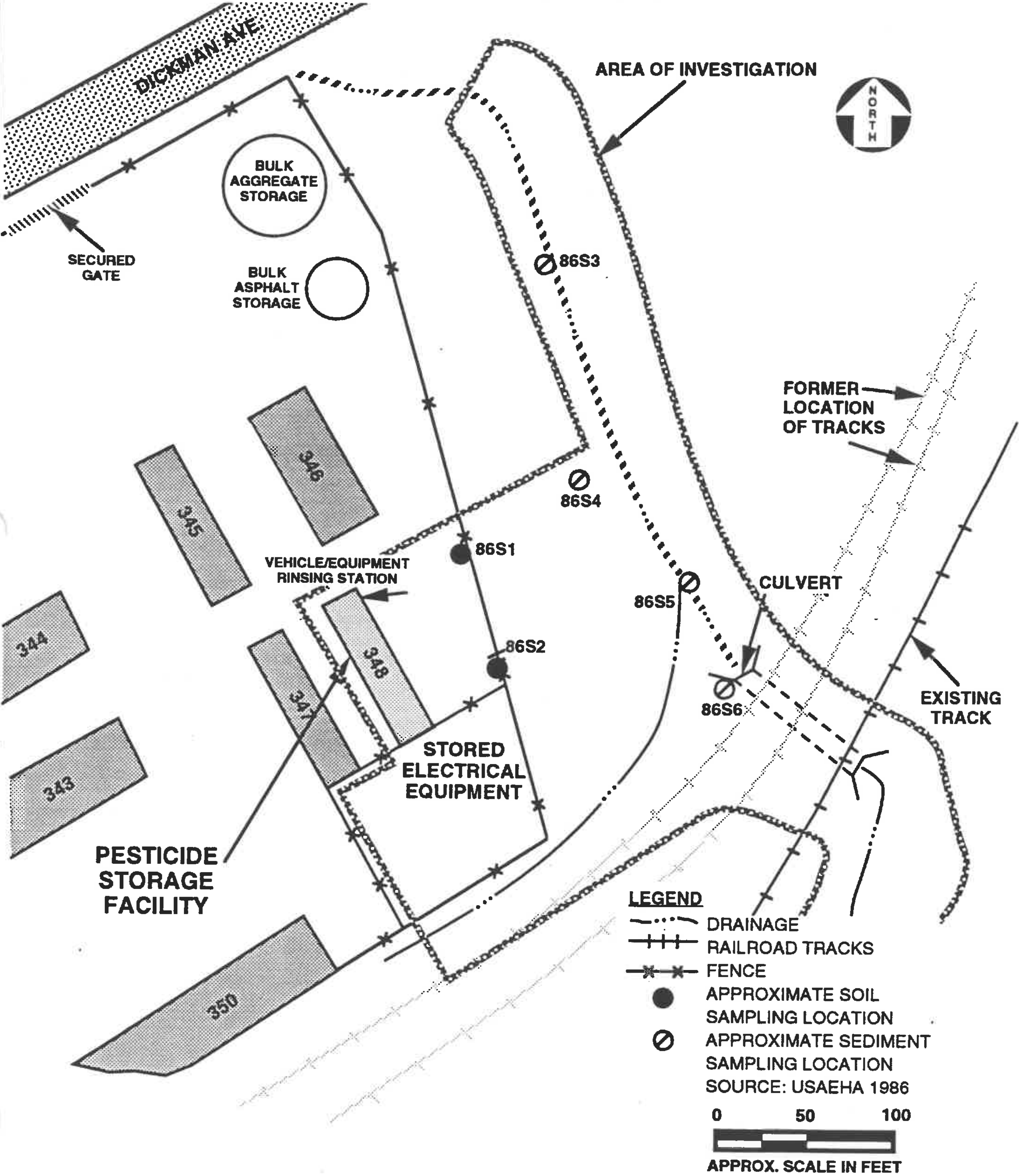
A "Closure Plan for Hazardous Waste Storage Facilities, Building 292 and Two CONEXs" was written in 1987 (DEH, 1987) for a portion of the formerly designated Building 292 (now Building 348) and for two CONEX containers. A CONEX is a ribbed metal container used for shipping and temporary storage of goods and materials by the Army. These were considered hazardous waste storage facilities and closure was finalized under the provisions of 40 Code of Federal Regulations (CFR) 265 on December 3, 1990. The CONEXs were located next to Building 348, as shown in Figure 1-14.

During 1988, according to the Polychlorinated Biphenyl (PCB) Program Manager, DEH, several PCB-containing electrical transformers were stored in these CONEX containers next to Building 348. In August 1990, wipe samples were collected from the inside of the CONEX containers located adjacent to the southeast corner of the PSF building. This sampling was conducted to

FIGURE 1-13

USAEHA APPROXIMATE SOIL/SEDIMENT SAMPLING LOCATIONS, MAY 1986

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



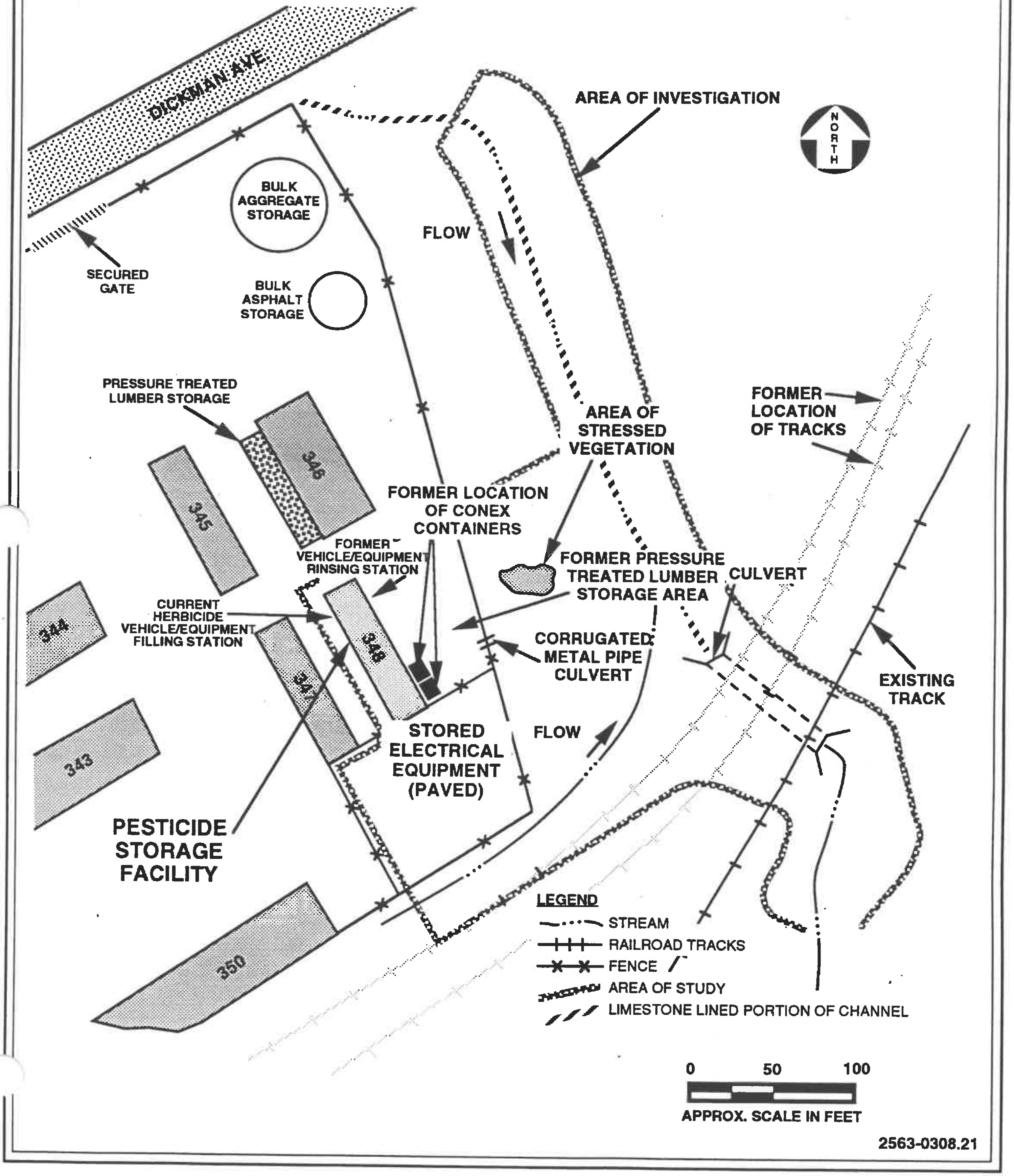
SOURCE: USAEHA 1986

2563-0308.21

FIGURE 1-14

PESTICIDE STORAGE FACILITY – 1992

FORT RILEY, KANSAS



comply with the procedures specified in the CONEX closure plan approved by the state of Kansas (KDHE, 1990). The final data report submitted by the contractor and verified by the Army showed the samples to be free of the pesticide and heavy metal contamination. After a review of the sampling results, the KDHE accepted the closure of Building 348 and CONEXs on December 3, 1990. The CONEX containers have since been removed by Fort Riley personnel (DEH, 1992b). Transformers are no longer stored along the southeast side of Building 343 and the northeast side of Building 344.

1.5 INITIAL REMEDIAL INVESTIGATION ACTIVITIES, 1990 TO 1993

Fort Riley was finalized on the NPL on August 30, 1990. Fort Riley and the U.S. Army Corps of Engineers began planning the RI/FS in 1990, and Planning Documents were issued for the PSF. These planning documents identified the field sampling objectives, procedures, and sample locations for the RI field investigation activities. The Draft-Final Planning Documents submitted December, 1991 included the following:

- Volume I - Work Plan
- Volume II - Site Safety and Health Plan
- Volume III - Quality Assurance Project Plan
- Volume IV - Field Sampling Plan

Subsequent to this submittal, modified planning documents were prepared during 1992. A Draft Modified Work Plan was submitted for regulatory review in May 1992. Draft Final Modified Planning documents were issued in September 1992 as follows:

- Volume I - Draft Final Modified Work Plan
- Volume II - Draft Final Modified Quality Assurance Project Plan
- Volume III - Draft Final Modified Site-Specific Safety and Health Plan
- Volume IV - Draft Final Modified Basic Site Safety and Health Plan
- Volume V - Draft Final Modified Field Sampling Plan

Field sampling activities occurred concurrent with the preparation of the Modified Planning Documents and sampling activities were performed on the following dates:

- A pilot hole soil boring was performed on January 24, 1992.

- Surface-water and sediment samples were collected from March 31 to April 2, 1992. Two additional sediment samples were collected on July 16, 1992.

- Soil samples at the site were collected April 4 to 8, 1992.

- Soil borings for monitoring well installations were drilled from April 28 to May 5, 1992. Monitoring wells were installed May 1 to 5, 1992.

- Four rounds of groundwater samples were collected at the site during the initial RI activities as follows:

July 14 to 23, 1992	Baseline Samples
November 5, 1992	First Quarter
February 3, 1993	Second Quarter
May 5 to 6, 1993	Third Quarter

During 1992 through 1993, the RI was conducted with the purpose of evaluating the nature and extent of contamination and developing information to support the evaluation of alternatives for remedial actions at the PSF (LAW, 1993a). Specific objectives of the initial RI activities were:

- To evaluate the nature and extent of constituent releases

- To determine the potential for contaminant migration

- To identify public health and environmental risks associated with the site in terms of regulatory environmental standards and advisories

- To provide information to serve as a basis for future response actions.

A brief summary of the initial RI field activities, analytical results, and conclusions is presented in this section. More detailed descriptions are documented in the RI report (LAW, 1993a). The site description in this section presents the site conditions prior to the Removal Action as interpreted based on the field sampling results in the RI report (LAW, 1993a). A BLRA was included in the RI report (LAW, 1993a) based on these interpreted site conditions.

1.5.1 Field Sampling Program

The initial RI field activities included sampling of the soils, groundwater, surface water, and sediments in the vicinity of the PSF. Surface soil samples were collected at four locations, ranging in depth from 0.25 to 1.5 feet. Shallow soil borings were collected at 20 locations, usually at depth intervals from 2.0 to 2.5 feet and 4.0 to 4.5 feet. Five monitoring wells were installed, and a total of 15 soil samples were collected from the monitoring well boreholes. Well PSF92-01, upgradient, and wells PSF92-02 through PSF92-05 downgradient, were installed at the approximate locations as shown on Figure 1-2. Six surface-water and fourteen sediment samples were collected from seven locations along the lined drainage ditch east and southeast of the site. These soil, groundwater, surface-water, and sediment samples are discussed below.

1.5.2 Analytical Results of Soil Samples Collected in 1992

The locations of surface and subsurface soil samples collected in 1992 at the PSF are shown on Figures 1-15 and 1-16. Surface soil sample PSFSS-01 and subsurface soil samples PSFSB-01A and PSFSB-01B were used to establish background concentrations for surface and subsurface soils, respectively. Several pesticides were detected in the soil samples including DDT and its metabolites (DDD and DDE), alpha- and gamma-chlordane, heptachlor, dieldrin, methoxychlor, endrin, Ronnel (Fenchlorphos) and malathion. Three distinct areas of pesticide contamination were indicated (Figure 1-17). This figure indicates the estimated extent of soil contamination at the PSF, as interpreted from soil sampling results in the RI report (LAW, 1993a), and not areas of contamination above any established action limit concentration (LAW, 1993a). The first area was around the north end of the PSF and extending east, and was attributed to rinse water from the washing of vehicles and pesticide spraying equipment running onto the ground and draining to the east. The second area occurred near the southeast corner of Building 348 and extended to the east, where the CONEX containers were formerly located. The third area of pesticide contamination was the location of stressed vegetation east of the PSF, near the drainage ditch to the east of Building 348. Acid herbicides were analyzed in surface soil sample PSFSS-04 collected from a 1- to 12-inch depth from this area, but were not detected in the sample. The source of the contamination may have been attributed to either a spill, or the result of surface run-off from the Building 348 area being conveyed in an erosion pathway which terminated in this area. A small area near the southwest corner of Building 348, under existing pavement, was also identified from sampling results.

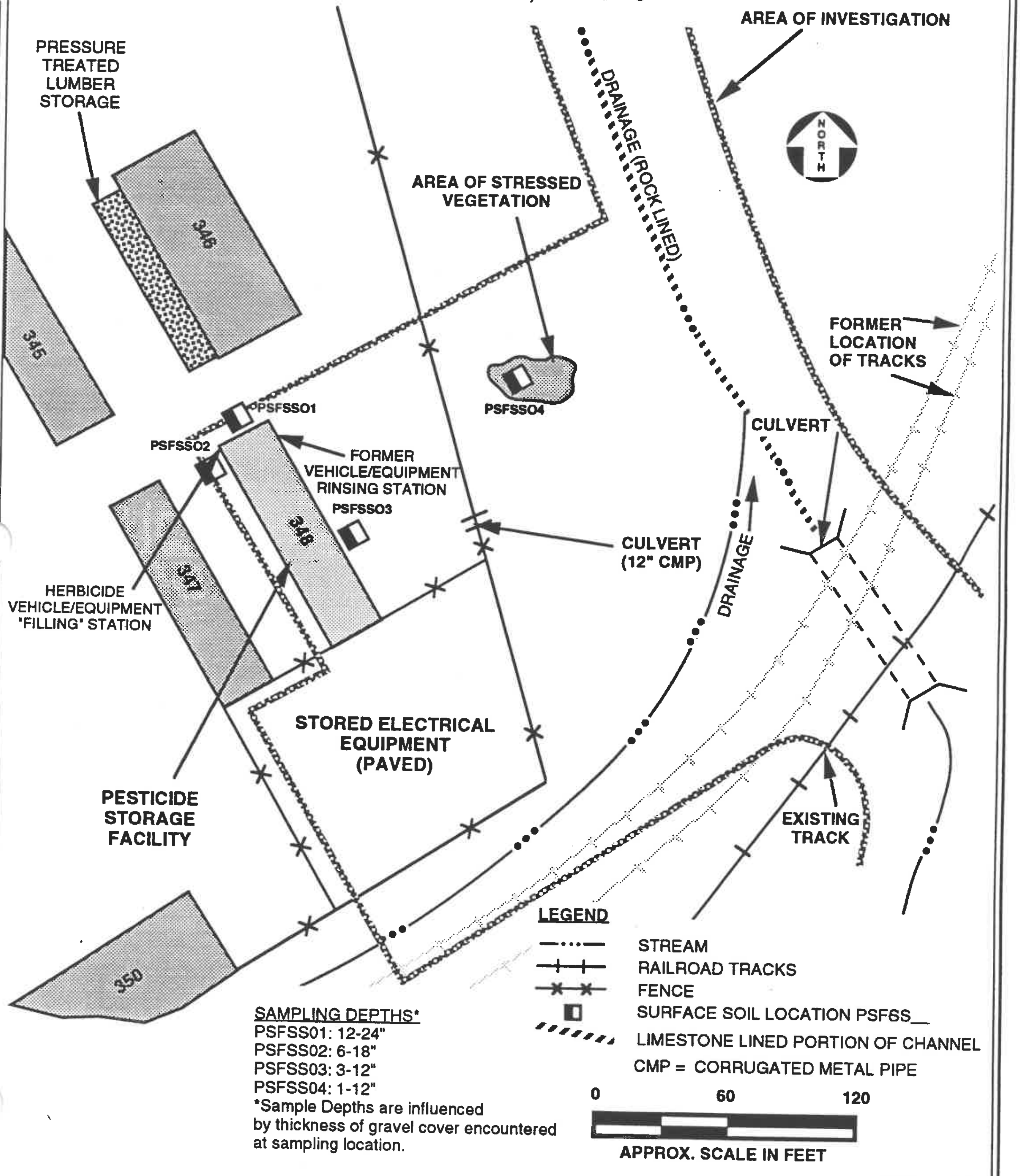
Of the metals analyzed, arsenic, barium, chromium and lead were routinely found in detectable concentrations in both background and PSF site samples. These metals are naturally occurring components of the earth's crust that are found in most soils and waters. Elevated concentrations of lead were detected in two samples: PSFSS-03 at 540 milligrams per kilogram (mg/kg) at the 0.25- to 1-foot depth and PSFSB-08A at 770 mg/kg at a 2- to 2.5-foot depth. Arsenic concentrations above the background concentrations were observed in two samples. Arsenic was detected at a maximum concentration of 120 mg/kg in a single sample (PSFSB-10C) at the 3.5- to 4.5-foot depth and at 20 mg/kg in sample PSFSB-02A at the 2- to 2.5-foot depth interval.

Several polynuclear aromatic hydrocarbons (PAHs) were detected in a single surface soil sample (PSFSS-O4) and several shallow soil samples. In sample PSFSS-04, five semi-volatile constituents were detected with fluoranthene (1.3 mg/kg), phenanthrene (0.78 mg/kg), and pyrene (1.0 mg/kg) at predominant concentration levels. In addition, several PAHs were detected in the soil at the 1- to 2-foot interval in the monitoring borehole sample MWSB-O2A. PAHs detected include acenaphthene, anthracene, chrysene, fluoranthene, naphthalene, phenanthrene, and pyrene. In subsurface soils, maximum detected concentrations were pyrene (4.1 mg/kg), fluoranthene (3.4 mg/kg), phenanthrene (2.7 mg/kg), and 2,4-dichlorophenol (2.3 mg/kg). Six other PAHs were detected at maximum concentrations less than 2 mg/kg and eight PAHs at less than 1 mg/kg. The primary areas of PAH concentrations were soils along the

FIGURE 1-15

SURFACE SOIL SAMPLE LOCATIONS – APRIL 1992

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



SAMPLING DEPTHS*
PSFSS01: 12-24"
PSFSS02: 6-18"
PSFSS03: 3-12"
PSFSS04: 1-12"
*Sample Depths are influenced by thickness of gravel cover encountered at sampling location.

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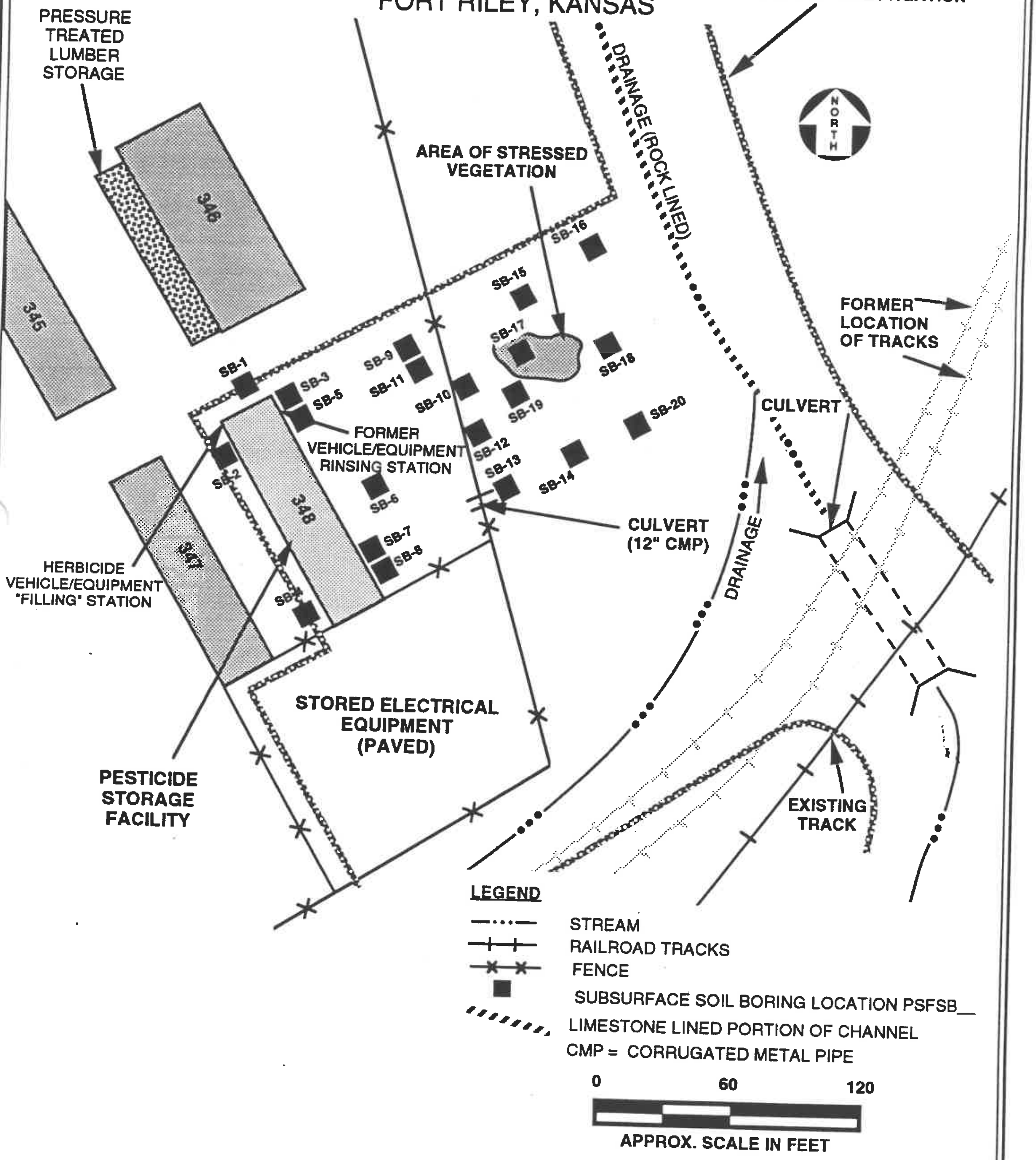
FIGURE 1-16

SUBSURFACE SOIL BORING SAMPLE LOCATIONS – APRIL 1992

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



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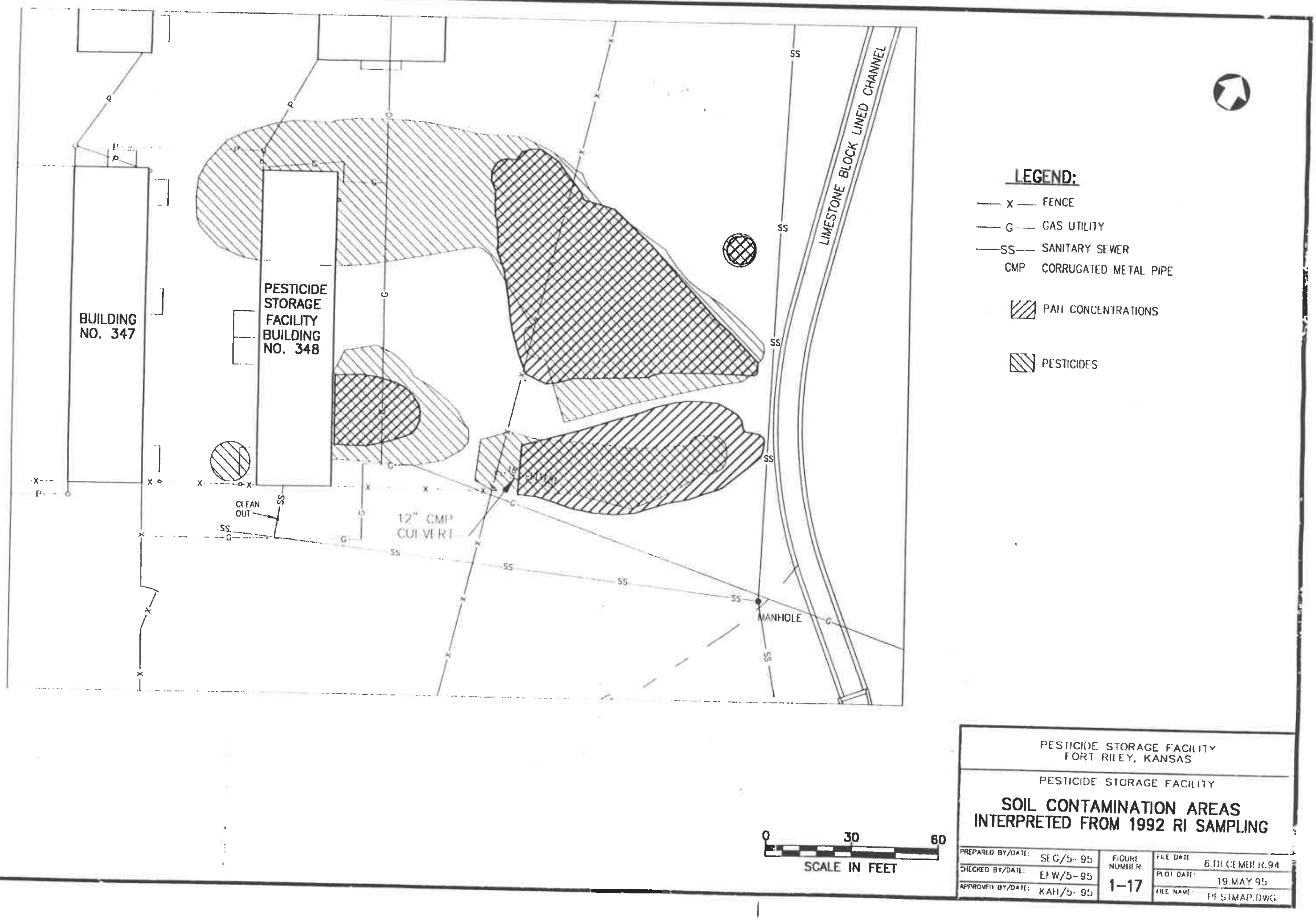

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

SOIL CONTAMINATION AREAS
INTERPRETED FROM 1992 RI SAMPLING

PREPARED BY/DATE:	SEG/5-95	FIGURE NUMBER:	FILE DATE	6 DECEMBER 94
CHECKED BY/DATE:	EFW/5-95	1-17	PLOT DATE:	19 MAY 95
APPROVED BY/DATE:	KAH/5-95		FILE NAME:	PESTMAP.DWG

fence due east of the PSF and extending east, and at the bottom of the culvert leading away from the southeastern corner of the fence. A third area of PAH concentration was located near the southeast corner of the PSF. The pattern of the PAH concentrations followed surface run-off patterns. Constituents of the asphalt paving activities conducted prior to collection of the soil samples, treated lumber, and asphalt stored in the DEH yard north and northwest of the PSF facility are potential sources. DEH records prior to 1990 and 1991 show what appears to be treated lumber stored adjacent to the eastern fence. This lumber was relocated to allow access for the RI field work. Potential sources of the PAHs at the PSF also could have included aromatic naphtha formulations used to dissolve pesticides, mixing, application, or spills; however, there were no reported or documented uses of PAHs to dissolve pesticides for past applications at the PSF. These areas of contamination are shown on Figure 1-17.

The volatile organic compound toluene was detected in two surface soil samples near detection limits (at 0.006 mg/kg in PSFSS-02 and at 0.0073 mg/kg in PSFSS-04), and in several of the shallow soil samples, usually at the 4.0- to 4.5-foot depth interval. Benzene was detected in soils of two monitoring well boreholes at depth intervals of 15 to 17 feet (MWSB-01A) and 21 to 25 feet (MWSB-01B). The maximum detected benzene concentration was 0.0066 mg/kg. Toluene and benzene are constituents found in gasoline.

1.5.3 Analytical Results of Groundwater - Baseline through Third Quarter Samples

This section presents a summary of the groundwater sampling performed during the initial RI activities. The September 1994 and December 1995 samples are discussed in Section 4. Groundwater samples were collected from the five monitoring wells (Figure 1-18) in July 1992, in order to establish baseline data for groundwater quality at the site (LAW, 1992). PSF92-01 served as a background well, while the four other wells were placed in locations believed downgradient to detect groundwater contamination originating from the PSF site. Quarterly groundwater sampling events were then conducted in November 1992, February 1993, and May 1993 (LAW, 1993c, 1993d, 1993e). Table 1-3 shows the frequencies of detection, the frequencies of exceedance of the respective Maximum Contaminant Levels (MCLs), and the concentration ranges of the metal constituents over all four sampling events.

Analytical results of the samples collected to establish baseline data (July 1992) showed metals and inorganics as the main constituents of the groundwater around the PSF, with the alkali earth metals (calcium, magnesium, potassium and sodium) exhibiting the highest concentrations. Concentrations (total and dissolved) of four metals (barium, beryllium, chromium and selenium) were consistent with background conditions. Only the metals manganese (total and dissolved), total aluminum, total iron and total zinc occurred slightly above background concentrations. Manganese exceeded the secondary MCL of 0.05 milligrams per liter (mg/L) in samples PSF92-02 and PSF92-03.

FIGURE 1-18

MONITORING WELL LOCATIONS

PESTICIDE STORAGE FACILITY – MAY 1992
FORT RILEY, KANSAS

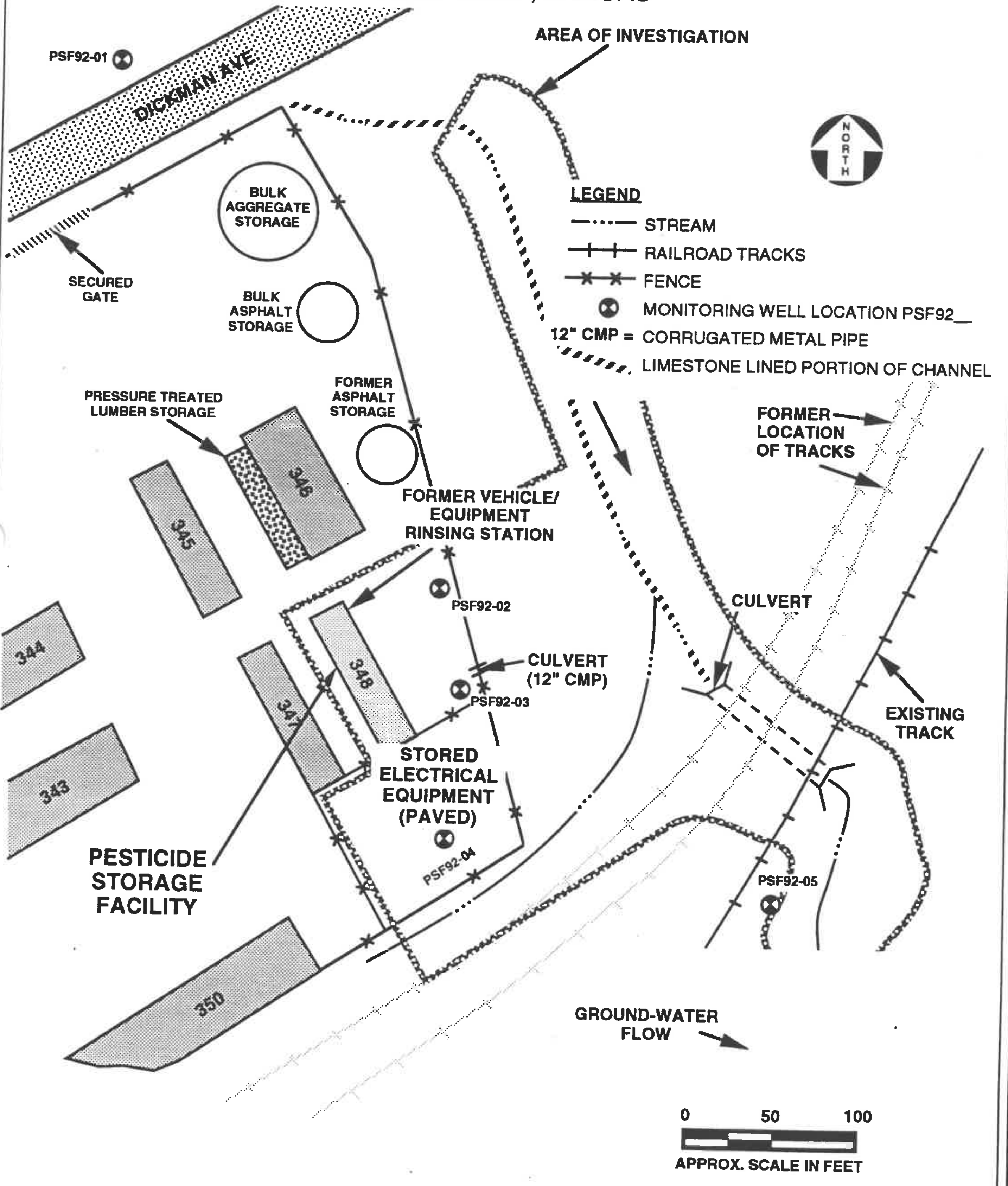

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TABLE 1–3

CHEMICALS DETECTED IN GROUNDWATER SAMPLES BASELINE THROUGH THIRD QUARTER

Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Maximum Concentration Detected in Background Sample	Frequency of Detection [a]	Method Detection Limit	Arithmetic Mean	Range of Detected Concentrations [b]	95% Upper Confidence Limit [c]
Volatile Organics:						
Methylene Chloride	9.3 T	3/4	0.005	0.0080	0.0018 – 0.021 T	0.051
Trichloroethene	ND	1/4	0.003	0.0019	< 0.003 – 0.003	0.0030
Dissolved Metals:						
Arsenic	ND	1/4	0.002	0.0045	< 0.002 – 0.015	0.54
Aluminum	ND	2/4	0.11	0.14	0.17 – 0.28	1.1
Barium	0.088	4/4	0.005	0.099	0.084 – 0.12	0.12
Beryllium	ND	4/4	0.001	0.0019	0.0015 – 0.003	0.0031
Calcium	8.8	4/4	0.093	210	140 – 340	380
Iron	ND	1/4	0.045	0.036	< 0.045 – 0.078	0.12
Magnesium	14	4/4	0.17	33	18 – 55	72
Manganese	0.024	4/4	0.001	0.052	0.031 – 0.083	0.10
Mercury	ND	1/4 d	0.0002	0.00018	< 0.0002 – 0.0004 d	0.00078
Potassium	3.3	4/4	0.22	8.7	3.8 – 19	39
Selenium	0.0011	4/4	0.001	0.0019	0.0012 – 0.0026	0.0033
Sodium	11	4/4	0.29	51	25 – 90	130
Vanadium	ND	1/4	0.007	0.0086	< 0.007 – 0.024	0.14
Zinc	0.0065 B_1	4/4 B_1	0.002	0.0066	0.0055 – 0.0075	0.0086
Total Metals:						
Antimony	0.022	1/16	0.031	0.017	<0.031 – 0.032	0.018
* Arsenic	ND	5/16	0.002	0.0026	< 0.002 – 0.016	0.0039
* Aluminum	ND	10/16	0.1	0.22	< 0.100 – 0.800	0.44
* Barium	0.2	16/16	0.005	0.13	0.060 – 0.13	0.10
* Beryllium	0.002	15/16	0.002	0.0022	< 0.0020 – 0.005	0.0028
Calcium	150	16/16	0.11	190	130 – 350	220
* Chromium	0.01	2/16	0.01	0.0060	< 0.01 – 0.014	0.0070
Cobalt	ND	1/16	0.01	0.0050	<0.01 – 0.009	0.0056
Copper	0.011	6/16	0.005	0.0046	<0.005 – 0.012	0.0064
Iron	0.071	12/16	0.050	0.32	0.050 – 1.5	1.3
Lead	ND	2/16	0.005 / 0.001	0.0011	<0.001 – 2.5	0.0016
Magnesium	26	16/16	0.17	30	18 – 56	36
* Manganese	0.034	16/16	0.015	0.046	0.023 – 0.091	0.057
Nickel	0.019	4/16	0.018	0.012	<0.018 – 0.024	0.014
Potassium	5.3	16/16	0.216	10	3.7 – 50	14
Selenium	0.003	16/16	0.001	0.0020	0.0011 – 0.0036	0.0024
Sodium	22	16/16	0.29	50	25 – 130	65
* Thallium	ND	2/16	0.001 – 100	0.0029	< 0.001 – 0.0029 e	NA
* Vanadium	0.011	4/16	0.007 – 0.010	0.0073	< 0.007 – 0.027	0.0097
Zinc	0.013	8/16	0.007	0.014	< 0.007 – 0.098	0.024
Wet Chemical Inorganics:						
Inorganic Chloride	147	16/16	0.2	110	39 – 399	180
* Nitrate	6.4	15/16	0.2	32	<0.2 – 165	250
Sulfate	85	16/16	0.2	180	108 – 386	230
Total Sulfide	ND	1/16	1.0	3.8	<1.0 – 52.5	3.4
Bicarbonate, as $CaCO_3$	249	12/16	1.0	270	<1.0 – 493	750000

Note: All concentrations are in mg/L (ppm). "Dissolved Metals" contains only baseline data.

ND=Not detected at concentrations greater than or equal to the Method Detection Limit.

NA=Not appropriate. (Due to the large number of NDs and large MDLs, calculation of a UCL for thallium was not performed).

* Selected as a potential chemical of concern

[a] Number of samples in which the chemical was positively detected divided by the number of samples available.

[b] Range does not include the concentration of chemicals detected in the background sample.

[c] The 95% Upper Confidence Limit is calculated using statistical procedures appropriate for characterizing lognormal populations (Gilbert, 1987). The UCL may be "artificially" elevated due to small sample size and large standard deviation of the data set.

[d] Total mercury was not detected in any sample. Since dissolved metals concentrations cannot exceed total metals concentrations, this result may be a false positive resulting from lab contamination.

[e] For thallium, the largest concentration actually detected was 0.0029 mg/L (see 9/10//93 letter in Appendix L). However, thallium was not detected using methods with MDLs as large as 0.110 mg/L.

T = Sample results are associated with the trip blank (indicates possible cross–contamination).

B_1 = Sample results are associated with the method blank (indicates possible lab contamination).

Concentrations (total and dissolved) of eight metals (barium, beryllium, calcium, iron, magnesium, manganese, selenium and zinc) detected in first, second and third quarter groundwater samples were consistent with the baseline concentrations. Arsenic was detected once in PSF92-06 (duplicate sample of PSF92-02 in the second quarter), and in PSF92-05 during all quarters. Arsenic did not exceed the MCL (0.050 mg/L). Total cadmium was only detected during the third quarter sampling event in PSF92-01 (background), PSF92-04, and PSF92-05 at 0.004 mg/L, 0.004 mg/L and 0.006 mg/L, respectively. The federal MCL for cadmium (0.005 mg/L) was exceeded once in the PSF92-05 sample. Total chromium was detected in two baseline samples: PSF92-01 at 0.010 mg/L, and PSF92-02 at 0.012 mg/L. It occurred again in PSF92-02 during the third quarter at 0.014 mg/L. The chromium MCL was never exceeded. Dissolved copper and total copper were detected in both background and downgradient wells at concentrations less than 0.012 mg/L. During the second and third quarters, dissolved and/or total copper were detected in each well. Total lead was detected in wells PSF92-03 (0.002 mg/L) and PSF92-04 (0.002 mg/L) only during the third quarter sampling event. In PSF92-05, both aluminum and iron increased during the first quarter and were detected at their maximum concentrations of 0.550 mg/L and 0.910 mg/L, respectively, then showed large decreases in the second quarter, and were below detection limits in the third quarter.

Thallium was analyzed for during all sampling events and was not detected during the baseline, first quarter, and second quarter sampling events. During these sampling events, USEPA Method 6010 (USEPA, 1986) was used in the analysis. After the second quarter event, the MCL for thallium was lowered to 0.002 mg/L, and Method 6010 no longer produced a detection limit below the MCL. The third quarter samples were analyzed using USEPA Method 7841 with a detection limit of 0.001 mg/L. Thallium was observed in two wells during this quarter. The originally reported thallium concentrations for the PSF92-02 third quarter sample and duplicate were 0.0017 mg/L and nondetect, respectively. During reanalysis, it occurred in sample PSF92-02 at 0.0029 mg/L and at 0.0016 mg/L in the duplicate sample for this well. For well PSF92-03, the thallium concentration was originally reported at 0.0025 mg/L. Upon reanalysis, the concentration was reported as 0.0013 mg/L. Thallium was not detected in the background well. These results indicated thallium results reported above and below the federal MCL for thallium (0.002 mg/L). As discussed in Section 4.2.1, uncertainties in reported thallium levels were caused by the high levels of calcium, magnesium, and sodium that are present at Fort Riley.

Of the inorganic constituents analyzed, first quarter and third quarter concentrations of nitrate were consistent with the baseline concentrations. During the February 3, 1993, second quarter sampling event, nitrate showed an increase from two to five times in all samples with the exception of PSF92-01. During this sampling quarter, nitrate exceeded the MCL (10 mg/L as N) in all site wells with the exception of the background well (PSF92-01). Discrepancies for nitrate in one second quarter water sample were also noted in the Fort Riley PSF (2/93) Fort Riley, KS, Chemical Quality Assurance Report, 21 June 1993 (CEMRD, 1993), resulting in uncertainty pertaining to these elevated second quarter results.

A quality assurance (QA) sample was collected for analysis from well PSF92-03 during the February 3, 1993, sampling event. This sample was analyzed by the U.S. Army Corps of Engineers, Missouri River Division Laboratory in Omaha, Nebraska. The QA lab result reported nitrate at less than 0.01 mg/L, while the sample analysis result was reported at 50.6 mg/L. The QA Report stated: "The extremely large discrepancy for nitrate analysis seems anomalous." Both the PSF92-03 and PSF92-03 QA samples were analyzed by USEPA Method 300.0 for nitrate, chloride, and sulfate, and no discrepancies were noted for chloride and sulfate.

Volatile organic compounds were not detected in the groundwater samples, with the exception of 0.003 mg/L of trichloroethylene in sample PSF92-05 detected once during the baseline sampling event. Pesticides and semi-volatile organics were analyzed for but not detected in the groundwater during these sampling events.

1.5.4 Analytical Results of Surface-Water Samples Collected in 1992

Analytical results of surface-water samples are presented in Appendix D-4. Only total metals and inorganic constituents naturally occurring in surface waters and soils were detected in the surface-water samples upstream and downstream from the PSF site (Figure 1-19). Total concentrations of aluminum, iron, and zinc increased immediately downstream of the PSF. Sulfates were observed to increase immediately downstream from the site.

1.5.5 Analytical Results of Sediment Samples Collected in 1992

Analytical results of sediment samples are presented in Appendix D-5. Sediments samples collected in the lined drainage ditch east of the PSF contained pesticides, volatile organic compounds, PAHs and metals (Figure 1-19). Pesticide concentrations increased immediately downstream of the PSF facility, and then gradually decreased further downstream.

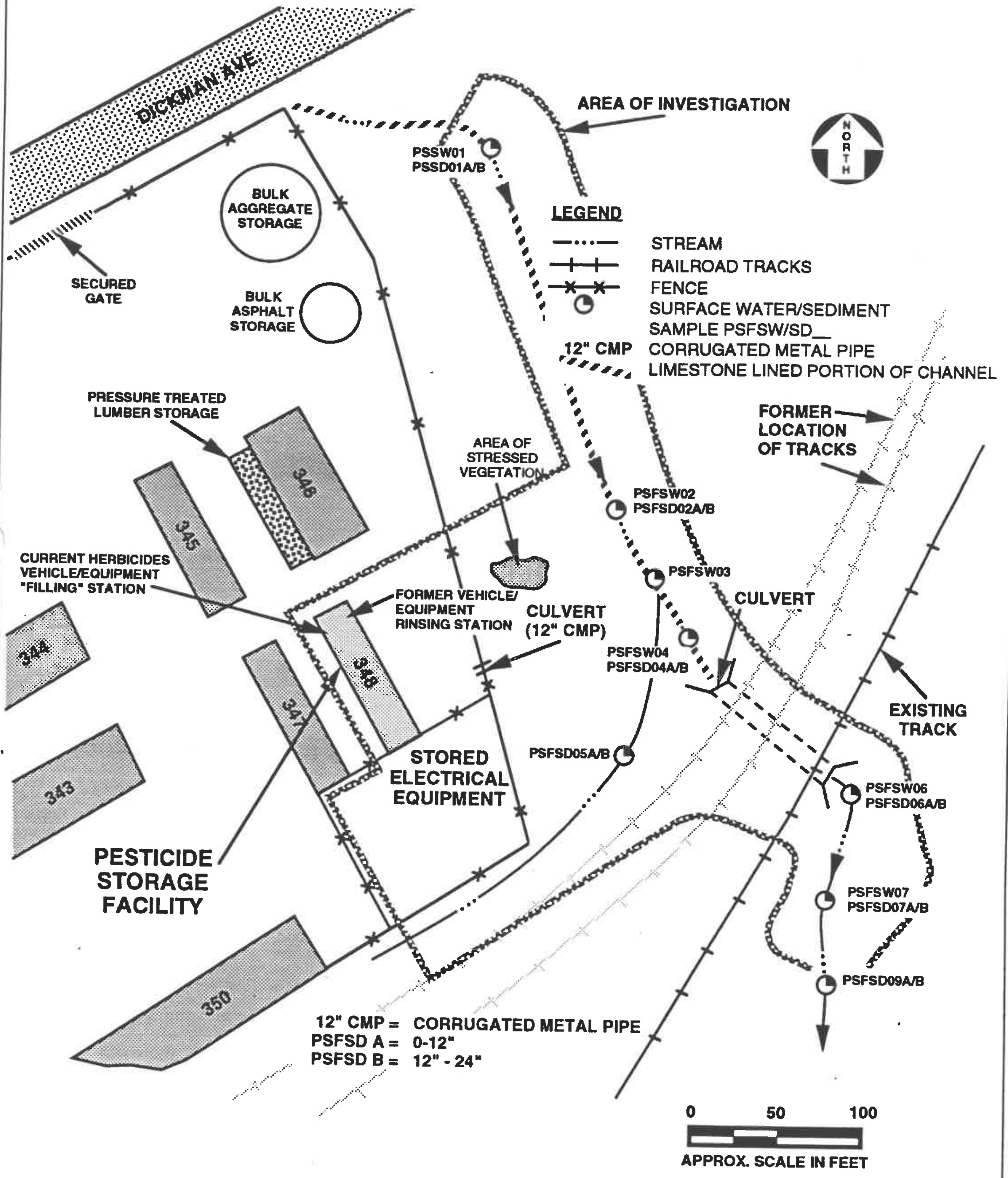
Sediment samples were composited from 0- to 1-foot and 1- to 2-foot depths. Several volatile organic compounds were detected in the sediments, including toluene, carbon disulfide, 1,2-dichloropropane and 1,1,2,2-tetrachloroethane. Carbon disulfide, 1,2-dichloropropane and 1,1,2,2-tetrachlorethane were only found in one sample each.

The metals arsenic, barium, cadmium, chromium and lead were found in the sediments both upstream and downstream. Of these, only lead showed an increase downstream from the PSF.

FIGURE 1-19

SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

PESTICIDE STORAGE FACILITY – MARCH-APRIL 1992
FORT RILEY, KANSAS



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1.5.6 Summary of Conclusions of December 1993 RI Report

The summary of conclusions derived from the evaluation of data collected during the PSF RI activities (1992 - 1993) is as follows:

- Of the constituents detected in soils, pesticides, PAHs and metals were found with the greatest frequency. The metals were also detected in upgradient samples and are naturally occurring in this area.
- Pesticides were indicated in three distinct areas in PSF soils: around the north end of the PSF and extending to the east; near the southeast corner of the PSF and extending to the east; and in the area of stressed vegetation near the drainage ditch to the east of the PSF (Figure 1-17).
- Pesticides detected in greatest frequency in the surface soils were chlordane, DDT and metabolites, and dieldrin; in subsurface soils, chlordane and DDT and metabolites.
- PAHs were detected in the soils in three areas of the PSF: along the fence to the east of the PSF and extending to the east; at the bottom of the culvert leading to the east from the southeastern corner of the fence; and near the southeastern corner of the PSF (Figure 1-17).
- The metals analyses of soil samples revealed that arsenic, barium, chromium, and lead were found in detectable concentrations in downgradient and background samples. Arsenic, chromium, and lead concentrations downgradient exceeded background levels in some samples; barium levels were consistent with background.
- Analytical results revealed that volatile organic compounds, pesticides, PAHs, and metals existed in the sediment within the drainage ditch to the east of the PSF. The metals were also detected in the upgradient sample and are naturally occurring in soils in the area.
- Analytical results revealed metals and inorganics in the groundwater samples collected from PSF wells and the background well, with metals generally detected at concentrations consistent with background concentrations; no pesticides and a single detection of toluene were observed.
- Constituents detected in the surface water consisted of various metals and inorganics detected upgradient and downgradient which are naturally occurring in the area. Downgradient concentrations were consistent with

the upgradient sample except that aluminum, iron, vanadium, zinc, and sulfate were slightly above background in some samples.

- Based on the conclusions derived from the analytical data and the resulting BLRA, the surface soils, subsurface soils, groundwater, and sediment may present potentially unacceptable risks to on-site workers and future residents, however, there are relatively few complete exposure pathways at the site. A summary of carcinogenic risk estimates from the BLRA is presented in Table 1-4. Noncarcinogenic risk estimates from the BLRA for these same pathways are presented in Table 1-5.

As presented in the BLRA, future groundwater use is unlikely at the site. As the groundwater use pathway is incomplete under current and probable future land uses at the site, risk estimates for a hypothetical future on-site groundwater use were calculated for information purposes only in the BLRA.

The ecological risk assessment concluded that negative impact to fauna and flora was not readily apparent. Any impacts would be minimized from selection by species of more favorable habitat locally available. Pesticides were not detected in downstream surface water (Kansas River) at the Southwest Funston Landfill site.

1.6 DRAFT FEASIBILITY STUDY DEVELOPMENT DURING 1993

A Draft FS was under development in February through May of 1993 based on the preliminary site characterization results available during the preparation of the RI report. The BLRA under review in the RI report indicated potentially unacceptable risks due to surface and subsurface soils, and Draft FS development focused on remedial actions addressing soil contaminants. Specific objectives identified for the Draft FS were: to identify appropriate remedial action objectives; to develop a range of site-specific remedial alternatives to address remedial action objectives; to evaluate and screen identified remedial alternatives; and to prepare initial cost estimates and a comparative analysis of identified alternatives.

The Draft FS included preliminary identification of applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) requirements. ARARs are the federal or state regulatory requirements which establish the criteria defining the cleanup goals for contaminants at the site. Remediation goals (RGs) were developed, which were based on identified ARARs and calculated risk-based contaminant levels when ARARs were not available to address the site contaminated media.

Remedial technologies were identified and initially screened utilizing the evaluation criteria of effectiveness, implementability and cost. Favorable technologies were combined to define

TABLE 1-4

SUMMARY OF CANCER RISKS FROM THE BASELINE RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	CANCER RISK
SOIL MEDIA		
Current Site Worker	Incidental ingestion of surface soil	1E-06
Current Site Worker	Dermal contact with surface soil	8E-04
Future Site Worker	Incidental ingestion of surface soil	6E-06
Future Site Worker	Dermal contact with surface soil	4E-03
Future Site Worker	Inhalation of fugitive dust	1E-06
Future Site Worker	Dermal contact with sediments	2E-06
Current Utility Worker	Dermal contact with surface soil	4E-06
Current Utility Worker	Dermal contact with subsurface soil	2E-06
Future Utility Worker	Dermal contact with surface soil	2E-05
Future Utility Worker	Dermal contact with subsurface soil	8E-06
Current Landscaper	Dermal contact with surface soil	1E-06
Current Landscaper	Dermal contact with subsurface soil	2E-06
Future Landscaper	Dermal contact with surface soil	2E-05
Future Landscaper	Dermal contact with subsurface soil	7E-06
Future Construction Worker	Incidental ingestion of surface soil	1E-06
Future Construction Worker	Dermal contact with surface soil	7E-05
Future Construction Worker	Dermal contact with subsurface soil	4E-05
Current/Future Recreational Child	Dermal contact with surface soil	NA
SEDIMENT MEDIA		
Future Site Worker	Dermal contact	2E-06
GROUNDWATER MEDIA (For Information Only)		
Future Site Resident (Adult)	Ingestion of ground water	2E-04
Future Site Resident (Adult)	Dermal contact	4E-07
Future Site Resident (Child)	Ingestion of ground water	NA
Future Site Resident (Child)	Dermal contact	NA

NA - Not assessed because cancer risks are not estimated for children.

TABLE 1-5

SUMMARY OF HAZARD INDICES FROM THE BASELINE RISK ASSESSMENT

Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX
SOIL MEDIA		
Current Site Worker	Incidental Ingestion of surface soil	2E-02
Current Site Worker	Dermal contact with surface soil	9E+00
Future Site Worker	Incidental ingestion of surface soil	6E-02
Future Site Worker	Dermal contact with surface soil	3E+01
Future Site Worker	Inhalation of fugitive dust	4E-07
Future Site Worker	Dermal contact with sediments	2E-02
Current Utility Worker	Dermal contact with surface soil	4E-02
Current Utility Worker	Dermal contact with subsurface soil	2E-02
Future Utility Worker	Dermal contact with surface soil	1E-01
Future Utility Worker	Dermal contact with subsurface soil	7E-02
Current Landscaper	Dermal contact with surface soil	1E-02
Current Landscaper	Dermal contact with subsurface soil	2E-02
Future Landscaper	Dermal contact with surface soil	1E-01
Future Landscaper	Dermal contact with subsurface soil	1E-01
Future Construction Worker	Incidental ingestion of surface soil	3E-01
Future Construction Worker	Dermal contact with surface soil	2E+02
Future Construction Worker	Dermal contact with subsurface soil	7E+00
Current/Future Recreational Child	Dermal contact with surface soil	2E+00
SEDIMENT MEDIA		
Future Site Worker	Dermal contact	2E-02
GROUNDWATER MEDIA (For Information Only)		
Future Site Resident (Adult)	Ingestion of ground water	4.6E+00
Future Site Resident (Adult)	Dermal contact	9.0E-03
Future Site Resident (Child)	Ingestion of ground water	2.2E+01
Future Site Resident (Child)	Dermal contact	1.0E-02

remedial action alternatives which were subjected to a detailed analysis for their potential ability to achieve site remedial action objectives and meet identified ARARs. Alternatives identified included a No Action alternative, institutional controls to limit site exposures, grading and capping of contaminated areas, and an excavation and off-site disposal alternative.

In May 1993, Fort Riley, the USEPA, and KDHE agreed to suspend the completion of the FS, and investigate a Removal Action option at the PSF site. To pursue a Removal Action, an EE/CA was prepared to document the development and evaluation of Removal Action alternatives.

1.7 DESCRIPTION OF REMOVAL ACTION COMPLETED IN 1994

After preparation and approval of the EE/CA, Fort Riley prepared an action memorandum for Removal Action at the PSF. A detailed discussion of the action memorandum is presented in Section 3. A rapid response contractor was retained by the United States Army Corps of Engineers (USACE) Omaha District to remove and properly dispose of the contaminated soil from the PSF site. A detailed discussion of the Removal Action is provided in Section 3 of the report.

1.8 ACTIVITIES FOLLOWING THE REMOVAL ACTION

1.8.1 Remedial Investigation Addendum And Feasibility Study Development During 1994 To 1995

The removal action removed contaminated soils from the PSF which considerably reduced potential health risks from exposure to contaminants at the site. As described in Section 2, the additional soil samples from the removal action also revealed that the actual soil contaminant distributions at the site differed from the estimates presented in the RI which characterized the site based on the limited RI sampling. Groundwater was also sampled again in September 1994, following the completion of the initial RI report (LAW, 1993a). The site characterization and BLRA risk estimates in the initial RI report (LAW, 1993a) were based on limited data and conditions which no longer existed at the site. Therefore, additional RI evaluation and FS development was initiated in late 1994 to provide a revised site characterization and a residual risk assessment (RRA). The RRA reevaluated risks based on current site conditions to provide a current basis for the identification of remedial action objectives and additional remedial action at the site. In this evaluation it was concluded that the removal action had successfully reduced soil exposure risks to acceptable levels. The evaluations concluded that the inorganics detected infrequently in the on-site wells were background related with the exception of nitrate.

After reviews by KDHE and the USEPA, these agencies requested additional groundwater monitoring and statistical evaluation of selected inorganics in PSF groundwater to provide additional evidence that these constituents represented background concentrations.

1.8.2 Additional Activities Conducted in 1995 and 1996

In December 1995, an additional round of groundwater samples was collected and analyzed for selected inorganics. In 1996, CEMRK completed a statistical comparison of these inorganic constituents in the PSF wells with the background wells. The complete report of the statistical evaluation is included in Appendix C. From the comparison, it was concluded that the inorganics evaluated in the PSF wells, including nitrate, were either statistically equivalent to background or were statistically below their respective MCLs. The statistical comparison was approved by KDHE on July 19, 1996.

Following the submittal and approval of the statistical evaluation, Removal Action and post-Removal Action Remedial Investigation data and evaluations were compiled into this report to document the activities and final conclusions. This report documents the removal action activities, presents a residual risk assessment and evaluates potential applicable or relevant and appropriate requirements. This report consolidates and updates discussions and deletes portions that are no longer appropriate (such as FS alternatives development) based on the revised findings.

2.0 REVISED PRE-REMOVAL NATURE AND EXTENT OF SOIL CONTAMINATION

Removal Action activities were initially based on the nature and extent of soil contamination predicted in the RI report (LAW, 1993a) (Section 3 provides a detailed description of the Removal Action activities). Because a limited number of soil samples were collected during the RI, additional soil sampling for pesticides was performed during Removal Action planning activities to better define the soil concentrations and to establish the initial limits of the Removal Action excavation. The information collected from these activities was used in planning the initial excavations at the PSF. Once initial excavation was completed, additional samples were collected from within excavated areas to measure remaining constituent levels. Based on the results of these samples, additional excavation was performed in some areas. Final confirmatory sampling was then conducted. The additional information obtained from these Removal Action activities indicated that site conditions differed significantly from the interpretations presented previously in the RI report (LAW, 1993a). A limited background soil sampling effort was also conducted during the Removal Action to evaluate selected metals and nitrate background concentrations at Fort Riley.

Additional site information was also discovered after the RI was completed. This information identified two former trenches that were dug at the site, as discussed in Section 1.2.2. Grading activities were also carried out across the site over the years to maintain suitable topography and restore eroded areas. Also, surface soil grading was performed within the area of investigation in the summer of 1993 to extend the fenced area south of Building 348 in an area where railroad tracks were previously removed and to construct a gravel surface. Areas possibly impacted by the grading activities associated with this work were sampled for pesticides during the Removal Action.

This section presents the soil sampling results from the Removal Action activities, and revised interpretations of the nature and extent of soil contamination at the PSF that existed prior to the Removal Action. The interpretation is based on the sampling results obtained from both the RI and Removal Action.

2.1 RESULTS OF LIMITED BACKGROUND SOIL SAMPLING

A limited background sampling effort was completed during the Removal Action. Twenty-two soil samples were collected and analyzed for arsenic, barium, beryllium, lead, thallium, and nitrate (CEMRK, 1994).

These samples were collected from locations believed representative of three specific geologic and hydrogeologic regimes at Fort Riley. The three regimes were the river valley alluvium, the river valley terrace deposits and the upland areas (not affected by the current erosional processes of the river valley) which contribute sediments to the valley.

In the upland areas, five samples, were taken from the upper most soils (because surface soils are very near bedrock on these cliffs) and from the exposed shale units below but not into the terrace deposits. Five grab samples were taken in each location and composited into each analytical sample for analysis.

In the alluvium and terrace materials, samples were taken from each foot of the upper 5 feet in each location and composited into one sample. The upper 5 feet were selected as the target interval because most of the soil contamination found at the PSF site was encountered in this depth interval. A total of 11 samples from the valley alluvium were collected from three separate areas in an attempt to identify different background levels at Fort Riley. Alluvium samples were collected from areas representative of sedimentary deposits from the Republican River Valley, Smoky Hill River Valley and Kansas River Valley areas. Samples A1 through A4 were collected from the Republican River Sediments. Sample A6 was collected from the Smoky Hill River sediment. Sample A5, collected near the junction of the Smoky Hill and Republican Rivers, and samples A7 through A11 were collected to represent the sediments of the Kansas River Valley.

The six samples collected from the terrace deposits were taken at approximately the same terrace elevation as the PSF site. These samples were collected from various areas at Fort Riley believed to approximate the natural background levels in the local terrace deposits which may result from either river sediments or from erosion from the uplands. Analytical results are included in Appendix D.

During the RI field activities, arsenic, barium, and lead were detected in two soil samples, (MWSBO1A at depths of 15 to 17 feet, and MWSBO1B at depths of 21 to 25 feet), analyzed from the upgradient well PSF92-01 soil boring which were considered representative of background conditions. Table 2-1 presents a summary of the background concentration ranges from the RI and Removal Action. Section 4 provides comparisons between the ranges of background soil concentrations to the ranges detected in soils remaining at the PSF after Removal Action excavations.

TABLE 2-1

RANGES FOR BACKGROUND METALS
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	BACKGROUND RANGE (mg/kg)	NUMBER OF BACKGROUND SAMPLES
Arsenic	1.2 - 7.1	25
Barium	31 - 200	25
Beryllium	<0.50-0.59	24
Chromium	6.7 - 9.3	3
Lead	4.3 - 46	25
Nitrate	<1.0 - 3.9	22
Thallium	<25	22

Sources: OHM, 1994 and LAW, 1993a

2.2 REVISED NATURE AND EXTENT OF SOIL CONTAMINATION

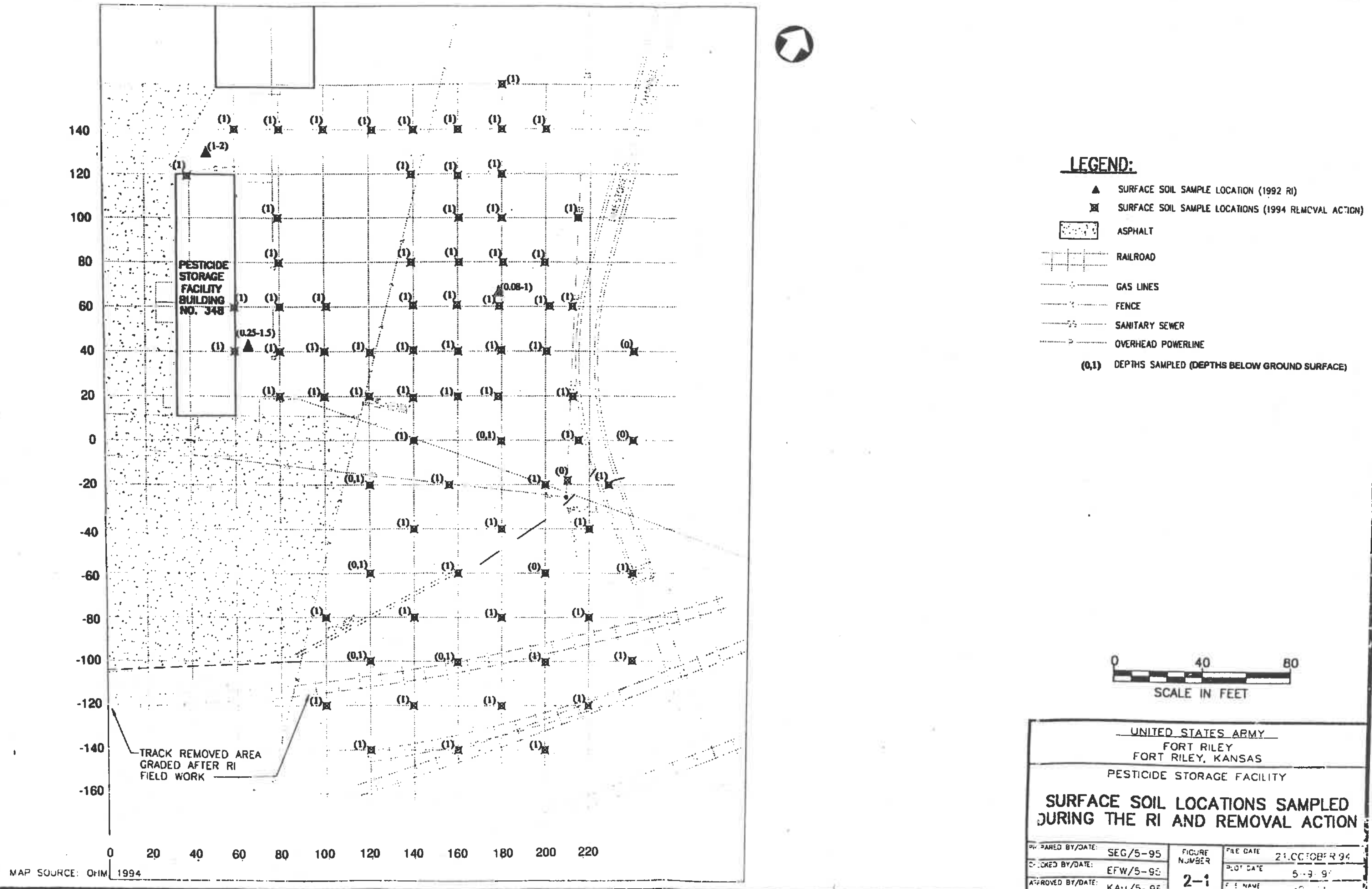
This section considers the additional data from the Removal Action soil sampling activities in conjunction with previous RI data to develop a revised nature and extent of soil contamination. Samples collected during the Removal Action were generally obtained on a control grid system at 20-foot intervals. Soil samples were collected from multiple depths at several points along this grid system during the Removal Action activities. These samples and the RI site investigation soil samples were related to this common grid system by overlaying computer-generated drawing files. A survey conducted during the RI field work (LAW, 1993a) and the drawing files produced by the rapid response contractor were combined to relate the RI sampling locations to this control grid system established for the Removal Action using the Building 348 "footprint" as the common reference.

The PSF site soil samples collected during the Removal Action were analyzed for the pesticides chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, and heptachlor. The chlordane values were reported as the total of alpha- and gamma-chlordane analyses. DDT metabolites 4,4'-DDD and 4,4'-DDE were analyzed for but not reported separately in 33 of 129 Removal Action soil samples. Data are therefore presented as "DDT and metabolites" for mapping purposes, with the metabolite concentrations added together with the 4,4'-DDT concentrations. Arsenic in PSF soils was analyzed in two samples from location RA-39 at depths of 5 and 7 feet during the Removal Action, and PAHs were not analyzed in Removal Action soil samples.

Consistent with the previous BLRA in the RI report (LAW, 1993a), surface soil is defined as soil less than 2 feet in depth, and subsurface soil is defined as soil at depths of 2 feet and greater. It should be noted that soil located under currently paved areas at depths less than 2 feet are considered subsurface because the paved surface is a barrier to direct contact with these soils. Surface and subsurface soils are evaluated separately in the following sections.

2.2.1 Surface Soil Evaluation

Table 2-2 presents analytical results for chlorinated pesticides obtained during the RI and Removal Action sampling activities for surface soil samples (depth less than 2 feet) collected at the site, the dates, and depths at which the samples were collected. The RI samples were composited from soil collected at depths below the asphalt and/or gravel cover at the sampled locations as indicated in Table 2-2. Removal Action samples were collected as grab samples at a discrete depth. Figure 2-1 shows the locations of these surface soil samples and also indicates the depths of the samples collected at each location. As indicated on this table and figure, three surface soil samples were collected during the RI, and 73 surface soil samples were collected during the Removal Action. Figures 2-2 through 2-4 summarize the Pre-Removal Action distributions of chlordane, DDT and metabolites, and dieldrin in surface soil interpreted from the sampling results. Sample locations from Figure 2-1 are also shown on these figures. The distributions shown on Figures 2-2 through 2-4 were generally based on linear interpolations of the detected concentrations. Areas of contamination indicated are influenced by the relative



MAP SOURCE: OHM 1994

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

SURFACE SOIL LOCATIONS SAMPLED DURING THE RI AND REMOVAL ACTION

PREPARED BY/DATE:	SEG/5-95	FIGURE NUMBER	FILE DATE	21 OCTOBER 94
CHECKED BY/DATE:	EFW/5-95	2-1	PLOT DATE	5-9-95
APPROVED BY/DATE:	KAH/5-95		FILE NAME	[illegible]

FIGURE 2-2

PRE-REMOVAL ACTION DISTRIBUTION OF CHLORDANE IN SURFACE SOIL

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

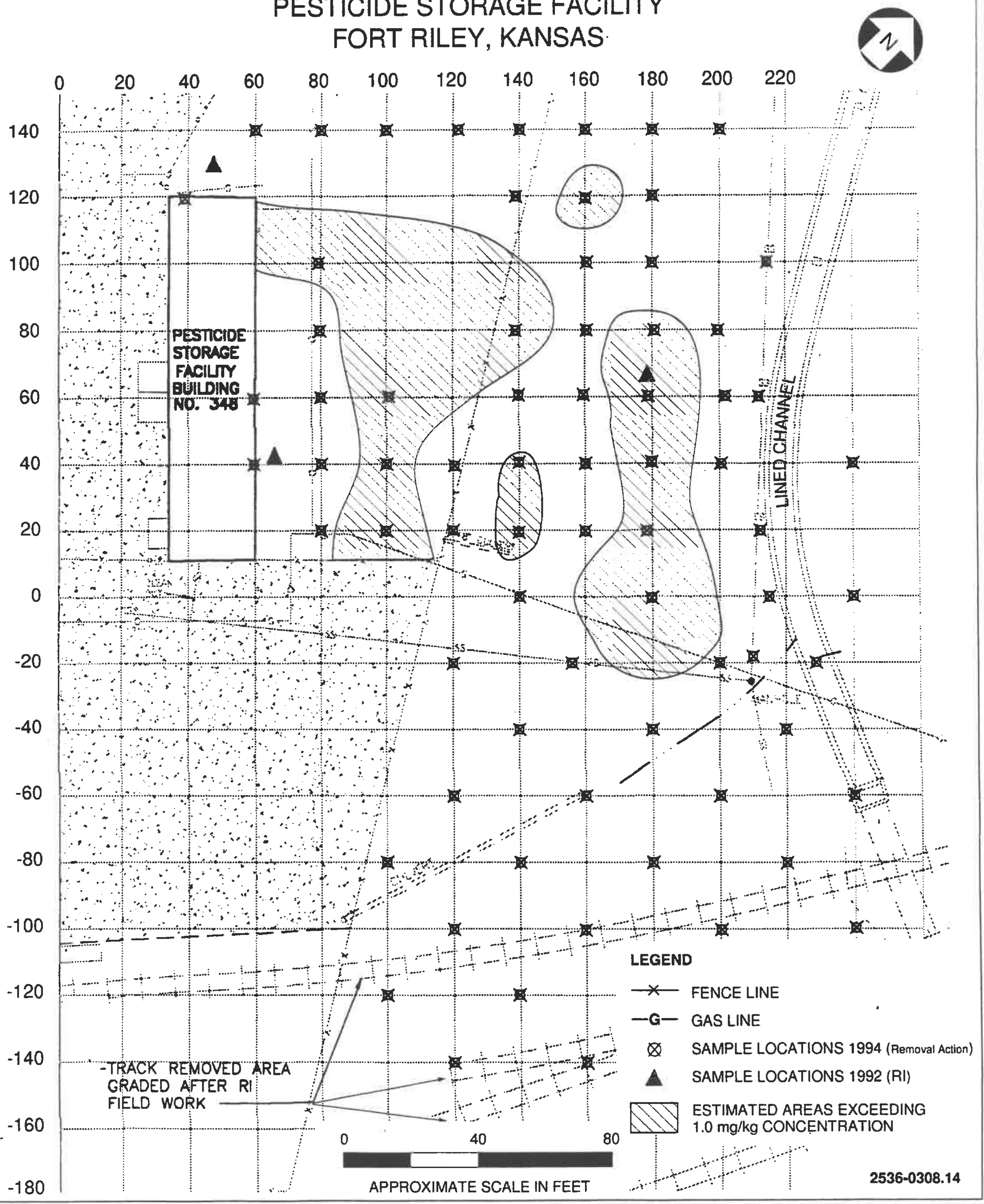


FIGURE 2-3

PRE-REMOVAL ACTION DISTRIBUTION OF DDT & METABOLITES IN SURFACE SOIL

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

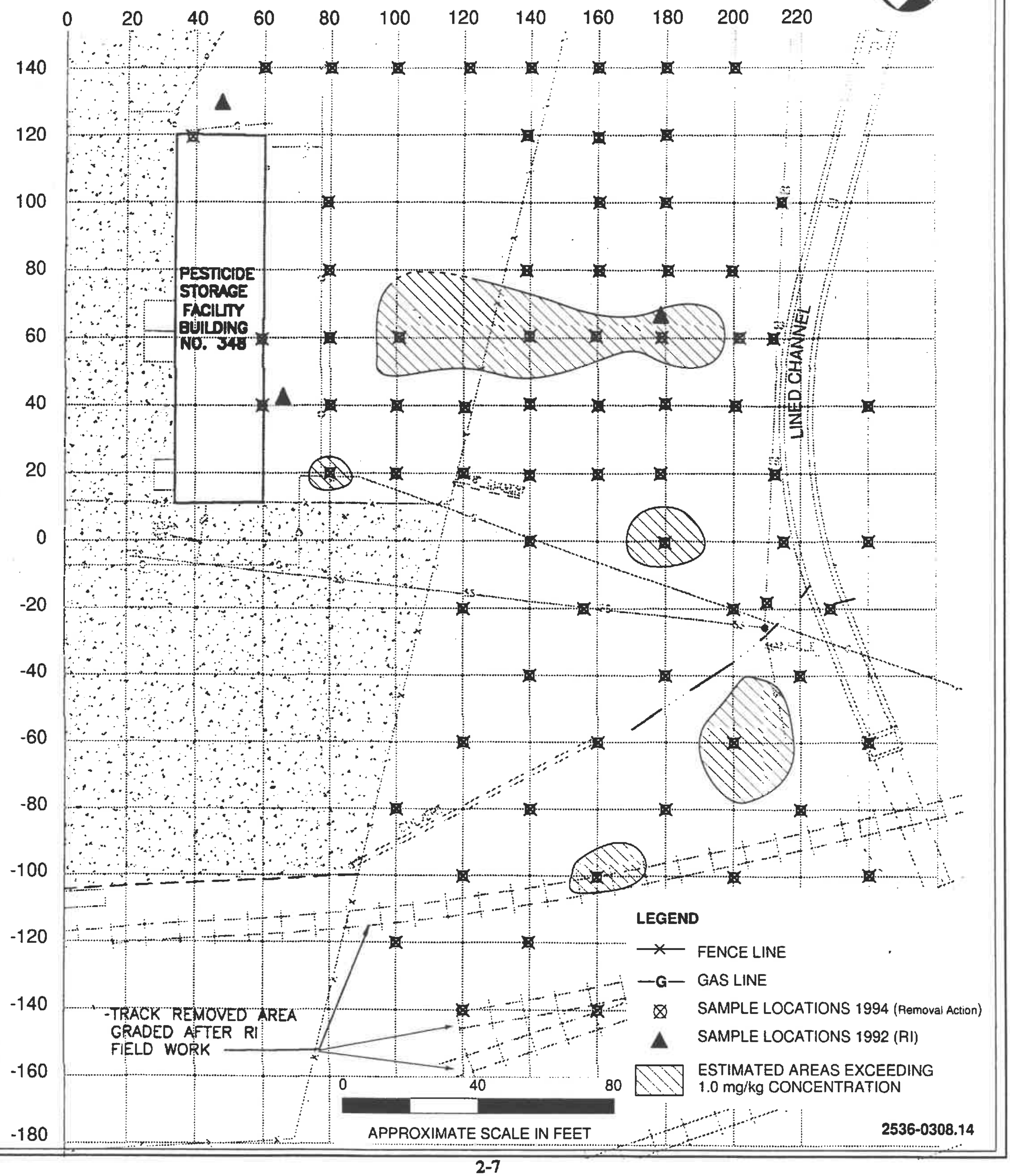


FIGURE 2-4

PRE-REMOVAL ACTION DISTRIBUTION OF DIELDRIN IN SURFACE SOIL

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

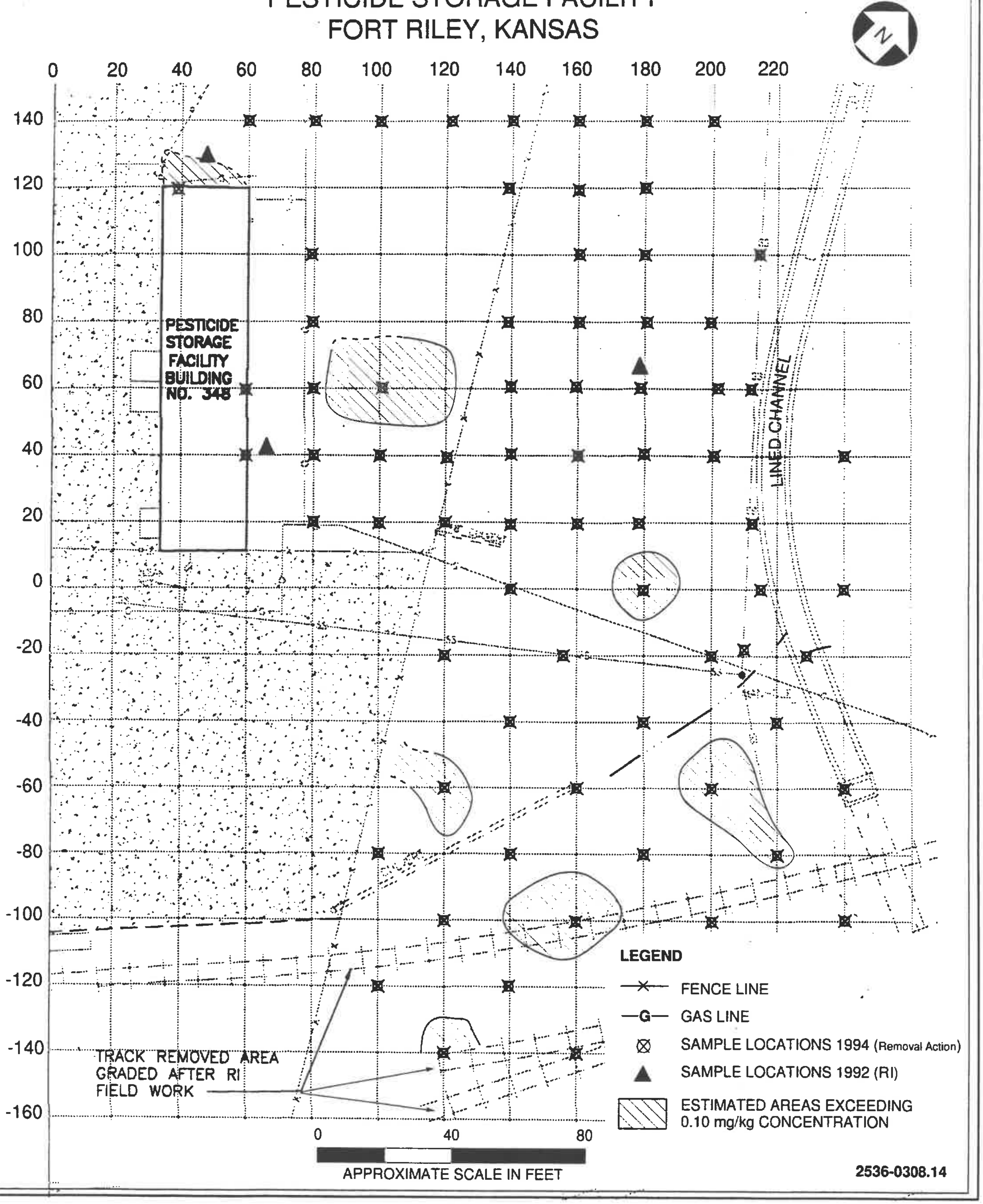


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TABLE 2-2

SURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA-01	180	160	03/07/94	1	<0.017	0.222	<0.003	<0.003
RA-02	60	140	02/04/94	1	<0.05	0.220	<0.005	<0.005
RA-03	80	140	02/04/94	1	0.057	<0.05	<0.005	<0.005
RA-04	100	140	02/04/94	1	<0.05	<0.05	<0.005	<0.005
RA-05	120	140	02/04/94	1	<0.05	<0.05	<0.005	<0.005
RA-06	140	140	02/24/94	1	0.024	0.022	<0.002	<0.001
RA-07	160	140	03/07/94	1	0.158	0.170	<0.003	<0.003
RA-08	180	140	03/07/94	1	<0.017	<0.003	<0.003	<0.003
RA-09	200	140	03/07/94	1	<0.033	0.040	<0.003	<0.003
RA-10	40	120	02/04/94	1	0.720	0.150	1.40	0.026
RA-13	140	120	02/04/94	1	0.083	0.380	0.032	<0.005
RA-14	160	120	02/24/94	1	1.60	0.810	<0.020	<0.010
RA-15	180	120	03/07/94	1	0.033	0.429	<0.003	<0.003
RA-17	80	100	03/08/94	1	1.25	<0.033	<0.033	0.026
RA-20.5	160	100	02/04/94	1	0.083	0.006	<0.005	<0.005
RA-21	180	100	03/07/94	1	<0.033	0.028	<0.003	<0.003
RA-22	215	100	03/07/94	1	<0.033	<0.003	<0.003	<0.003
RA-24	80	80	02/04/94	1	<0.05	<0.05	<0.005	<0.005
RA-27	140	80	03/07/94	1	2.80	0.194	<0.003	0.011
RA-27.5	160	80	03/07/94	1	0.721	0.223	0.030	<0.003
RA-28	180	80	02/04/94	1	1.80	0.570	<0.005	<0.005
RA-28.5	200	80	02/24/94	1	0.034	0.011	0.007	0.001
RA-29	60	60	02/04/94	1	0.670	<0.050	<0.005	0.009
RA-30	80	60	03/30/94	1	<0.028	DDD 0.024 DDT 0.054 DDE 0.039	<0.003	<0.0009
RA-31	100	60	02/04/94	1	<0.050	<0.050	<0.005	<0.005
	100	60	03/30/94	1	3.50	DDD <0.003 DDT 1.71 DDE <0.009	0.407	0.031
RA-32	140	60	03/07/94	1	<0.330	2.63	<0.066	<0.066
RA-33	160	60	03/07/94	1	<0.831	1.26	<0.166	<0.166
RA-34	180	60	02/04/94	1	2.90	1.90	0.023	0.012
RA-34.5	200	60	02/04/94	1	0.200	0.150	<0.005	<0.005
RA-35	212	60	02/24/94	1	0.740	<0.120	<0.040	ND(1)
RA-37	80	40	03/30/94	1	0.034	DDE 0.046 DDD <0.002 DDT <0.003	<0.003	<0.0009

TABLE 2–2

SURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA–38	100	40	03/30/94	1	1.12	DDT 0.730 DDD <0.003 DDE <0.009	<0.003	0.009
RA–38.5	120	40	02/04/94	1	<0.050	<0.050	0.041	<0.005
RA–40	140	40	02/04/94	1	1.20	0.480	0.027	<0.005
RA–40.5	160	40	02/04/94	1	0.370	0.096	<0.005	<0.005
RA–41	180	40	02/24/94	1	1.50	0.400	0.030	<0.010
RA–41.5	200	40	02/24/94	1	0.300	0.064	0.014	0.010
RA–42	240	40	03/07/94	0	<0.033	0.012	<0.003	<0.003
RA–43	80	20	03/30/94	1	0.418	DDE 0.346 DDD 0.454 DDT 0.273	0.030	<0.009
RA–44	100	20	3/30/94	1	3.84	DDE 0.096 DDD 0.275 DDT 0.482	<0.003	0.017
RA–45	120	20	02/24/94	1	<0.020	0.013	0.015	<0.001
RA–46	140	20	02/24/94	1	1.50	0.790	0.038	<0.010
RA–47	160	20	02/24/94	1	0.250	0.062	0.015	<0.010
RA–48	180	20	02/24/94	1	1.50	0.240	0.032	<0.010
RA–49	215	20	03/07/94	1	<0.033	<0.003	<0.003	<0.003
RA–50	140	0	03/07/94	1	<0.017	0.026	<0.003	<0.003
RA–51	180	0	03/30/94	1	3.44	DDT 0.592 DDD 0.316 DDE 0.593	0.072	ND(1)
	180	0	03/07/94	0	<0.410	0.644	0.142	<0.082
RA–52	215	0	03/07/94	1	<0.033	0.044	0.009	<0.003
RA–53	240	0	03/07/94	0	<0.033	0.012	<0.003	<0.003
RA–54	210	–18	03/08/94	0	0.221	0.095	0.036	<0.003
RA–55	120	–20	03/30/94	0	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
			03/07/94	1	<0.083	0.218	0.026	<0.017
RA–56	156	–20	03/07/94	1	0.309	0.605	<0.003	<0.003
RA–57	200	–20	03/07/94	1	0.260	0.369	0.051	<0.004
RA–58	229	–20	03/07/94	1	<0.017	<0.003	<0.003	<0.003
RA–59	120	–60	03/30/94	0	<0.034	DDE 0.126 DDD 0.107 DDT 0.167	0.074	<0.001
	120	–60	03/08/94	1	0.358	0.434	0.121	<0.003

TABLE 2-2

SURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA-60	140	-40	03/07/94	1	<0.033	0.050	0.007	<0.007
RA-61	180	-40	03/07/94	1	<0.017	0.112	0.024	<0.003
RA-62	220	-40	03/07/94	1	0.072	0.288	0.022	<0.003
RA-63	60	40	02/04/94	1	<0.050	<0.050	<0.005	<0.005
RA-64	160	-60	03/08/94	1	0.140	<0.003	0.014	<0.003
RA-65	200	-60	05/19/94	0	0.021	DDE 0.847 DDD 0.335 DDT 1.29	0.158	<0.001
RA-66	240	-60	03/08/94	1	<0.033	0.172	0.017	<0.003
RA-67	100	-80	03/08/94	1	0.151	0.143	0.032	<0.003
RA-68	140	-80	03/08/94	1	0.218	0.047	0.013	<0.003
RA-69	180	-80	03/08/94	1	<0.033	0.091	0.017	<0.003
RA-70	220	-80	03/08/94	1	0.439	0.667	0.109	0.004
RA-71	120	-100	03/30/94	0	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.011
	120	-100	03/30/94	1	<0.034	DDT 0.378 DDE 0.188 DDD <0.003	0.082	<0.001
RA-72	160	-100	03/30/94	0	<0.034	DDT 1.21 DDD 0.659 DDE 0.852	0.238	<0.001
	160	-100	03/30/94	1	<0.034	DDE 0.232 DDD 0.071 DDT 0.213	0.064	<0.001
RA-73	200	-100	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-74	240	-100	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-75	100	-120	03/30/94	1	<0.034	DDD 0.164 DDE 0.111 DDT 0.327	0.054	<0.001
RA-76	140	-120	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

TABLE 2–2

SURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
RA–77	180	–120	03/30/94	1	<0.034	DDE 0.040 DDT 0.079 DDD <0.002	<0.004	<0.001
RA–78	220	–120	03/30/94	1	<0.034	DDE 0.061 DDT <0.002 DDD <0.003	<0.004	<0.001
RA–79	120	–140	03/30/94	1	<0.034	DDT 0.379 DDD 0.163 DDE 0.254	0.107	<0.001
RA–80	160	–140	03/30/94	1	<0.034	DDE 0.036 DDT 0.075 DDD <0.003	<0.004	<0.001
RA–81	200	–140	03/30/94	1	<0.034	DDE 0.203 DDT 0.175 DDD 0.100	<0.004	<0.001
SB–1	47.9	129.8	04/08/92	1–2	0.750	DDT 0.670 DDD <0.071 DDE 0.180	0.094	<0.035
SB–7	67.4	39.8	04/05/92	0.25–1.5	0.059	DDT 0.450 DDD <0.008 DDE 0.094	<0.008	<0.004
SB–17	178.7	66.5	04/06/92	0.08–1	1.300	DDT <0.074 DDD <0.074 DDE 1.80	<0.074	<0.037

RA – Prefix samples from Removal Action (Appendix E).
SB – Prefix samples from RI (LAW, 1993a).
ND – Not detected.
* DDT metabolites (DDD and DDE) only reported for select samples.
Results for metabolites presented if analyzed.
(1) Detection limit not reported by laboratory.

locations of samples to each other. Additional maps showing the sampled locations and detected concentrations that were reviewed to generate these figures are included in Appendix D for information.

Chlordane

The revised Removal Action RG was 1.58 mg/kg for chlordane and seven samples exceeded this concentration. Areas of chlordane concentrations above 1.0 mg/kg are shown on Figure 2-2 which shows that four distinct areas of chlordane at concentrations exceeding 1.0 mg/kg were indicated from the sampling results. The maximum detected concentration of chlordane in surface soils was 3.84 mg/kg (sample RA-44) which occurred approximately 40 feet east of the southeast corner of Building 348 within the gravel area inside the fence. Chlordane was also detected at similar concentrations at sample RA-31 (3.50 mg/kg), about 40 feet north of sample RA-44 also in the gravel area inside the fence. These samples were collected within the largest area of contamination just east of Building 348. Samples collected at RA-28 (1.80 mg/kg), RA-34 (2.90 mg/kg), and RA-51 (3.44 mg/kg) defined the other large area of contamination located about 65 feet downgradient from the gravel area. Two small areas of contamination were also identified. The isolated area about 80 feet east of the southern end of Building 348 was defined by sample RA-40 (1.20 mg/kg) and RA-46 (1.50 mg/kg). The small area about 100 feet east of the northern end of Building 348 was defined by sample RA-14 at 1.60 mg/kg. RI and Removal Action sampling results indicated diffuse areas of contamination at low levels probably due to the erosion of contaminated soils during rainstorms and the mixing of soils during grading activities carried out over the years at the site. Concentrations were also likely reduced by degradation over time as discussed in the RI report (LAW, 1993a), which showed that higher contaminant concentrations existed at the site prior to the RI sampling. At the northern, southern, and eastern boundaries of sampling, chlordane was only detected infrequently at low levels below 1.0 mg/kg. Sampling results from the soils in the area disturbed by the grading associated with extending the fenced area southward did not indicate contamination at levels above 1.0 mg/kg.

DDT and Metabolites

Areas of DDT and metabolites at concentrations exceeding 1.0 mg/kg are shown on Figure 2-3 which indicates five distinct areas of contamination. The revised Removal Action RG was 1.73 mg/kg and four samples exceeded this concentration level. The largest area shown east of the building was identified by samples RA-32 (2.63 mg/kg) and RA-34 (1.90 mg/kg). The isolated areas near the removed tracks were also identified by samples RA-65 (2.472 mg/kg) and RA-72 (2.721 mg/kg). Samples collected nearest to RA-65 and RA-72 did not exceed 1.0 mg/kg, and these areas were estimated using a linear interpolation of detected concentrations between the samples. This method resulted in estimated areas of contamination influenced by the relative locations of adjacent samples. Two small areas of contamination were identified upstream and downstream from a 12-inch culvert that existed east of the building. These were defined by sample RA-43 at 1.073 mg/kg nearest the building and RA-51 at 1.501 mg/kg further east and downstream. These three areas identified nearest Building 348 were likely the result of past erosion and deposition processes. The largest area also followed surface run-off patterns to the east. The historical source responsible for the two other areas nearest the railroad tracks is not apparent as surface run-off from around the building does not contact these areas. Site grading activities at the PSF and degradation processes are believed to have resulted in the low levels of DDT below 1.0 mg/kg observed in many samples at the site, indicating a diffuse area of contamination existed. These results also indicated that the soils in the area disturbed by the grading to extend the fenced area were not contaminated at levels above 1.0 mg/kg.

Dieldrin

The revised Removal Action RG was 0.127 mg/kg for dieldrin and four samples exceeded this concentration level. Figure 2-4 shows that the locations of previously contaminated surface soils above 0.10 mg/kg generally followed patterns similar to the DDT contamination discussed in the previous paragraph. An exception was that the highest detected concentration (1.40 mg/kg) was located at sample RA-10 near the northwest corner of Building 348. Limited samples were collected in this area which is near the existing asphalt paving; however, this sample appeared to represent an isolated area of contamination. Low levels of dieldrin were detected within the gravel area inside the fence and in areas outside the fence to the east and south of the PSF building. The area of contamination shown within the gravel area east of the building was based only from sample RA-31, at 0.407 mg/kg. The detections outside the fenced area (samples RA-51, RA-59, RA-65, RA-70, RA-72, RA-79) were primarily along or at the bottom of the hillside slope and in areas likely to have been impacted by erosion and deposition from surface run-off. Observed concentrations in these samples varied from 0.109 mg/kg (RA-70) to 0.238 mg/kg (RA-72) which were also likely the result from past grading activities at the PSF and degradation over time. These results indicated that the soils in the area disturbed by the grading to extend the fenced area were not contaminated at levels above 0.10 mg/kg.

Heptachlor

Heptachlor was detected infrequently in surface soils at levels at or below 0.031 mg/kg, which was below the Removal Action RG for this constituent (0.05 mg/kg). Because the heptachlor RG was not exceeded in surface soil samples collected during the Removal Action, heptachlor was not mapped.

2.2.2 Subsurface Soil Evaluation

Table 2-3 presents analytical results for chlorinated pesticides obtained during the RI and Removal Action sampling activities for subsurface soil samples (2-foot depths and greater) collected at the PSF site. As indicated in Table 2-3, 55 subsurface soil samples were collected during the RI and 129 subsurface soil samples were collected during the Removal Action. Figure 2-5 shows the locations of the subsurface samples and the various depths at these locations where soil samples were collected for analysis. Removal Action samples were collected as discrete grab samples at specific depth, while the previous RI soil samples were collected by compositing soil from a 1-foot depth interval. Figures 2-6 through 2-9 summarize the extent of chlordane, DDT and metabolites, dieldrin, and heptachlor in subsurface soils. These maps also show the sampled locations from Figure 2-5. Additional maps showing the sampled locations and detected concentrations that were reviewed to generate these figures are included in Appendix D. RI samples collected as composites from 1.5- to 2.5-foot depths were included with the Removal Action samples from the 2- and 3-foot depths. RI samples collected from a composite at the 3.5- to 4.5-foot depth were included with Removal Action samples from 4- to 5-foot depths for mapping. Although Removal Action samples were collected at discrete depths, the Removal Action and RI samples collected from within each 1-foot depth increment were combined for mapping purposes. This was done to provide more data at each depth increment mapped to limit the interpolations needed between data points and allowed contaminated areas to be identified in 1-foot depth increments consistent with Removal Action excavations.

Chlordane

As seen in Figure 2-6, areas of chlordane concentrations exceeded 1.0 mg/kg were identified at depths of 2 to 3 feet, 4 to 5 feet, and 6 to 7 feet. At the 2- to 3-foot depth, 10 samples exceeded the RG concentration (1.58 mg/kg). At depths of 4 to 5 feet, 6 samples, and at depths of 6 feet and greater no samples exceeded the RG. An area of chlordane contamination adjacent to the east side and extending around the northeast corner of Building 348 was defined by samples RA-29 at 5.35 mg/kg, RA-23 at 3.36 mg/kg, RA-16 at 2.67 mg/kg, and SB-5 at 1.58 mg/kg at the 2- to 3-foot depth. At the 4- to 5-foot depth, sample SB-3 at 3.10 mg/kg was the only sample collected along the building which exceeded the 1.0 mg/kg concentration. This sample was used to estimate the contaminated area extending around the northeast corner of the building. Contamination in this area is likely the result of previous operating practices as discussed in the RI report (LAW, 1993a).

A prevalent second area of contamination approximately parallel to and about 30 feet east of the fence at the site, running about the length of Building 348 was defined by samples RA-20.5, SB-12, RA-32, RA-34, RA-40, RA-40.5, and RA-47, at the 2- to 3-foot depth. This area may identify the location of the former trenches excavated at the site which were discussed in Section 1.2.2. The maximum chlordane concentration detected at the 2- to 3-foot depth was 5.89 mg/kg, detected at RA-47. In this area east of the fence (samples RA-46 and RA-41), chlordane

TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA-01	180	160	03/08/94	3	<0.017	<0.003	<0.003	<0.003
RA-07	160	140	03/08/94	3	<0.017	<0.003	<0.003	<0.003
RA-08	180	140	03/08/94	3	<0.017	<0.003	<0.003	<0.003
RA-09	200	140	03/08/94	3	<0.016	<0.003	<0.003	<0.003
RA-10	40	120	02/04/94	5	<0.050	<0.050	<0.005	<0.005
RA-11	80	120	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	80	120	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-12	100	120	03/30/94	5	0.563	DDT 0.447 DDD 0.149 DDE 0.130	<0.003	<0.0009
	100	120	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-12.5	120	120	03/30/94	5	0.280	DDT 0.280 DDD ND(1) DDE 0.050	ND(1)	ND(1)
	120	120	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-13	140	120	03/30/94	2	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	140	120	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009

TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
RA-14	160	120	03/30/94	2	<0.028	DDT 0.036 DDD 0.023 DDE 0.020	<0.003	<0.0009
	160	120	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	160	120	04/08/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
	160	120	04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-15	180	120	03/08/94	3	<0.017	<0.003	<0.003	<0.003
RA-16	60	100	04/08/94	2	2.67	DDT 0.509 DDD 0.218 DDE 0.132	0.020	0.129
RA-17	80	100	03/08/94	3	<0.017	<0.003	<0.003	<0.003
	80	100	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	80	100	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-18	100	100	03/30/94	5	<0.05	<0.05	<0.005	<0.005
	100	100	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	100	100	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-19	120	100	03/30/94	5	0.175	DDT 0.097 DDD <0.003 DDE 0.060	<0.003	<0.0009
	120	100	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
RA–20	140	100	03/30/94	2	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	140	100	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–20.5	160	100	03/30/94	2	5.67	DDT 0.970 DDD 0.304 DDE 0.389	<0.003	0.014
	160	100	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–21	180	100	03/08/94	3	<0.016	<0.003	<0.003	<0.003
RA–22	215	100	03/07/94	3	<0.033	<0.003	<0.003	<0.003
RA–23	60	80	04/08/94	2	3.36	DDT 1.95 DDD 0.925 DDE 0.332	<0.004	<0.001
	60	80	02/04/94	5	<0.05	<0.05	<0.005	<0.005
RA–25	100	80	05/19/94	2	0.048	DDT 0.051 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–26	120	80	02/04/94	5	<0.05	<0.05	<0.005	<0.005
RA–27	140	80	03/08/94	3	<0.033	0.050	0.006	<0.003
	140	80	03/30/94	5	2.19	DDT 2.29 DDD 0.296 DDE 0.449	<0.003	<0.0009
	140	80	04/08/94	5	0.683	DDT 0.493 DDD 0.124 DDE 0.144	<0.004	0.003
	140	80	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	140	80	04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and[1] Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA–27.5	160	80	03/30/94	5	1.53	DDT 2.53 DDD 0.913 DDE 0.344	<0.003	0.004
	160	80	03/30/94	7	1.34	DDT 3.36 DDD 1.34 DDE 0.488	<0.003	0.005
	160	80	05/19/94	8	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–28	180	80	03/30/94	2	0.298	DDT 0.035 DDD 0.029 DDE 0.033	<0.003	<0.0009
	180	80	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–29	60	60	04/08/94	2	5.35	DDT <0.002 DDD <0.003 DDE 0.034	<0.004	0.038
RA–30	80	60	03/30/94	3	0.049	DDT <0.002 DDD <0.003 DDE 0.018	<0.003	<0.0009
	80	60	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–31	100	60	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	100	60	03/30/94	5	<0.028	DDT 0.186 DDD 0.017 DDE 0.041	<0.003	<0.0009
RA–32	140	60	03/08/94	3	2.32	0.225	<0.016	<0.016
	140	60	03/30/94	5	4.87	DDT 1.69 DDD 0.128 DDE 0.292	<0.003	<0.027
	140	60	04/08/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
	140	60	03/30/94	7	0.167	DDT 0.034 DDD <0.003 DDE 0.012	<0.003	<0.0009
	140	60	04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA–33	160	60	03/07/94	3	0.409	0.264	0.004	<0.003
	160	60	02/04/94	5	<0.050	<0.050	<0.005	<0.005
	160	60	03/30/94	5	0.272	DDT 0.105 DDD <0.0005 DDE 0.027	<0.0006	0.001
	160	60	03/30/94	7	ND(1)	ND(1)	ND(1)	ND(1)
RA–34	180	60	03/30/94	2	2.98	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	0.008
	180	60	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–36	65	40	04/08/94	5	0.201	DDT 0.112 DDD 0.084 DDE 0.049	<0.004	<0.001
	65	40	04/08/94	5	0.042	DDT <0.002 DDD 0.019 DDE <0.011	<0.004	<0.001
	65	40	04/08/94	5	0.266	DDT 0.768 DDD 0.271 DDE 0.254	<0.004	<0.001
RA–37	80	40	03/30/94	3	<0.028	DDT 0.017 DDD 0.011 DDE 0.022	<0.003	<0.0009
	80	40	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE 0.010	<0.003	<0.0009
RA–38	100	40	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	100	40	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA–39	130	40	03/30/94	5	<0.028	DDT <0.002 DDD 0.001 DDE <0.009	<0.003	<0.0009

TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA-40	140	40	03/30/94	2	4.09	DDT 0.829 DDD 0.531 DDE 1.00	<0.003	0.011
	140	40	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	140	40	03/30/94	5	0.332	DDT 0.068 DDD 0.023 DDE 0.066	<0.003	<0.0009
	140	40	04/08/94	5	0.623	DDT 0.221 DDD 0.081 DDE <0.011	<0.004	<0.001
	140	40	04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-40.5	160	40	03/30/94	2	3.51	DDT 0.959 DDD 0.570 DDE 1.16	<0.003	0.013
	160	40	03/30/94	4	0.826	DDT 0.077 DDD 0.034 DDE 0.013	<0.0032	<0.0009
RA-41	180	40	03/30/94	2	0.302	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	180	40	03/30/94	4	10.2	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-43	80	20	03/30/94	3	0.087	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	80	20	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
RA-44	100	20	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
	100	20	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and[1] Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
RA–46	140	20	03/30/94	2	0.172	DDT 0.013 DDD 0.018 DDE 0.043	<0.003	<0.0009
	140	20	03/30/94	4	3.54	DDT 0.472 DDD 0.586 DDE 0.794	<0.003	0.008
	140	20	04/08/94	4	8.71	DDT 0.917 DDD 0.513 DDE <0.011	<0.004	<0.001
	140	20	05/19/94	4	0.059	DDT 0.016 DDD <0.003 DDE 0.036	<0.003	<0.0009
RA–47	160	20	03/30/94	2	5.89	DDT 0.715 DDD 0.365 DDE 0.666	<0.003	0.023
RA–48	180	20	03/30/94	2	0.325	DDT 0.039 DDD <0.003 DDE 0.043	<0.003	<0.0009
	180	20	03/07/94	3	<0.033	<0.003	<0.003	<0.003
	180	20	03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.009
RA–49	215	20	03/07/94	3	<0.033	<0.003	<0.003	<0.003
RA–50	140	0	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–51	180	0	03/07/94	3	0.329	0.553	0.034	<0.003
	180	0	03/30/94	5	0.562	DDT 0.144 DDD <0.003 DDE 0.126	<0.004	<0.001
RA–52	215	0	03/07/94	3	<0.033	<0.003	<0.003	<0.003
RA–55	120	–20	03/08/94	3	<0.016	0.026	<0.003	<0.003
	120	–20	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
RA-56	156	-20	03/08/94	3	<0.033	0.143	0.007	<0.003
RA-57	200	-20	03/08/94	3	<0.033	0.012	<0.003	<0.003
RA-58	229	-20	03/08/94	4	<0.017	<0.003	<0.003	<0.003
RA-59	120	-60	03/08/94	3	0.140	<0.003	<0.003	<0.003
	120	-60	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE 0.060	<0.004	<0.001
RA-60	140	-40	03/08/94	3	<0.017	<0.003	<0.003	<0.003
RA-61	180	-40	03/08/94	3	0.070	0.053	0.011	<0.003
RA-64	160	-60	03/08/94	3	<0.016	0.011	<0.003	<0.003
RA-67	100	-80	03/08/94	3	<0.017	<0.003	<0.003	<0.003
	100	-80	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-68	140	-80	03/08/94	3	2.39	0.055	<0.003	<0.003
	140	-80	05/19/94	4	0.026	DDT 0.184 DDD 0.072 DDE 0.501	<0.003	<0.0009
	140	-80	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-69	180	-80	03/08/94	3	0.080	0.109	0.022	<0.003
	180	-80	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA-70	220	-80	03/08/94	3	0.081	0.044	0.009	<0.003
RA-71	120	-100	03/30/94	3	<0.034	DDT 0.153 DDD 0.044 DDE 0.251	0.066	<0.001
	120	-100	03/30/94	5	<0.034	DDT 0.198 DDD 0.079 DDE 0.378	0.042	<0.001

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
RA–72	160	–100	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
	160	–100	03/30/94	5	<0.034	DDT 0.098 DDD <0.003 DDE 0.053	0.023	<0.001
RA–73	200	–100	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
	200	–100	03/30/94	5	<0.034	DDT 0.036 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–74	240	–100	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–75	100	–120	03/30/94	3	<0.034	DDT 0.154 DDD 0.051 DDE 0.076	<0.004	<0.001
RA–76	140	–120	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–77	180	–120	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–78	220	–120	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–79	120	–140	03/30/94	3	<0.034	DDT 0.070 DDD 0.044 DDE 0.089	<0.004	<0.001
RA–80	160	–140	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
RA–81	200	–140	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
SB-1	47.9	129.8	04/08/92	2.0-2.5	0.046	DDT 0.016 DDD <0.008 DDE <0.008	<0.008	<0.004
	47.9	129.8	04/08/92	4.0-4.5	0.166	DDT 0.087 DDD <0.008 DDE 0.024	0.027	<0.004
SB-2	26.8	111.9	04/07/92	0.5-1.5*	3.200	DDT 1.000 DDD <0.062 DDE 0.270	0.077	0.300
	26.8	111.9	04/07/92	2.0-2.5	0.420	DDT 0.042 DDD <0.039 DDE <0.039	<0.039	0.045
	26.8	111.9	04/07/92	4.0-4.5	0.320	DDT <0.370 DDD <0.370 DDE <0.370	<0.037	0.028
SB-3	69.7	117.6	04/05/92	2.0-2.5	0.210	DDT 7.70 DDD <0.390 DDE <0.390	<0.390	<0.200
	69.7	117.6	04/05/92	4.0-4.5	<0.180	DDT 4.50 DDD <0.370 DDE <0.370	<0.370	<0.180
	69.7	117.6	04/05/92	4.0-4.5	3.10	DDT 33.0 DDD <1.50 DDE <1.50	<1.50	<0.740
SB-4	24.8	19.1	04/07/92	2.0-2.5	0.181	DDT 0.140 DDD <0.016 DDE 0.031	<0.016	<0.008
	24.8	19.1	04/07/92	4.0-4.5	0.125	DDT 0.096 DDD <0.016 DDE 0.021	<0.016	<0.008
SB-5	71.4	109.5	04/05/92	2.0-2.5	1.580	DDT 0.850 DDD <0.039 DDE 0.110	0.200	0.230
	71.4	109.5	04/05/92	3.5-4.5	0.142	DDT 0.053 DDD <0.008 DDE 0.008	0.010	0.017
SB-6	89.3	55.9	04/07/92	2.0-2.5	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
	89.3	55.9	04/07/92	4.0-4.5	0.008	DDT 0.014 DDD <0.007 DDE <0.007	<0.007	<0.004

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
SB–7	67.4	39.8	04/07/92	2.5–3.0	0.123	DDT 0.750 DDD <0.070 DDE 0.160	<0.070	<0.035
	67.4	39.8	04/07/92	4.0–4.5	0.194	DDT 2.800 DDD <0.150 DDE <0.240	<0.150	<0.077
SB–8	66.8	29.1	04/07/92	2.0–2.5	0.070	DDT 0.440 DDD <0.043 DDE 0.110	<0.043	<0.021
	66.8	29.1	04/07/92	4.0–4.5	0.012	DDT 0.150 DDD <0.008 DDE 0.020	<0.008	<0.004
SB–9	120.4	114.9	04/07/92	1.5–2.5	0.780	DDT 5.700 DDD <0.380 DDE 0.870	<0.380	<0.190
	120.4	114.9	04/07/92	4.0–4.5	0.410	DDT 2.600 DDD <0.370 DDE 0.420	<0.370	<0.190
SB–10	140.6	83.4	04/04/92	1.5–2.5	0.890	DDT <0.071 DDD 0.360 DDE 0.180	<0.071	<0.035
	140.6	83.4	04/04/92	3.5–4.5	0.122	DDT 0.057 DDD <0.009 DDE 0.036	<0.009	<0.004
	140.6	83.4	04/04/92	3.5–4.5	0.148	DDT 0.083 DDD 0.025 DDE 0.052	<0.016	<0.008
SB–11	118.4	105.6	04/07/92	2.0–2.5	0.122	DDT 0.032 DDD <0.008 DDE 0.026	<0.008	0.005
	118.4	105.6	04/07/92	4.0–4.5	0.430	DDT 0.150 DDD <0.067 DDE 0.110	<0.067	<0.034
SB–12	134.7	66.3	04/08/92	2.0–2.5	0.76	DDT 0.150 DDD 0.430 DDE 0.190	<0.039	<0.020
	134.7	66.3	04/08/92	4.0–4.5	1.700	DDT 0.100 DDD <0.069 DDE 0.170	<0.069	<0.034

TABLE 2–3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
SB–13	132.4	19.4	04/06/92	1.5–2.5	0.096	DDT 0.049 DDD 0.052 DDE <0.009	<0.009	<0.004
	132.4	19.4	04/06/92	1.5–2.5	0.340	DDT 0.190 DDD <0.042 DDE 0.150	<0.042	<0.021
	132.4	19.4	04/06/92	4.0–4.5	0.020	DDT 0.012 DDD <0.010 DDE <0.010	<0.010	<0.005
SB–14	150.9	13.9	04/04/92	2.0–2.5	0.135	DDT 0.130 DDD <0.009 DDE 0.053	<0.009	<0.005
	150.9	13.9	04/04/92	4.0–4.5	0.010	DDT 0.012 DDD <0.008 DDE <0.008	<0.008	<0.004
SB–15	184.8	86.1	04/04/92	2.0–2.5	0.009	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
	184.8	86.1	04/04/92	4.0–4.5	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
SB–16	200.9	95.6	04/04/92	1.5–2.5	0.138	DDT 0.310 DDD <0.037 DDE <0.037	<0.037	<0.019
	200.9	95.6	04/04/92	3.5–4.5	0.013	DDT 0.025 DDD <0.008 DDE <0.008	<0.008	<0.004
SB–17	178.7	66.5	04/06/92	1.5–2.5	0.560	DDT 0.610 DDD <0.041 DDE 0.370	<0.041	<0.020
	178.7	66.5	04/06/92	1.5–2.5	0.940	DDT 1.30 DDD 0.040 DDE 0.750	<0.040	<0.020
	178.7	66.5	04/06/92	4.0–4.5	0.016	DDT 0.025 DDD <0.007 DDE <0.007	<0.007	<0.004

TABLE 2−3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates X	Coordinates Y	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
SB−18	197.0	58.0	04/05/92	2.0−2.5	0.078	DDT 0.170 DDD <0.008 DDE 0.110	<0.008	<0.004
	197.0	58.0	04/05/92	4.0−4.5	0.036	DDT 0.082 DDD <0.008 DDE 0.022	<0.008	<0.004
SB−19	176.8	56.0	04/04/92	2.0−2.5	0.031	DDT 0.050 DDD <0.008 DDE 0.026	<0.008	<0.004
	176.8	56.0	04/04/92	4.0−4.5	0.025	DDT 0.036 DDD <0.008 DDE 0.022	<0.008	<0.004
SB−20	190.6	24.7	04/08/92	2.0−2.5	0.011	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
	190.6	24.7	04/08/92	4.0−4.5	0.026	DDT 0.025 DDD <0.008 DDE 0.011	<0.008	<0.004
PSF92−01	81.2	318.4	04/28/92	15−17	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
	81.2	318.4	04/28/92	21−25	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
PSF92−02	124.1	94.7	05/05/92	4−8	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
	124.1	94.7	05/05/92	8−12	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
	124.1	94.7	05/05/92	14−16	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
	124.1	94.7	05/05/92	20−22	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004

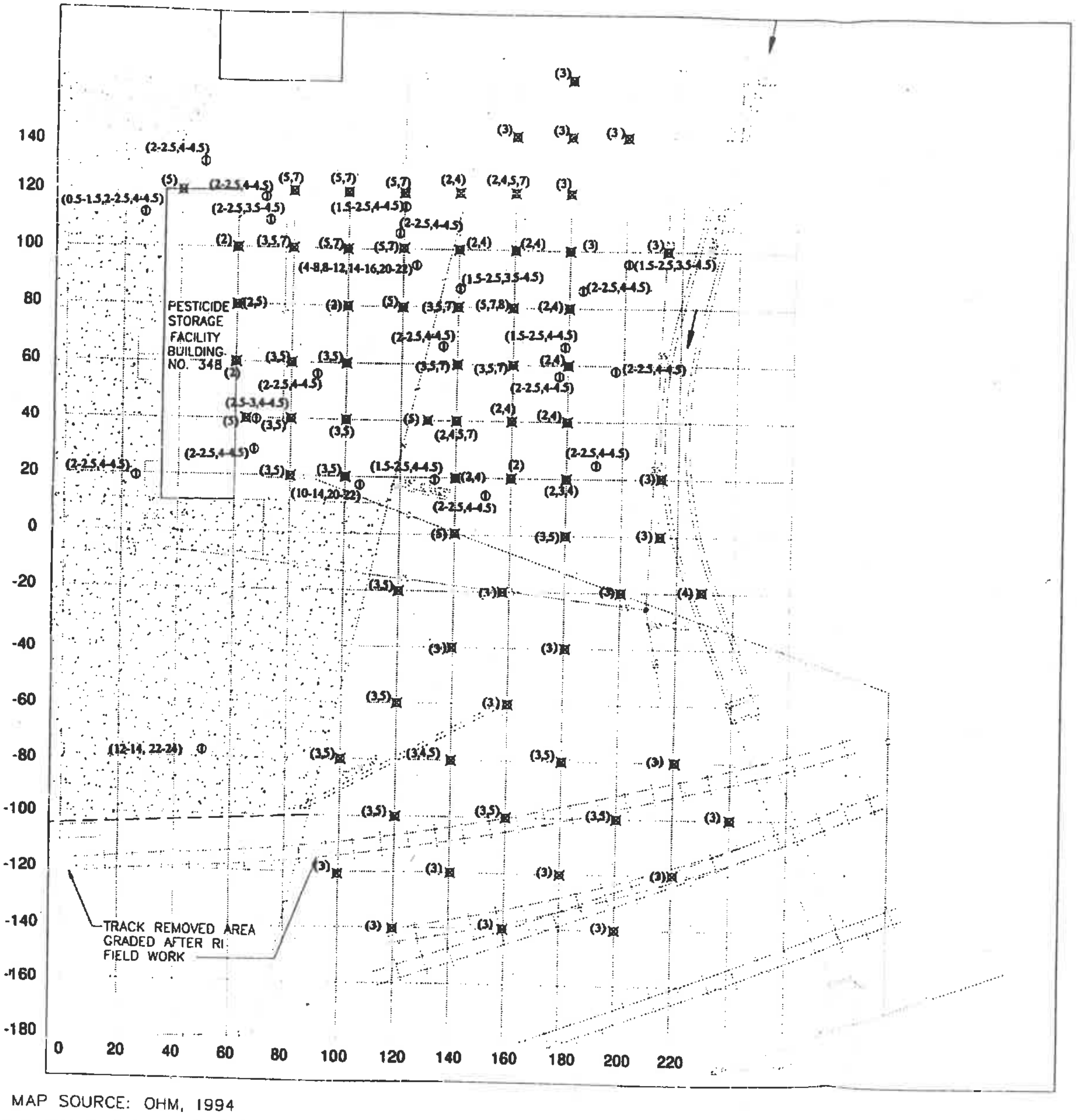
TABLE 2-3

SUBSURFACE SOIL SAMPLE ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES

Pesticide Storage Facility
Fort Riley, Kansas

Sample Location I.D.	Coordinates		Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
	X	Y						
PSF92-03	105.8	18.5	05/02/92	10-14	0.005	DDT <0.008 DDD <0.008 DDE <0.008	0.009	<0.004
	105.8	18.5	05/02/92	20-22	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
PSF92-04	49.8	-77.9	05/04/92	12-14	0.033	DDT <0.007 DDD <0.007 DDE 0.012	0.013	<0.004
	49.8	-77.9	05/04/92	22-24	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
PSF92-05	179.6	-233.4	04/29/92	9-11	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
	179.6	-233.4	04/29/92	17-19	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004

RA - Prefix samples from Removal Action (Appendix E)
SB and PSF92 - Prefix samples from RI (LAW, 1993a)
ND - Not detected
* Currently under asphalt, considered subsurface.
** DDT metabolites (DDD and DDE) only reported for select samples. Results for metabolites presented if analyzed.
(1) Detection limit not reported by laboratory.



MAP SOURCE: OHM, 1994

LEGEND:

- Ⓘ SOIL SAMPLE LOCATIONS COLLECTED 1992 (RI)
- ☒ SOIL SAMPLE LOCATIONS COLLECTED DURING REMOVAL ACTION (1994)
- ▨ ASPHALT
- RAILROAD
- GAS LINES
- SANITARY SEWER (APPROX. LOCATION)
- OVERHEAD POWER LINE
- (3,5,7) DEPTHS SAMPLED (DEPTHS BELOW GROUND SURFACE)

0 40 80
SCALE IN FEET

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

SUBSURFACE SOIL LOCATIONS SAMPLED DURING THE RI AND REMOVAL ACTION

PREPARED BY/DATE:	SEG/5-95	FIGURE NUMBER	2-5	FILE DATE:	12-5-94
CHECKED BY/DATE:	EFW/5-95			PLOT DATE:	5-1-95
APPROVED BY/DATE:	KAH/5-95			FILE NAME:	fr02.DWG

FIGURE 2-6

PRE-REMOVAL ACTION DISTRIBUTION OF CHLORDANE IN SUBSURFACE SOIL

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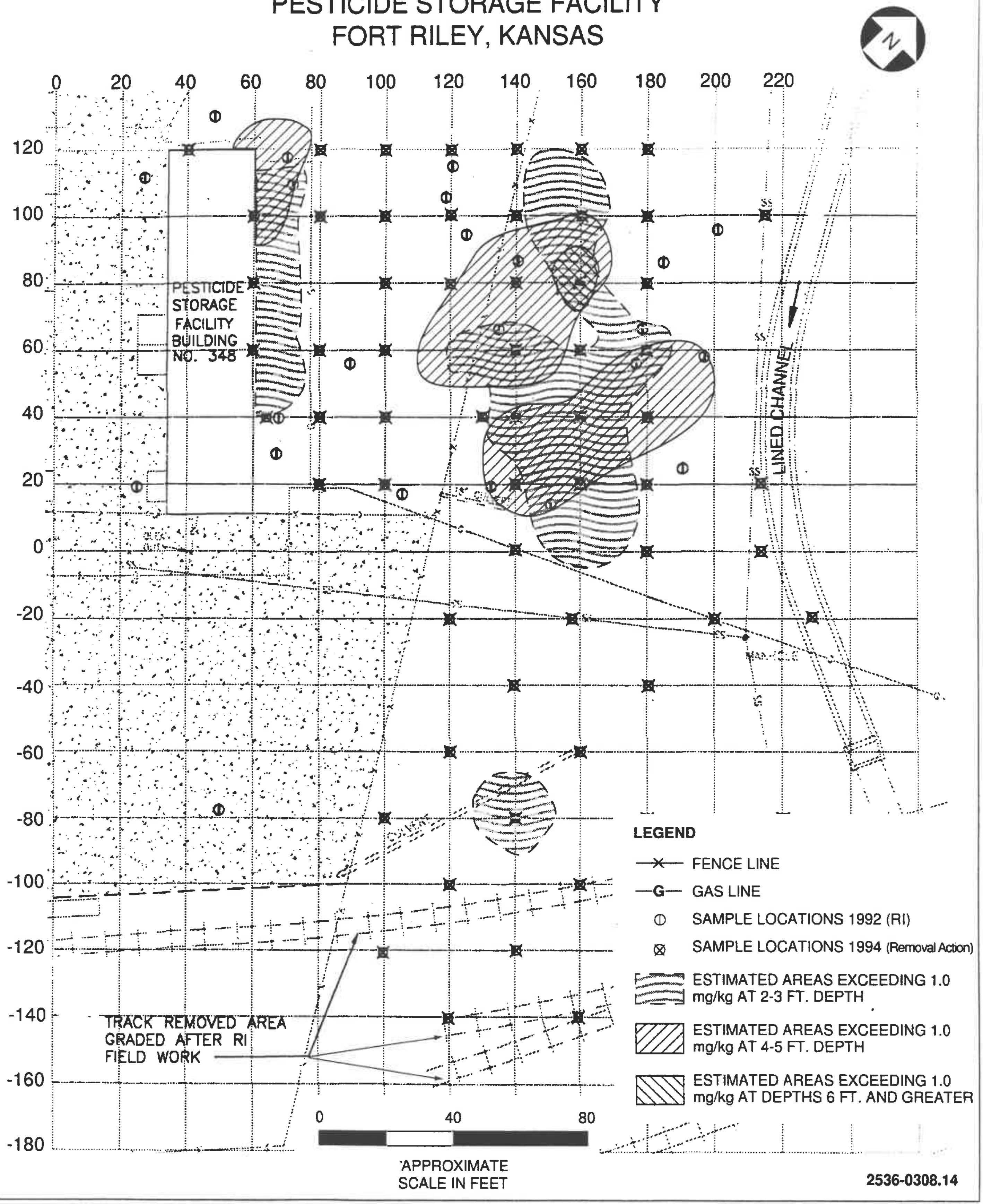
FORT RILEY, KANSAS



concentrations of 8.71 and 10.2 mg/kg, respectively, were detected at the 4- to 5-foot depth which exceeded the maximum concentrations detected at the 2- to 3-foot depth. Contamination in this area may have extended northward under the contaminated area identified by the samples at the 2- to 3-foot depth. These sampling results show that contaminant concentrations can vary and may increase with depth at the site. These conditions are the believed result of the site grading and trenching activities conducted over the years which had caused an irregular distribution of contaminated soils at the site. One of these trenches was reported to be approximately 4 feet deep, 6 feet wide and running the length of Building 348. The areal distribution and depths of detected contamination was similar to this historical information. Chlordane was detected once at a concentration exceeding 1.0 mg/kg at depths greater than 5 feet, at sample RA-27.5 (1.34 mg/kg) at a depth of 7 feet. Chlordane was not detected at the 8-foot depth in this location, which was within this trench area.

The third area of contamination at a depth of 3 feet south of the PSF working area (RA-68 at 2.39 mg/kg). This area is centered at grid coordinates 140 and -80, southeast of Building 348. Sediment deposits as the source of this contamination is not apparent as surface run-off from around the Building area drained eastward in an area farther north. Contamination may be related to site grading activities. Lower levels of contamination were also detected in the vicinity surrounding these three areas. Sampling data indicated that contamination was confined within the study area as chlordane was not detected in the most northern and southern samples at the site.

DDT and Metabolites

The revised Removal Action RG for DDT and metabolites was 1.73 mg/kg. Areas of DDT and metabolite concentrations exceeding 1.0 mg/kg are indicated in Figure 2-7. Exceedances above the RG concentration were as follows: at depths of 2 to 3 feet -7 samples; at depths of 4 to 5 feet -7 samples; at a depth of 7 feet -1 sample; and, at depths exceeding 8 feet no samples exceeded the RG. As seen in this figure contamination was also identified in the well-defined area approximately 30 feet east of the fence that may to be the location of the former trenches discussed previously. As with the chlordane contamination in the area identified near the northeast corner of Building 348, the maximum detected DDT concentration (33.0 mg/kg at SB-3) was higher at the 4- to 5-foot depth than at the 2- to 3-foot depth (7.70 mg/kg at SB-3). Two other areas of DDT contamination were also observed within the gravel area just east of Building 348, in similar locations as the chlordane contamination, being identified by samples RA-23 at 3.207 mg/kg at the 2- to 3-foot depth and SB-7 at 2.80 mg/kg at the 4- to 5-foot depth. At the 2- to 3-foot and 4- to 5-foot depths, lower levels of contamination (less than 1.0 mg/kg) were detected in the vicinity surrounding the area that may indicate the former trench, extending approximately 100 feet to the south and 30 feet to the north of these trenches.

DDT contamination was also detected above 1.0 mg/kg at a depth of 7 feet within the area that may have been former trenches. A single sample (RA-27.5) detected at 5.188 mg/kg indicated a localized area of contamination existed directly below the contamination detected at the 4- to

FIGURE 2-7

PRE-REMOVAL ACTION DISTRIBUTION OF DDT & METABOLITES IN SUBSURFACE SOIL

PESTICIDE STORAGE FACILITY
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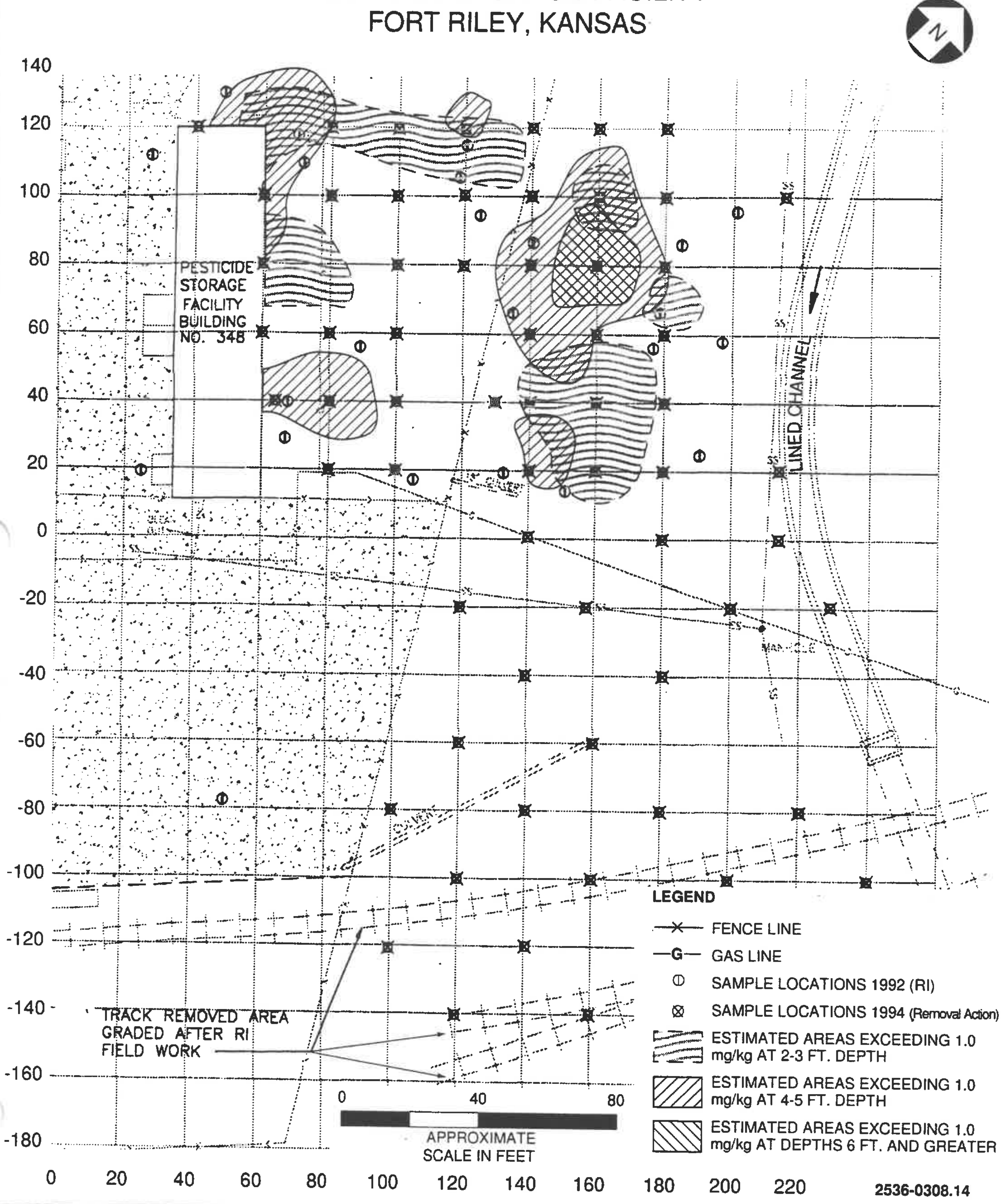

5-foot depth increment (3.79 mg/kg). These results indicated an increase in the contaminant concentration with increased soil depth in this area, further confirming the irregular pattern of contamination that existed at the PSF site. DDT was not detected at the 8-foot depth in this area or in the areas sampled east of Building 348 inside the fence during Removal Action sampling. Because DDT was not detected in samples at the 8-foot depth, soil samples were not obtained during the Removal Action at depths exceeding 8 feet. RI samples collected previously below this depth did not have DDT concentrations exceeding 1.0 mg/kg.

Dieldrin

Dieldrin concentrations detected in subsurface soils during the RI and Removal Action sampling events are presented in Figure 2-8. Figure 2-8 indicates a single area of contamination at the 2- to 3-foot depth, defined by sample SB-5 which exceeded the revised Removal Action RG of 0.127 mg/kg at 0.200 mg/kg. Sample SB-5 was collected as a composite sample from depths of 2 to 2.5 feet. Dieldrin was only detected in four samples at the 4- to 5-foot depth. The maximum detected concentration at the 4- to 5-foot depth range was 0.042 mg/kg, at RA-71. Dieldrin was detected in only two soil samples collected at depths exceeding 5 feet (0.009 mg/kg in PSF92-03 at 10 to 14 feet, and 0.013 mg/kg in PSF92-04 at 12 to 14 feet).

Heptachlor

As shown in Figure 2-9, an area of heptachlor contamination exceeding the revised Removal Action RG of 0.05 mg/kg was located near the northeast corner of Building 348. Three samples collected at depths of 2 to 3 feet exceeded the RG concentration. The maximum detected concentration in this area at the 2- to 2.5-foot depth was 0.230 mg/kg, detected in sample SB-5 which defined this area. Heptachlor was infrequently detected in other areas of the site, and these detections at concentrations below 0.05 mg/kg were within the former trench area discussed previously. The maximum site concentration of heptachlor was detected at 0.300 mg/kg in sample SB-2 under the existing pavement near the northwest corner of Building 348 and was therefore not mapped. At depths of 4 to 5 feet, heptachlor was only detected in six samples, and the maximum concentration detected was 0.028 mg/kg, at the SB-2 sample location near the northwest corner of Building 348. Heptachlor was detected in only one sample at depths exceeding 5 feet (0.005 mg/kg in sample RA-27.5 at 7 feet).

Arsenic

Arsenic was analyzed in 2 subsurface soil samples during the Removal Action (RA-39 at depths of 5 and 7 feet), and 26 soil samples during the RI. In subsurface soils, arsenic exceeded the Fort Riley background concentration range in samples at four locations in separate areas of the site (SB-10, SB-13, SB-02, and RA-39). Concentrations in only two samples were significantly above the background range, which were SB-10 (120 mg/kg) at a 3.5- to 4.5-foot depth, and SB-02 (20 mg/kg) at a 2- to 2.5-foot depth which is under existing pavement west of the PSF building. Therefore, arsenic concentrations were not mapped.

FIGURE 2-8

PRE-REMOVAL ACTION DISTRIBUTION OF DIELDRIN IN SUBSURFACE SOIL

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

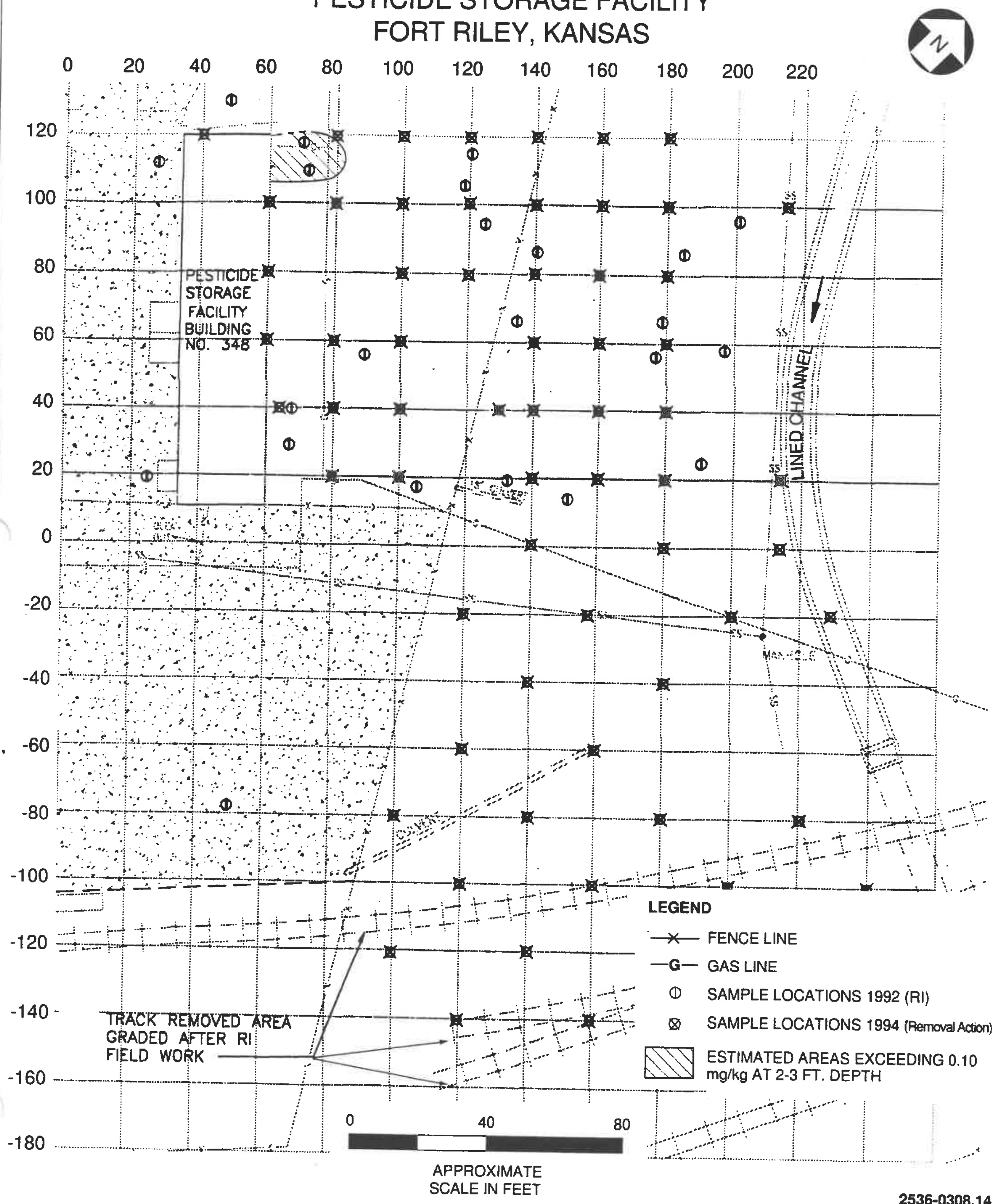

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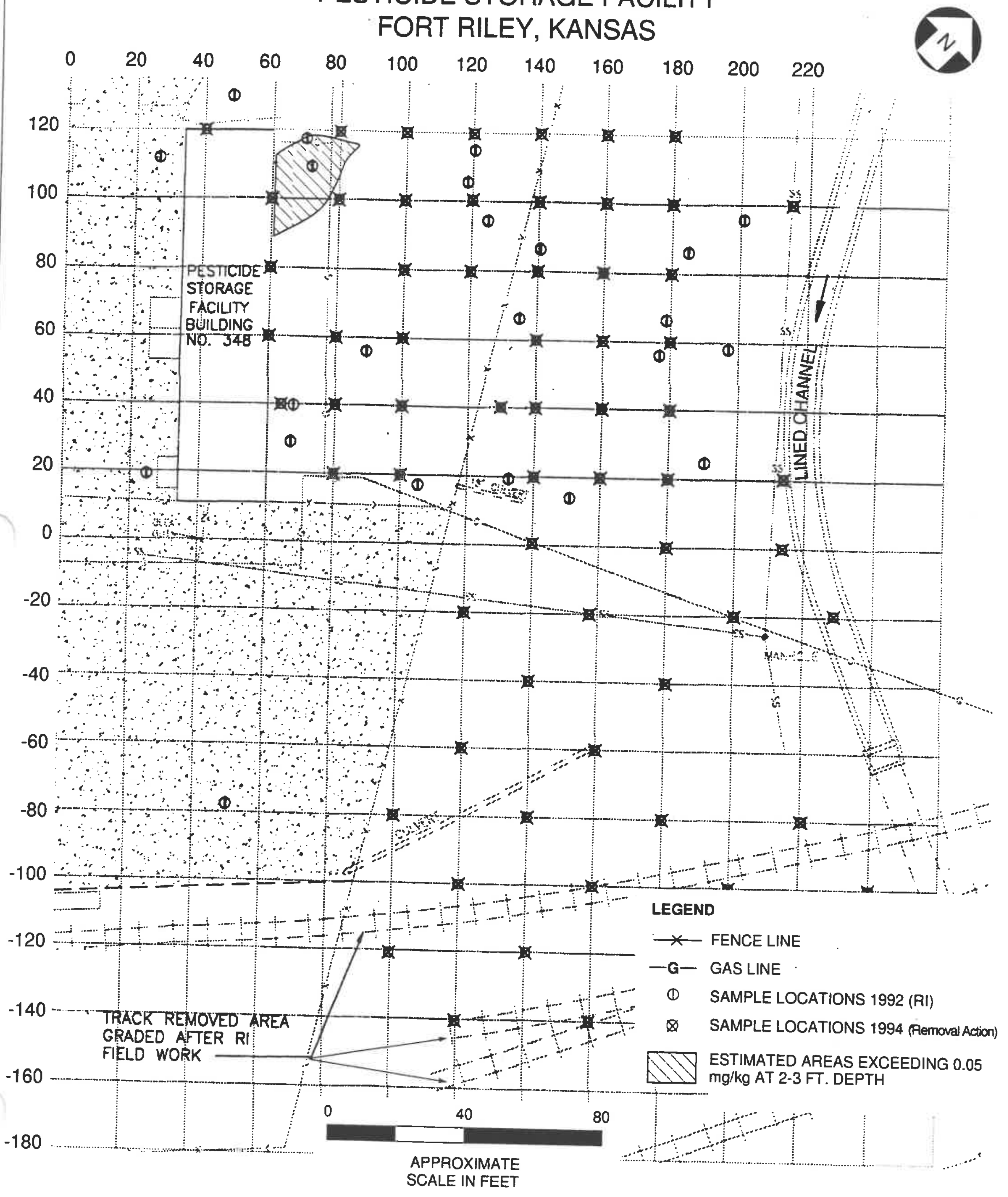
FIGURE 2-9

PRE-REMOVAL ACTION DISTRIBUTION OF HEPTACHLOR IN SUBSURFACE SOIL

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



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2.3 COMPARISON OF REMOVAL ACTION EXCAVATIONS WITH DISTRIBUTIONS OF PESTICIDES IN SOILS

A summary of the Removal Action activities is presented in Section 3. In this section, the distributions of contamination estimated from the RI data are compared with the revised projections using RI and Removal Action data. The Removal Action excavations are also compared with these revised distributions of contaminants.

The extent of surface soil contamination was not mapped in the RI Report (LAW, 1993a) because only three surface soil samples were collected, and a comparison cannot be made with the projections of surface soil contamination. Area estimates of pesticide contaminated subsurface soil were made in the RI Report (LAW, 1993a), based on the limited data that were available. Samples obtained during the RI would not be expected to characterize the contamination nearly as well as exploratory samples obtained when the soils were actually being excavated.

Figures 2-10 through 2-13 provide graphical comparisons of the subsurface distributions of chlordane, DDT and metabolites, dieldrin, and heptachlor from the RI report (LAW, 1993a) with the revised projections using RI and Removal Action data. The comparisons are made considering depths at or below 2 feet. Individual comparisons at the various depth increments were not attempted, because the data have indicated that the contaminants in the soil are not evenly dispersed and varied greatly in concentrations between samples laterally and vertically. The contamination areas indicated on Figures 2-10 through 2-13 are intended to show general areas of contamination interpreted from the soil samples and not absolute limits of contamination above the stated concentrations. The areas shown were linearly interpolated from the sample results. Interpolations from the samples are influenced significantly by the relative locations of samples to each other.

As seen on Figures 2-10 and 2-11, additional areas of chlordane and DDT and metabolites above 1.0 mg/kg were identified from the additional data collected during the Removal Action. In Figure 2-10 the chlordane distribution near the northeast corner of the building was predicted in the RI based on the limited sample spacing in this area. Removal Action samples were collected frequently in this area on the established 20-foot grid and a better definition of the contamination resulted in a reduced areal distribution. Similarly, in other areas, the distributions of DDT and metabolites near Building 348 were better defined from Removal Action data, and resulted in expanded areas being identified. Areas east of the fence were also defined by the Removal Action data for chlordane and DDT and metabolites which were not predicted in the RI. Dieldrin and heptachlor were both detected in an area east of and near the northeast corner of Building 348. Dieldrin was only detected during the RI at a concentration exceeding 0.10 mg/kg and was not detected in any Removal Action soil samples above this concentration. The areas of dieldrin and heptachlor contamination predicted in the RI Report (LAW, 1993a) were generally confirmed during the Removal Action. As seen on Figures 2-12 and 2-13, these areas

FIGURE 2-10

ESTIMATED SUBSURFACE SOIL CHLORDANE DISTRIBUTIONS FROM RI VERSUS RI AND REMOVAL ACTION DATA

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

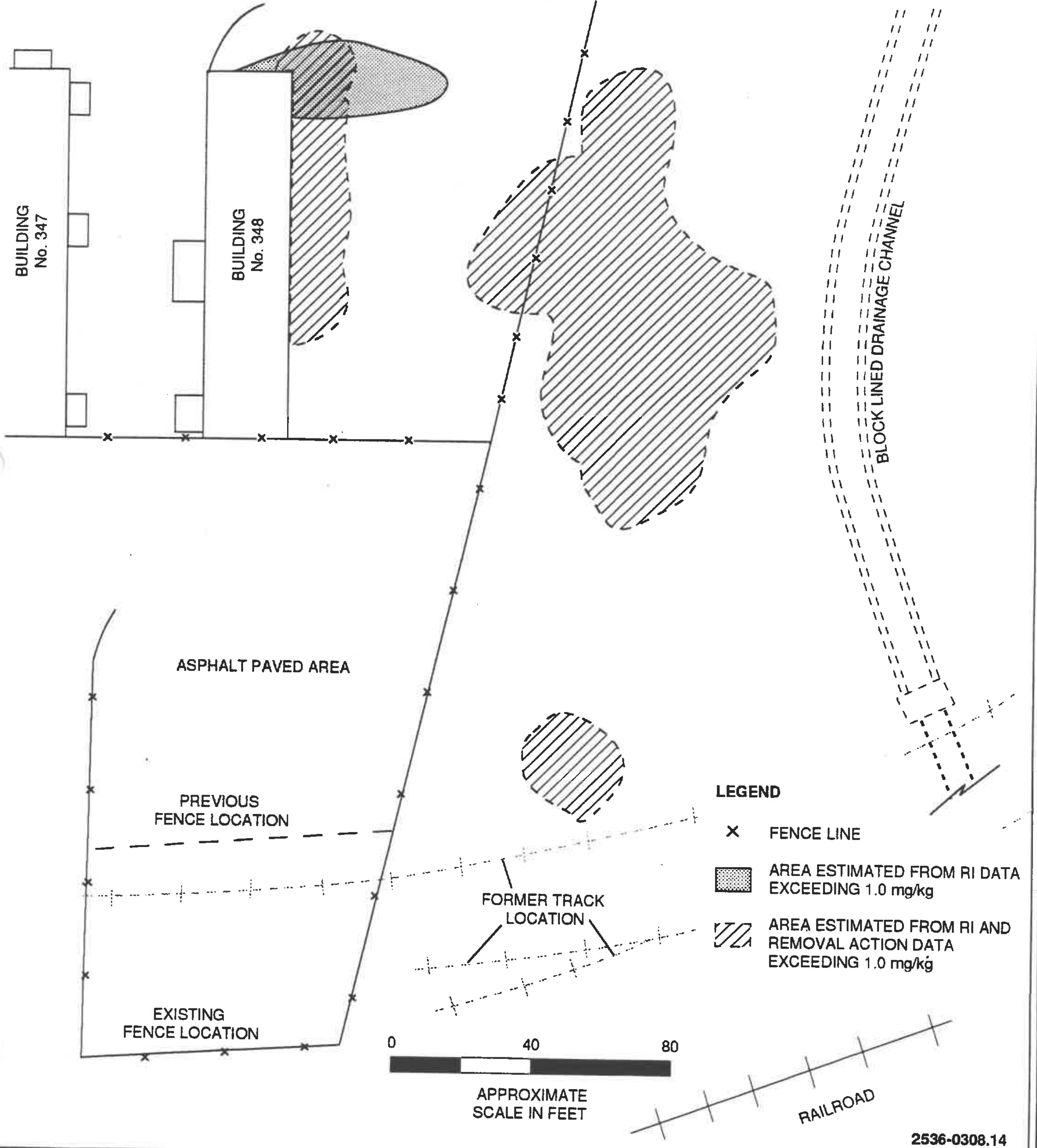

FIGURE 2-11

ESTIMATED SUBSURFACE SOIL DDT & METABOLITES DISTRIBUTIONS FROM RI VERSUS RI AND REMOVAL ACTION DATA

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

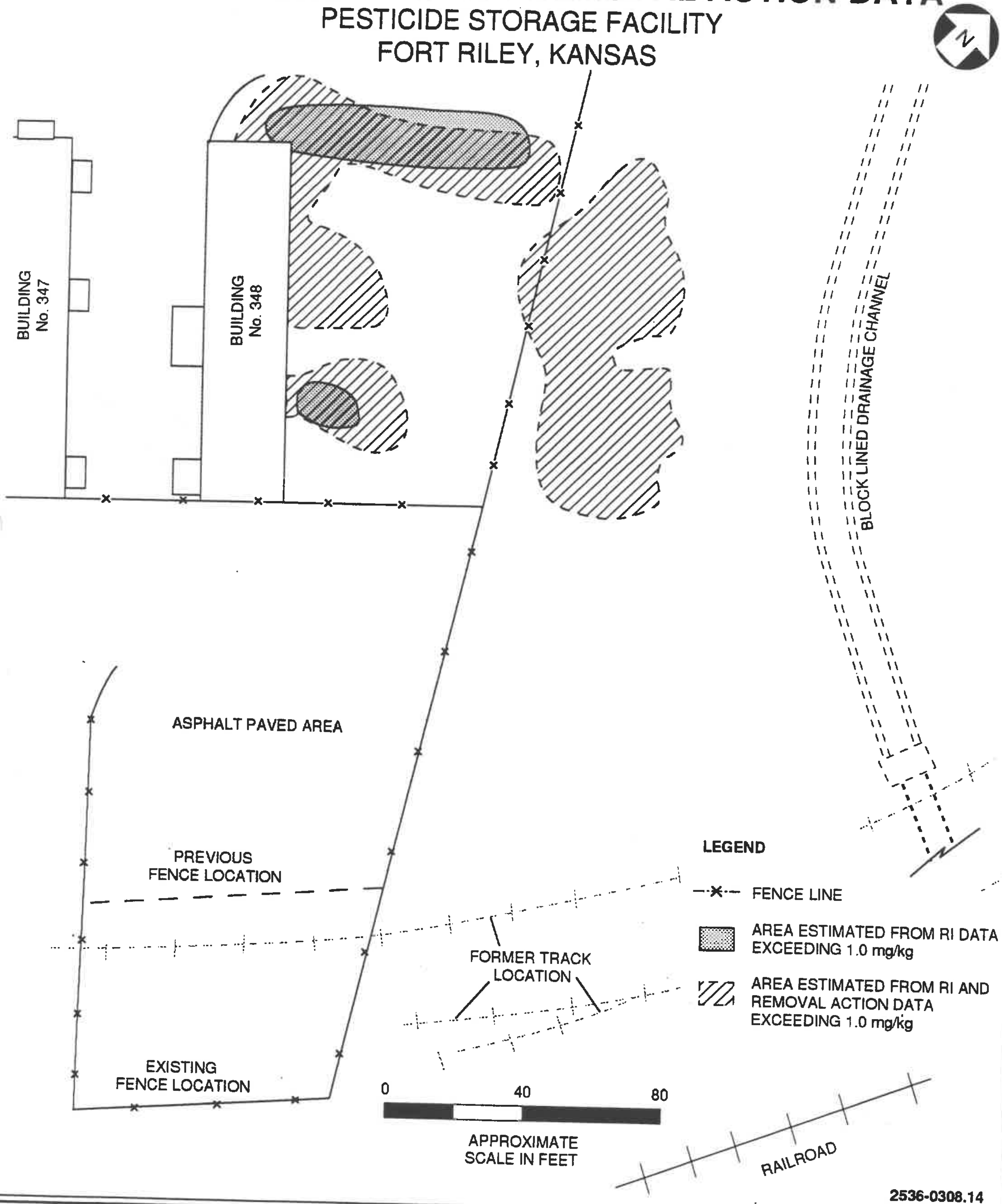

FIGURE 2-12

ESTIMATED SUBSURFACE SOIL DIELDRIN DISTRIBUTIONS FROM RI DATA VERSUS RI AND REMOVAL ACTION DATA

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

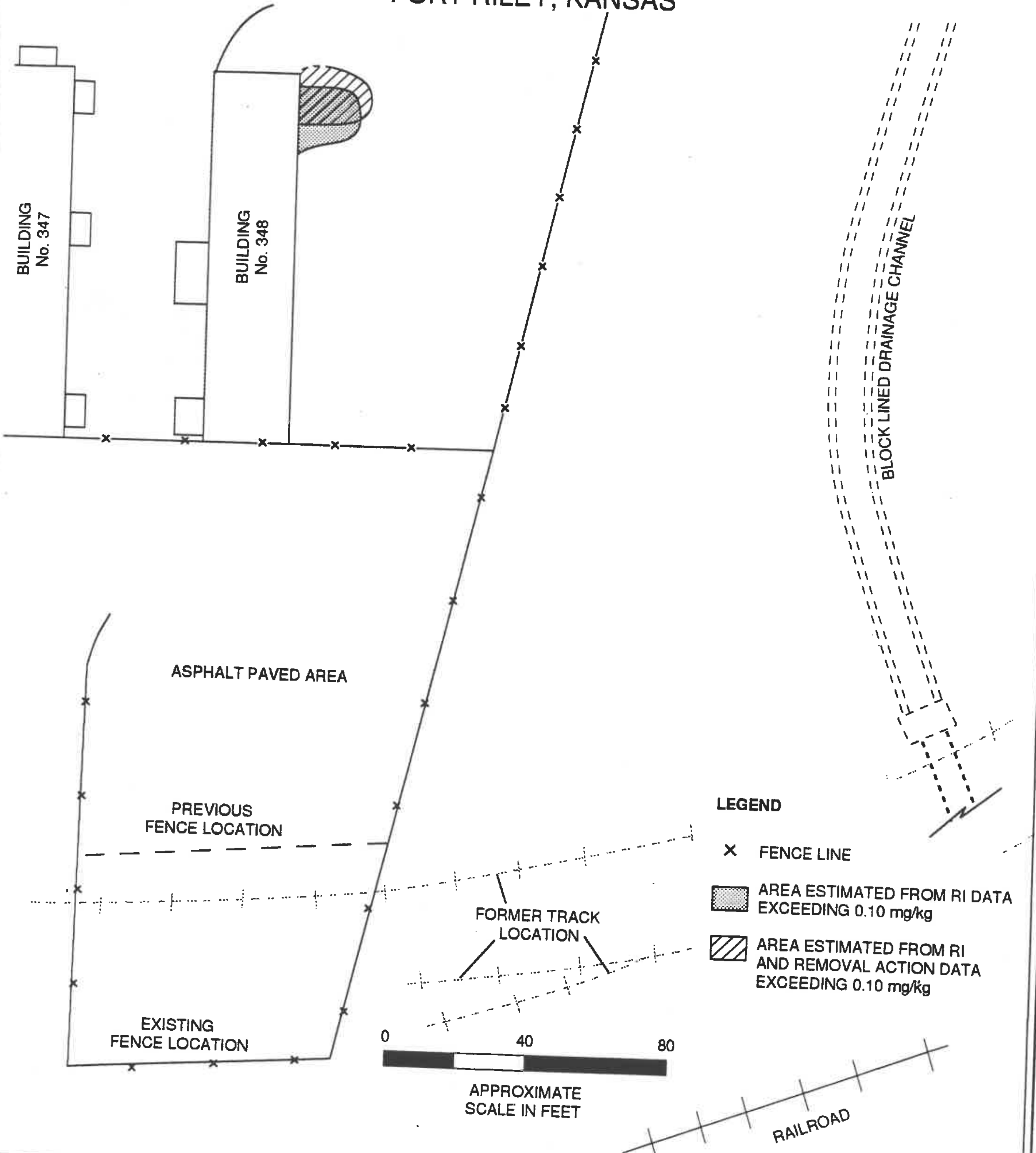

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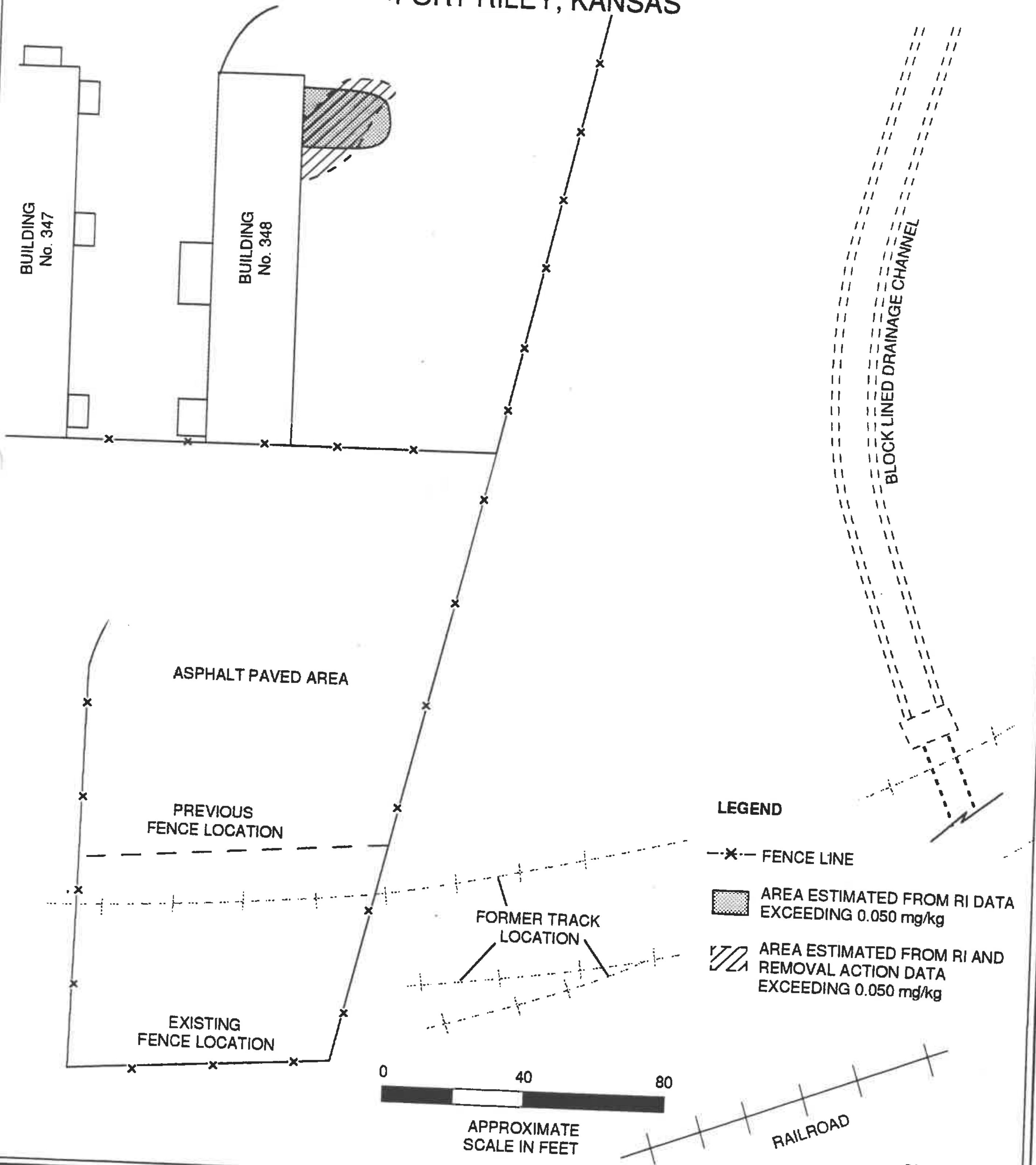
FIGURE 2-13

ESTIMATED SUBSURFACE SOIL HEPTACHLOR DISTRIBUTIONS FROM RI VERSUS RI AND REMOVAL ACTION DATA

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



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were further defined by the additional samples. During the Removal Action excavations, a sanitary sewer lateral was discovered in an area approximately 30 feet south of the northeast corner of Building 348, being about 20 feet east of the building. The depth of this line in the vicinity of the building was 3 to 4 feet. Pesticide-contaminated soils at levels of concern were not detected at a depth exceeding 4 feet in the vicinity of this sewer, and the sewer was not identified as a historical source of contaminants.

Estimated distributions of pesticides in surface soils and subsurface soils at depths below 2 feet exceeding the Removal Action RGs are compared with the Removal Action excavation in Figures 2-14 and 2-15, respectively. The area centered at RA-65 (grid location 200, -60) was defined by a single surface soil sample with DDT and metabolites detected at 2.472 mg/kg and dieldrin at 0.158 mg/kg. The area shown was influenced by the relative positions of the adjacent samples which had detected concentrations less than the Removal Action RGs. Contaminant distributions presented on Figure 2-15 were developed by compositing the subsurface distributions at depths below 2 feet. As seen in these figures, the identified distributions of pesticides were substantially within the excavated areas. Section 4 presents a description of the current site conditions following the Removal Action excavations.

FIGURE 2-14

REMOVAL ACTION EXCAVATIONS COMPARED WITH SURFACE SOIL DISTRIBUTION OF PESTICIDES

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS

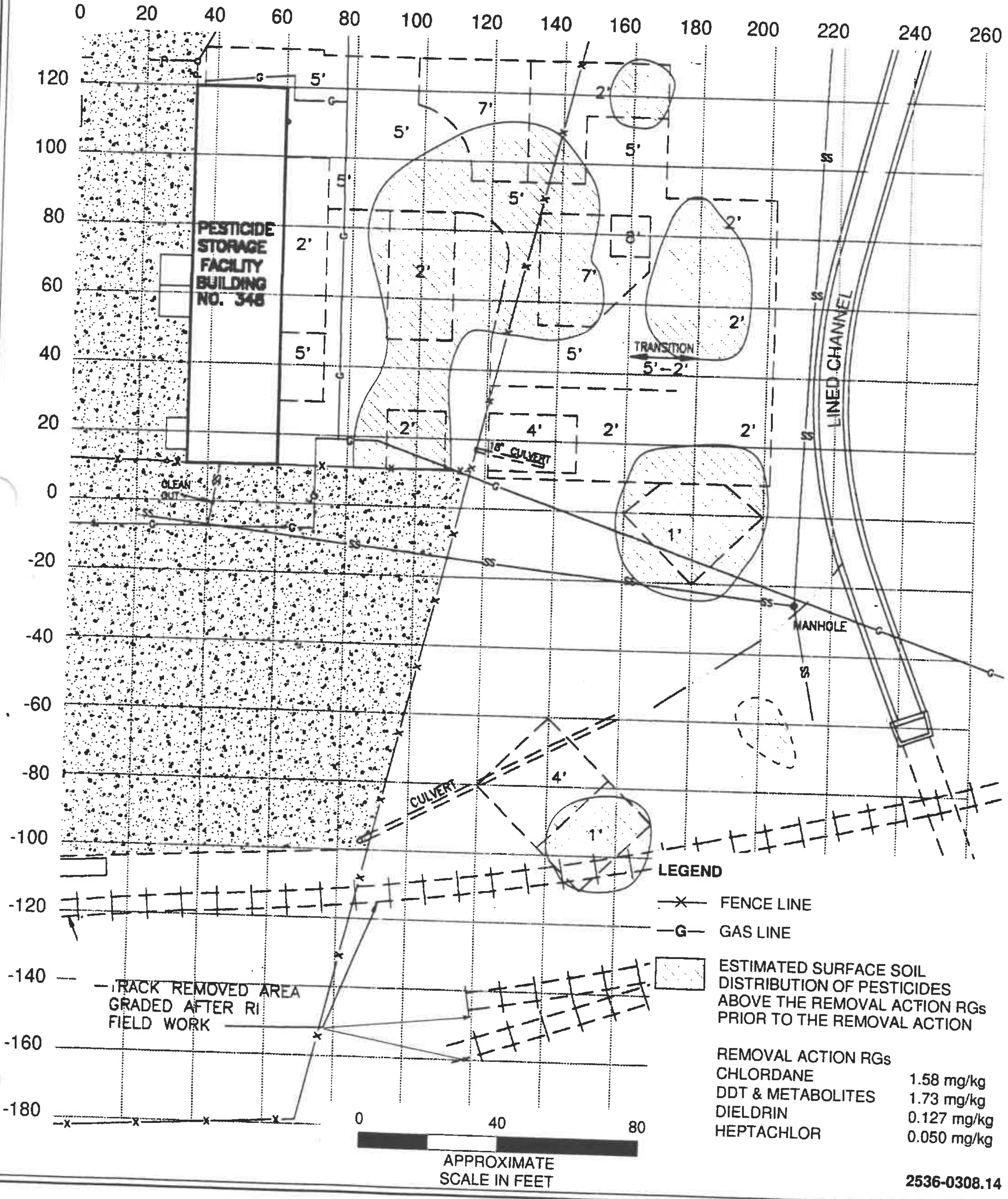

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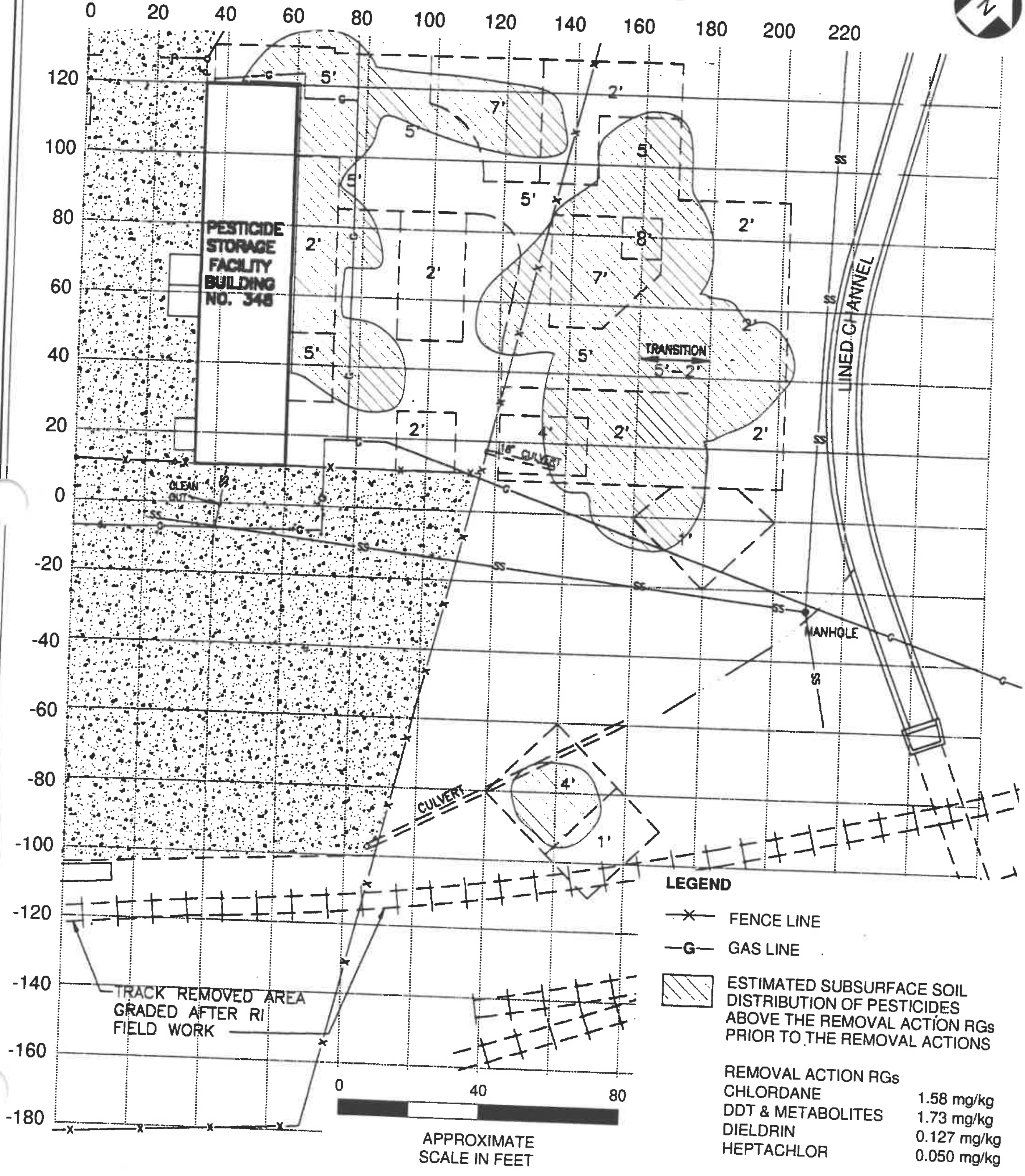
FIGURE 2-15

REMOVAL ACTION EXCAVATIONS COMPARED WITH SUBSURFACE SOIL DISTRIBUTION OF PESTICIDES

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



3.0 REMOVAL ACTION REPORT

This section provides a summary of the Removal Action activities completed at the PSF site. The Removal Action process is discussed, followed by brief summaries of the EE/CA, Action Memorandum, and the construction activities accomplished at the PSF site in completing the Removal Action.

3.1 REMOVAL ACTION PROCESS

As discussed above, Fort Riley investigated a Removal Action option for the site. The authority for Fort Riley, as the lead agency, to proceed with a Removal Action is described in Section (2)(e)(1) of Executive Order 12580 (USEPA, 1991a). The appropriateness of a Removal Action was evaluated considering such factors as potential exposure to human health and the environment and potential for migration of contaminants in soils at the site. Because the site posed no immediate threat to human health and the environment, it was determined that a non-time-critical Removal Action was appropriate. Fort Riley initiated a non-time-critical Removal Action, in accordance with Section 300.415 of the National Contingency Plan (NCP), to address the PSF site. By definition, as a non-time-critical Removal Action, at least six months lead time was available prior to initiation of any response actions. Because this six-month planning period was available, per NCP 300.415, Fort Riley conducted an engineering evaluation/cost analysis (EE/CA). Under this process, an EE/CA report is required to document the lead agency's (the Army in this case) desire to perform a Removal Action and to identify and evaluate Removal Action alternatives being considered. The preferred alternative is also identified.

3.2 ENGINEERING EVALUATION/COST ANALYSIS (EE/CA) FOR PSF - 1993

During May through September 1993, the Fort Riley DEH prepared an EE/CA for a Removal Action at the PSF (DEH, 1993a). The EE/CA addressed only soil contamination at the PSF. The Draft FS (LAW, 1993b) served as the basis for the EE/CA development. The purpose of the report was to assess the appropriateness of performing non-time-critical Removal Action activities at the PSF to address the risks due to arsenic and pesticides in the soils. The stated objectives of the EE/CA report were as follows:

- Determine if a Removal Action was appropriate to protect human health and the environment.

- Identify and evaluate alternative conceptual options, and recommend options for a Removal Action which were consistent with the needs for a Removal Action, which could be incorporated into the permanent solution to remediate the site, and could meet the time schedule for construction.

- Develop an alternative that met safety and health requirements and that allowed for the continuing use of the site.

Similar to a Feasibility Study, the EE/CA included information presented in the RI report (LAW, 1993a), under review at the time of EE/CA preparation. An immediate threat to human health, necessitating an immediate Removal Action, was not identified. The RI revealed that the soil was contaminated with arsenic and primarily the pesticide DDT and its metabolites (DDE and DDD), chlordane, dieldrin, and heptachlor. These constituents were the primary contributors to risk, and, based on the presence of these constituents of concern, implementation of early action was evaluated by Fort Riley.

In addition to arsenic, the pesticides chlordane, 4,4'-DDT, heptachlor, and dieldrin in the soil were included as contaminants to be addressed in the EE/CA remedial alternatives evaluation. These compounds exceeded proposed Resource Conservation and Recovery Act (RCRA) Corrective Action Levels (CALs) (Federal Register, 1990), and were the primary contributors to carcinogenic risk. The RCRA CALs were initially used as screening concentration levels to define the extent of contamination because calculation of risk-based RGs was under development.

The broad scope of the Removal Action was to prevent or minimize the actual or potential exposure of site receptors to hazardous contaminants at the PSF. Specific objectives of the Removal Action were identified in the EE/CA as follows:

- Minimize potential exposure to soils for site receptors

- Minimize potential for contamination migration through erosion and leaching

- Consistency with Final Remedy

- Attainment of ARARs to the extent practical

The requirements of the environmental laws determined to be "applicable" or "relevant and appropriate" (ARARs) were identified. Based on the ARARs, general response actions were identified to categorize potential remedial actions for the PSF, considering the constituents of concern (arsenic, chlordane, 4,4-DDT, heptachlor and dieldrin). The general response actions included: (1) No-Action; (2) Institutional Controls; (3) Containment; (4) Treatment; and (5) Removal/Disposal. The various potential remedial technologies associated with the general response actions were identified and screened.

Based on the results of the technology screenings, six remedial action alternatives were developed and evaluated for their potential to achieve site remedial action objectives and the cleanup criteria.

Alternative 1 -	No Action
Alternative 2 -	Institutional Controls
Alternative 3 -	Institutional Controls/Grading
Alternative 4 -	Institutional Controls/Grading/Capping (Asphalt Cap)
Alternative 5 -	Institutional Controls/Grading/Capping (Asphalt/Concrete Cap)
Alternative 6 -	Removal and Disposal

The EE/CA completed in August 1993 resulted in Fort Riley recommending Alternative 5 as the preferred Removal Action. Upon completion of the EE/CA report by Fort Riley, the report was added to the Administrative Record for Fort Riley NPL sites. A 30-calendar-day public comment period was held from 17 August 1993 to 16 September 1993 in accordance with the Inter Agency Agreement (IAG) and the NCP. Fort Riley published a notice of the EE/CA report in local newspapers and scheduled a public meeting on 7 September 1993 to present the EE/CA report to the public and solicit comments. No members of the public attended the public meeting. Comments made on the EE/CA by the USEPA and KDHE resulted in further consideration of more cost-effective and permanent alternatives than Alternative 5. Among the alternatives considered was excavation, soil stabilization, and disposal in a corrective action management unit (CAMU) on-post at the Custer Hill Sanitary Landfill. This was a viable alternative technically, but uncertainties related to cost and the impact of weather conditions resulted in off-post disposal being selected as the most predictable and cost-effective alternative.

3.3 ACTION MEMORANDUM FOR REMOVAL ACTION - DECEMBER 1993

In December 1993, the Fort Riley DEH prepared an Action Memorandum for Removal Action at the PSF to document the Army's decision to take a Removal Action at the PSF (DEH, 1993b). The memorandum also served as a vehicle to obtain USEPA Region VII and KDHE concurrence with the selected Removal Action alternative. The Removal Action selected in the Action Memorandum consisted of the excavation of PSF site soils exceeding the following risk-based remediation goals (cleanup levels):

• Chlordane	0.17 mg/kg
• DDT	0.66 mg/kg
• Dieldrin	0.014 mg/kg
• Heptachlor	0.050 mg/kg
• Arsenic	0.12 mg/kg

These cleanup levels were based on the "Future Site Worker" surface soil exposure scenario as defined in the BLRA. These concentration levels were calculated using a target risk level of 1×10^{-6} for each constituent and the site worker scenario. Note that these cleanup criteria were later revised during the Removal Action as discussed in the next section.

During development of the Action Memorandum, contaminated soils at the PSF were determined not to be RCRA-listed, hazardous wastes as no records or knowledge of documented spills of pure products had been found. Excavated soils would have been classified as characteristic hazardous waste if they failed the Toxicity Characteristic Leaching Procedure (TCLP) tests (USEPA, 1993c). In the Action Memorandum, Fort Riley expressed their intent to dispose of the excavated soils at a RCRA Subtitle C permitted facility, if found to be hazardous wastes. Nonhazardous soils would be disposed in a RCRA Subtitle D permitted facility.

The Action Memorandum decision to excavate and dispose of contaminated soil, as opposed to the EE/CA recommendation to cap the PSF site, was based on comments received from USEPA Region VII and KDHE (USEPA, 1993b; KDHE, 1993b). Unlike capping, excavation was seen as a permanent remedy which removed the source area (soil) and reduced the mobility, toxicity, and volume of contamination at the PSF. The USEPA had expressed a preference for a permanent, protective remedy for addressing site contaminants requiring no long-term maintenance at the PSF (USEPA, 1993c).

The Removal Action performed at the PSF site is briefly described in the following section.

3.4 REMOVAL ACTION ACTIVITIES

As explained in Section 3.3, the Action Memorandum documented the Army's decision to take a Removal Action at the PSF and was the vehicle by which Fort Riley obtained USEPA Region VII and KDHE concurrence with the Removal Action. Following this concurrence, Fort Riley utilized the United States Army Corps of Engineers' (USACE) Omaha District "Rapid Response" contracting capabilities for execution of the Removal Action. A rapid response contractor was retained by the USACE to remove contaminated soils from the PSF site at Fort Riley, Kansas. Preliminary planning and discussions pertaining to the execution of the Removal Action took place in December 1993. The Work Plan for the Removal Action was completed January 28, 1994, and field work began on January 31, 1994. Sampling data from the investigations prior to the excavation as well as data from confirmation sampling during the excavation was used to define the pre-removal site characterization presented on Section 2. The following time line describes the sequence of events during the Removal Action.

• Exploratory and pre-characterization sampling and background samples	January 31, 1994 - February 11, 1994

Second round of exploratory sampling	February 23, 1994 - February 24, 1994
Third round of exploratory sampling	March 7, 1994 - March 12, 1994
Site setup, excavation, transportation, and confirmation sampling	March 17, 1994 - March 31, 1994
Additional sampling based on analytical results, additional excavation	April 4, 1994 - April 9 and 24, 1994
Field administrative personnel meeting with USACE on-site representative, and Fort Riley representative	April 18, 1994 - April 23, 1994
Complete excavation, transportation	May 16, 1994 - May 27, 1994
Final confirmation sampling	May 19, 1994
Complete site restoration at PSF	June 15, 1994 - June 17, 1994

In general, the tasks involved in the Removal Action were:

- Sampling, analytical testing, and site preparation prior to excavation
- Excavation of soil
- Confirmatory sampling and analysis
- Development of revised RGs
- Characterization, transportation, and disposal of excavated soil
- Site restoration

Appendix D of this report contains the following information:

- Figures depicting soil excavation and analytical data prepared by the rapid response contractor.

Appendix E of this report contains the following information:

- The waste manifest for soil disposed at the Peoria Disposal Company, Peoria, Inc.

- Waste profile and waste characterization data used to support the waste manifest.

The site file contains additional information which includes the following:

- Rapid response daily work orders
- Rapid response quality control daily reports
- Rapid response weekly reports
- Photo documentation
- Transportation and disposal summaries

The Removal Action activities and the consistency with the Removal Action objectives are summarized below.

3.4.1 Sampling and Analytical Testing Prior to Excavation

Initially, the areas to be excavated were defined based on the sampling results described in the RI report (LAW, 1993a). The volume of soil to be removed from these areas was initially estimated by the rapid response contractor at 850 cubic yards (1,100 tons), assuming a unit soil weight of approximately 96 pounds per cubic foot. During the removal action, the actual limits of excavation were further defined by a series of sampling, excavation, and confirmatory sampling events. Prior to excavation, the soil samples were collected from PSF site for analysis for pesticides (chlordane, DDT, dieldrin, and heptachlor) per USEPA Method 3050/8080 and for arsenic per USEPA Method 3050/6010. Samples were sent to an off-site laboratory for analysis. The preliminary site sampling began February 4, 1994 and continued with additional sampling rounds on February 23, 1994, March 7, 1994, and March 17, 1994. Sampling at the PSF began with a 200 by 160 foot grid laid out on 20 foot intersections.

Three bench marks were established for this grid:

- Points 60, 120
- 60, 40 on Building 348's foundation
- 42 feet north of the corner of Building 348 on the corner of Building 346's loading dock

In meetings prior to and during the sampling, several changes were discussed and made relating to the Contractors Sampling and Analysis Plan. The USACE on-site representative changed three sample points and added two to the PSF area after reviewing previous data.

The following 4.5- to 5-foot points were removed:

- 60, 120
- 80, 120
- 120, 100

The above-referenced points were replaced by the following 4.5- to 5-foot points:

- 60, 80
- 120, 80
- 160, 60

Two 1-foot samples were added at:

- 140, 120
- 200, 60

A total of 27 samples (5 arsenic and 22 pesticide) were taken during this round.

On February 24, 1994 new points were added to the grid, primarily in the southeastern corner. An additional ten 1-foot deep samples were taken and analyzed for pesticides only.

Beginning March 7, 1994 further sampling was conducted to define the limits of excavation. An extensive sampling effort to the south and northeastern end of the suspected contaminated area was conducted based on previous sampling results. At this time, the grid was expanded to include negative coordinates.

New samples points at the surface and at 1 and 3 feet were added to an expanded grid that measured 240 feet east, 80 feet south (-80), and 160 feet north of the origin. Fifty-nine samples were taken. After a review of previous sampling data, analysis of DDT was expanded to include its metabolites DDD and DDE.

In an effort to determine naturally-occurring concentrations of metals in soils, background soil composite samples were collected at various locations at or near Fort Riley on February 7 and 8, 1994. The samples were analyzed for arsenic, beryllium, thallium, nitrate, lead, and barium. Section 2.1 of this report summarizes the results of these background soil samples.

3.4.2 Excavation of Soil and Sampling During Excavation

Excavation of soil was completed in phases with each phase followed by additional soil sampling. The soil sampling data were used to plan excavations for the subsequent phase to remove soil with concentrations above RGs.

Results from previous sampling events indicated a need for further sampling to define the outer limits of excavation. Further sampling effort was concentrated in areas further to the southeastern end of the suspected contaminated area. Sampling was conducted from March 17th through March 30th after excavation of suspected areas of contamination. Various samples were taken at the intersections of the 20-foot grid at the surface, at 1-foot intervals to 5 feet and at 7 feet. Sample points were inside the excavated area as well as south of the excavation. Additional samples were taken following the revised grid that was expanded to 240 feet east, 140 feet south (-140), and 160 feet north of the origin. Approximately 108 samples were taken and analyzed for pesticides only.

Based on the initial scope of work and on subsequent exploratory data that were generated, the contractor commenced excavation at the site on March 27, 1994. Air monitoring was performed during initial excavation activities. Based on the results, monitoring requirements were downgraded for the remainder of the work. The initial phase of excavation was completed on March 30, 1994. Based on the results of soil samples taken at the completion of the initial excavation, Fort Riley initiated additional excavation at the site. Additional excavations commenced on May 17, 1994, and were completed on May 19, 1994. In order to remove contaminated soil to the established RGs but not excavate areas which were below levels of concern, the soils at the PSF were excavated to varying depths across the site. Figure 3-1, prepared by the rapid response contractor, shows a plan view of the site and the depths to which different areas were excavated. Excavation primarily involved the area east of Building 348, out to approximately 20 feet west from the lined drainage ditch. An area was also excavated on the north side of the building from the building wall out directly north 10 feet. Section 4 provides additional descriptions of the site conditions following the Removal Action.

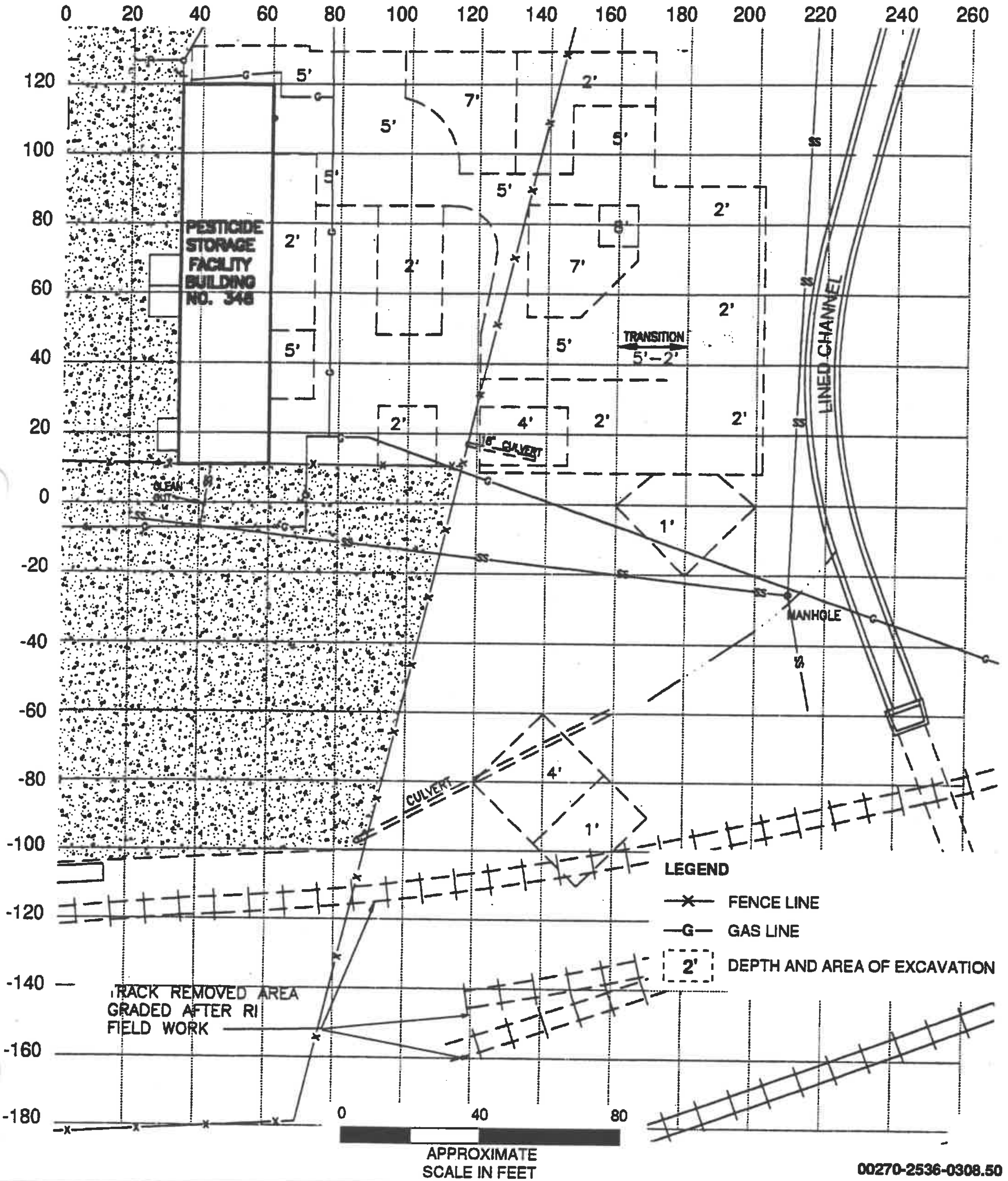
Confirmatory sampling continued during the Removal Action to further define limits of excavation. Sampling was conducted on April 8, and May 19, 1994. These sampling events identified a greater area of contamination than anticipated from the available RI data. Appendix D-6 presents drawings and analytical results for various depths of the excavation. After some excavation activities in late March, samples from within excavated areas were taken on April 8. Additionally, composite samples were taken along walls of the excavation, from parts of the floor of excavated areas, and from areas where limited excavation had occurred due to irregular and/or truncated dimensions. Samples were taken at the surface and at 2 foot depths in the excavations. A total of 23 samples were taken.

On May 19, the limits for final excavation were established based on a review of the analytical data from previous sampling events. After partial backfill of clean areas was completed to allow final excavation, the last areas of excavation were sampled. Final sampling was conducted with 11 confirmatory samples being sent to an off-site laboratory for pesticide analysis.

FIGURE 3-1

FINAL REMOVAL ACTION EXCAVATIONS

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



3.4.3 Development of Revised Remediation Goals

The RGs for the Removal Action were initially calculated using the exposure scenarios presented in the BLRA of the Draft RI report (LAW, 1993a) for the future site worker. A 10^{-6} carcinogenic risk level was used in the calculation of RGs. Absorption factors utilized in the BLRA assumed a default of 100 percent dermal absorption of chemicals, meaning that 100 percent of a chemical exposure was absorbed into the skin. This 100 percent absorption rate was extremely conservative. The exploratory sampling events discussed above identified a greater than anticipated area of contamination. The significant increase in the scope and cost of the Removal Action activities which could result from this expanded area of contamination prompted Fort Riley and the USACE to reassess the RGs. The RGs were temporarily revised to an order of magnitude higher to allow continuance of excavations while a detailed evaluation of the RGs was performed.

The RGs for the chemicals comprising most of the risk in the BLRA (i.e., chlordane, dieldrin, and DDT) were recalculated based on revised absorption factors. A revised RG was not calculated for heptachlor because this chemical was not a "risk driver" in the BLRA. New absorption factors that represent the upper bound proportion of the pesticides that would be retained in the skin (ATSDR 1987-1993) were agreed upon for use by USEPA Region VII because they were supported by adequate data. The revised RGs were also based on a carcinogenic target risk level of 10^{-6} and are compared with the RGs presented in the Action Memorandum in Table 3-1. These RG concentration levels were used to establish the initial limits for the excavations at the site.

The RG for arsenic was also revised. Arsenic levels in RI background soil samples ranged from 1.2 to 2.4 mg/kg, based on a single surface soil and two subsurface soil samples. These concentrations exceeded the previously calculated risk-based RG of 0.12 mg/kg, and showed that arsenic background levels should be considered to establish a revised RG for the Removal Action. A limited background sampling effort was performed during the Removal Action as discussed in Section 2.1 to collect background data for arsenic. The maximum arsenic concentration found in the background sampling was 7.1 mg/kg.

To confirm limits of excavation, the soil was analyzed for the constituents of concern and the concentrations were compared to the RGs established for the site. Surface RGs were utilized as the cleanup levels for both surface and subsurface soil. This approach is considered conservative because the potential for chronic exposure to surface soil is greater than that for subsurface soil. Confirmatory samples were taken from the initially established excavations at the PSF site. These samples showed that certain points remained above the revised action levels that were established. Samples which exceeded the revised RGs were, in general, at locations under asphalt adjacent to Building 348, areas adjacent to the building foundation where the excavation would have endangered the structural integrity of the building, or at sufficient depth

TABLE 3-1

COMPARISON OF REVISED REMEDIAL GOALS FOR SOILS USED FOR THE REMOVAL ACTION EXCAVATIONS WITH REMEDIAL GOALS FROM THE ACTION MEMORANDUM

Pesticide Storage Facility
Fort Riley, Kansas

CONSTITUENT	ACTION MEMORANDUM RGs		REVISED RGs	
	Absorption Factor	Remedial Goal (mg/kg)	Absorption Factor	Remedial Goal (mg/kg)
Chlordane	100%	0.17	10.9%	1.58
DDT	100%	0.66	37.8%	1.73
Dieldrin	100%	0.014	10.9%	0.127
Heptachlor	100%	0.050	100%	0.050
Arsenic	100%	0.12	NA	7.1(1)

References for absorption factors per ATSDR, 1987-1993
NA Not applicable
(1) Remedial goal of background soil concentrations was established.

that soils from this area would not be available for exposure considering surface soil exposure scenarios. Details on the current site characterization, including an evaluation of soil remaining at the site, are provided in Section 4.

3.4.4 Characterization, Transportation, and Disposal of Excavated Soil

As stated in Section 3.3, contaminated soils were not considered listed hazardous wastes, but would be classified as characteristic hazardous waste if they failed the TCLP analysis. All soil removed from the site was characterized by the rapid response contractor as nonhazardous because, based on the results of the sampling and analysis activities, the soil did not exhibit a characteristic of hazardous waste. The TCLP testing results show all elements to be nondetect with the following two exceptions.

- Barium - 1.01 mg/L (Limit is 100 mg/L)
- Cadmium - 0.008 mg/L (Limit is 1.0 mg/L)

The waste transportation and disposal included 2,604 tons of nonhazardous, pesticide-contaminated soils from the PSF, which is approximately 1,500 tons more soil than initially estimated. Table 3-2 presents the amount of soil removed per day. The rapid response contractor also disposed of the investigation derived waste (drill cuttings) generated during the RI activities. The liquid investigation derived waste (from groundwater sampling) was used for dust control during the Removal Action. Transportation and disposal summary tables, and the manifests and waste profile packages for the PSF are included in Appendix E.

The pesticide-contaminated soils from the PSF were excavated and loaded for transportation on March 27 to March 30, 1994; April 7, 8, and 9, 1994; and May 17 and 18, 1994. Because several discrete samples showed elevated results for pesticides, the USACE Omaha District decided to dispose of the soils by direct burial in a Subtitle C landfill. Disposal in a Subtitle C landfill was also cost effective, considering availability of Subtitle D landfills which could take these soils, which while not RCRA hazardous waste, were considered "special wastes" or otherwise classified in various states. The soils were manifested and shipped using lined semi-trailer dump trucks supplied by Fort Transfer to Peoria Disposal Company's Landfill No. 1 in Peoria, Illinois. Drums of drill cuttings and related materials from the RI investigations at the PSF were delivered to the site by Fort Riley and were disposed of by inclusion with the soils. Illinois Hazardous Waste manifests were used for tracking the waste. These manifests and laboratory analyses prepared by the rapid response contractor can be found in Appendix E. No manifest discrepancies or exception reports were noted for this soil.

TABLE 3–2

DAILY SOIL DISPOSAL AMOUNTS
Pesticide Storage Facility
Fort Riley, Kansas

Day	Amount of Soil Removed (Tons)
March 27, 1994	298
March 28, 1994	375
March 29, 1994	536
March 30, 1994	344
April 7, 1994	360
April 8, 1994	112
May 17, 1994	300
May 18, 1994	279
TOTAL	2,604

3.5 SITE RESTORATION

At the completion of the final excavation, final samples were taken as described in Section 3.4.2. The site was then backfilled and graded to existing contours. Site restoration was completed on May 27, 1994. The purpose of the final samples was to document site conditions upon completion of the Removal Action. The temporary fence was removed, and the permanent fence was reinstalled. With the permanent fence in place, the maintenance yard inside the fence was brought to final grade using stone from a local haul road (the haul road temporarily established for removal activities at the Colyer Manor Site, located in Camp Forsyth at Fort Riley).

The rapid response contractor mobilized on June 15, 1994, to remedy erosion problems created outside the permanent fence by heavy rains. Topsoil was placed in the area outside the fence, and the area was seeded, fertilized, and covered with fabric to protect the seed from erosion.

3.6 COMPLIANCE WITH ARARs

ARARs were identified in the EE/CA (DEH,1993a) as described in Section 3.2 and were included in the Action Memorandum (DEH, 1993b). Compliance with ARARs to the extent practicable was a primary objective of the Removal Action, as reflected in the procedures established for construction. All ARARs were met with the exception of isolated exceedances of the remediation goal ARARs. This exception is presented in Section 4.1.3. Other ARARs were met with implementation of the following requirements.

- OSHA
- Land Disposal Requirements
- Procedures for Planning and Implementing Off-site Response Actions
- National Emission Standards for Hazardous Air Pollutants
- National Ambient Air Quality Standards
- Ambient Air Quality Standards and Air Pollution Control Regulations
- Solid Waste Management Regulations
- Stormwater Discharge Requirement, National Pollutant Discharge Elimination System

In addition, because off-site disposal was selected at the PSF site, procedures used for the loading and transporting of excavated materials followed the applicable Department of Transportation regulations for the transport of solid waste material.

4.0 POST REMOVAL SITE CHARACTERIZATION

The site characterization presented in Section 1.5.2 included a summary of the analytical data from soil samples collected at the PSF site as part of the RI field work during March through May 1992 (LAW, 1993a). Section 2 discussed soil sampling during Removal Action activities and summarized site conditions based on samples obtained during both the Removal Action and the RI. Section 3 presented a discussion of the Removal Action activities at the site. Section 4.1 summarizes the current site conditions using sampling results from soils remaining at the PSF site following Removal Action excavations. This section also includes a comparison of background concentrations (as discussed in Section 2.1) to concentrations remaining in the PSF soils.

Only soils were addressed by the Removal Action. Therefore, surface-water and sediment site characterizations presented in the RI report (LAW, 1993a) are still relevant. Surface-water and sediment characterization data are fully described in the RI report (LAW, 1993a) and are, therefore, not repeated in this section. Additional groundwater sampling rounds were completed in September 1994 and December 1995 following the finalization of the RI report (LAW, 1993a). Section 4.2 discusses the previous groundwater sampling results from the RI report (LAW, 1993a) and provides a comparison of these results with the September 1994 results. Also included in this section are the sampling results from December 1995, and a summary of the statistical comparison of specific inorganics in the PSF groundwater to background concentrations which was performed by CEMRK (CEMRK, 1996). Section 4.3 discusses site-specific hydrology based on the more recent groundwater sampling data; Section 4.4 provides general contaminant fate and transport information for classes of compounds detected at the site; and Section 4.5 summarizes current site conditions based on visual observations.

4.1 SUMMARY OF CURRENT SOIL DATA EVALUATION

The following subsections discuss separately analytical results for the surface and subsurface soils currently present at the site. As part of the RI activities, surface and subsurface soils were sampled at the PSF site (LAW, 1993a). Locations of these samples were shown on Figures 1-15 and 1-16. Soil samples were also taken from the monitoring well borings during the RI. Extensive sampling of the PSF soils was performed by the rapid response contractor to further define the areas of pesticide contamination for the Removal Action described in Sections 1.7 and 2.

For purposes of evaluation of the soil data and performing the residual risk assessment (RRA) presented in Section 5 consistent with the BLRA, the site soil samples were partitioned between surface soils (depths less than 2 feet), and subsurface soils (2 feet and greater).

4.1.1 Evaluation of Surface Soil Pesticides Analytical Results

Table 4-1 presents analytical results for surface soil sample locations (not removed during the Removal Action) along with dates and depths at which the samples were collected. As discussed in Section 2, analysis of these soils analyzed for the pesticides chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, and heptachlor. The DDT metabolites 4,4'-DDD and 4,4'-DDE were only analyzed for select soil samples. Only one remaining surface soil sample location exceeded the removal RGs - Dieldrin and combined DDD, DDE, and DDT, though the individual DDT metabolites did not exceed the RG.

Table 4-1 presents results for the metabolites if analyzed. Figure 4-1 shows locations of surface soil samples for soil still remaining at the site. The only soils remaining represented by surface samples are those where no excavation took place. Detections of the pesticides were distributed throughout the site where surface soils remain. However, these occurrences were at relatively low concentrations. Figure D-16 identifies the locations of remaining surface soil samples, and Figures D-17 through D-20 in Appendix D-6 show the analytical results for pesticides analyzed which are plotted at their respective locations. Table 4-2 presents the minimum and maximum concentrations encountered for these pesticides in surface soils, along with detection frequencies and Removal Action RG exceedance frequencies. Figure 4-2 shows the location of remaining surface soil samples exceeding Removal Action RGs. The compound DDT and its metabolite, DDE, had the highest frequencies of occurrence, being detected in 67 percent of the surface soil samples. As mentioned above, DDT and its metabolites were evaluated separately. Heptachlor was detected in only 4 percent of the surface samples. Chlordane, DDD and dieldrin showed similar frequencies of occurrence at 32 percent, 39 percent, and 38 percent, respectively. Surface soil results for each pesticide are discussed below.

The Removal Action RG for chlordane was 1.58 mg/kg. As shown in Table 4-2, the maximum detected concentration of chlordane was 1.12 mg/kg (sample RA-38, located approximately 40 feet east of Building 348). Thus, none of the surface soil samples collected following the Removal Action contained chlordane above the RG, indicating that soils with chlordane levels above the RG were removed from the site during the Removal Action excavation.

The Removal Action RG for DDT and metabolites was 1.73 mg/kg. The highest concentrations of DDE and DDT were 0.847 mg/kg and 1.29 mg/kg, respectively, at the surface (sample RA-65, located approximately 100 feet east of the fence line). The highest concentration of DDD was 0.454 mg/kg at 1 foot (sample RA-43, located approximately 20 feet east of Building 348). As shown in Table 4-2, none of the surface soils contained DDT, DDD, or DDE at concentrations which exceeded the RG. As shown on Figure 4-2, when added together, DDT and metabolites only exceed the Removal Action RG in one sample, RA-65, at a concentration of 2.472 mg/kg. In Figure 4-2, results for DDT and metabolites are added together, but on Table 4-1 and for risk purposes (Section 5), DDT and metabolites are evaluated separately.

TABLE 4–1

REMAINING SURFACE SOIL ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES FOLLOWING THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
180	160	RA–01	03/07/94	1	<0.017	0.222	<0.003	<0.003
60	140	RA–02	02/04/94	1	<0.05	0.220	<0.005	<0.005
80	140	RA–03	02/04/94	1	0.057	<0.05	<0.005	<0.005
100	140	RA–04	02/04/94	1	<0.05	<0.05	<0.005	<0.005
120	140	RA–05	02/04/94	1	<0.05	<0.05	<0.005	<0.005
140	140	RA–06	02/24/94	1	0.024	0.022	<0.002	<0.001
160	140	RA–07	03/07/94	1	0.158	0.170	<0.003	<0.003
180	140	RA–08	03/07/94	1	<0.017	<0.003	<0.003	<0.003
200	140	RA–09	03/07/94	1	<0.033	0.040	<0.003	<0.003
180	120	RA–15	03/07/94	1	0.033	0.429	<0.003	<0.003
180	100	RA–21	03/07/94	1	<0.033	0.028	<0.003	<0.003
215	100	RA–22	03/07/94	1	<0.033	<0.003	<0.003	<0.003
80	80	RA–24	02/04/94	1	<0.05	<0.05	<0.005	<0.005
80	60	RA–30	03/30/94	1	<0.028	DDD 0.024 DDT 0.054 DDE 0.039	<0.003	<0.0009
212	60	RA–35	02/24/94	1	0.740	<0.120	<0.040	ND(1)
80	40	RA–37	03/30/94	1	0.034	DDE 0.046 DDD <0.002 DDT <0.003	<0.003	<0.0009
100	40	RA–38	03/30/94	1	1.12	DDT 0.730 DDD <0.003 DDE <0.009	<0.003	0.009
240	40	RA–42	03/07/94	0	<0.033	0.012	<0.003	<0.003
80	20	RA–43	03/30/94	1	0.418	DDE 0.346 DDD 0.454 DDT 0.273	0.030	<0.009
120	20	RA–45	02/24/94	1	<0.020	0.013	0.015	<0.001
215	20	RA–49	03/07/94	1	<0.033	<0.003	<0.003	<0.003
140	0	RA–50	03/07/94	1	<0.017	0.026	<0.003	<0.003
215	0	RA–52	03/07/94	1	<0.033	0.044	0.009	<0.003
240	0	RA–53	03/07/94	0	<0.033	0.012	<0.003	<0.003
210	–18	RA–54	03/08/94	0	0.221	0.095	0.036	<0.003
120	–20	RA–55	03/30/94	0	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
		RA–55	03/07/94	1	<0.083	0.218	0.026	<0.017
156	–20	RA–56	03/07/94	1	0.309	0.605	<0.003	<0.003
200	–20	RA–57	03/07/94	1	0.260	0.369	0.051	<0.004
229	–20	RA–58	03/07/94	1	<0.017	<0.003	<0.003	<0.003
120	–60	RA–59	03/30/94	0	<0.034	DDE 0.126 DDD 0.107 DDT 0.167	0.074	<0.001
		RA–59	03/08/94	1	0.358	0.434	0.121	<0.003

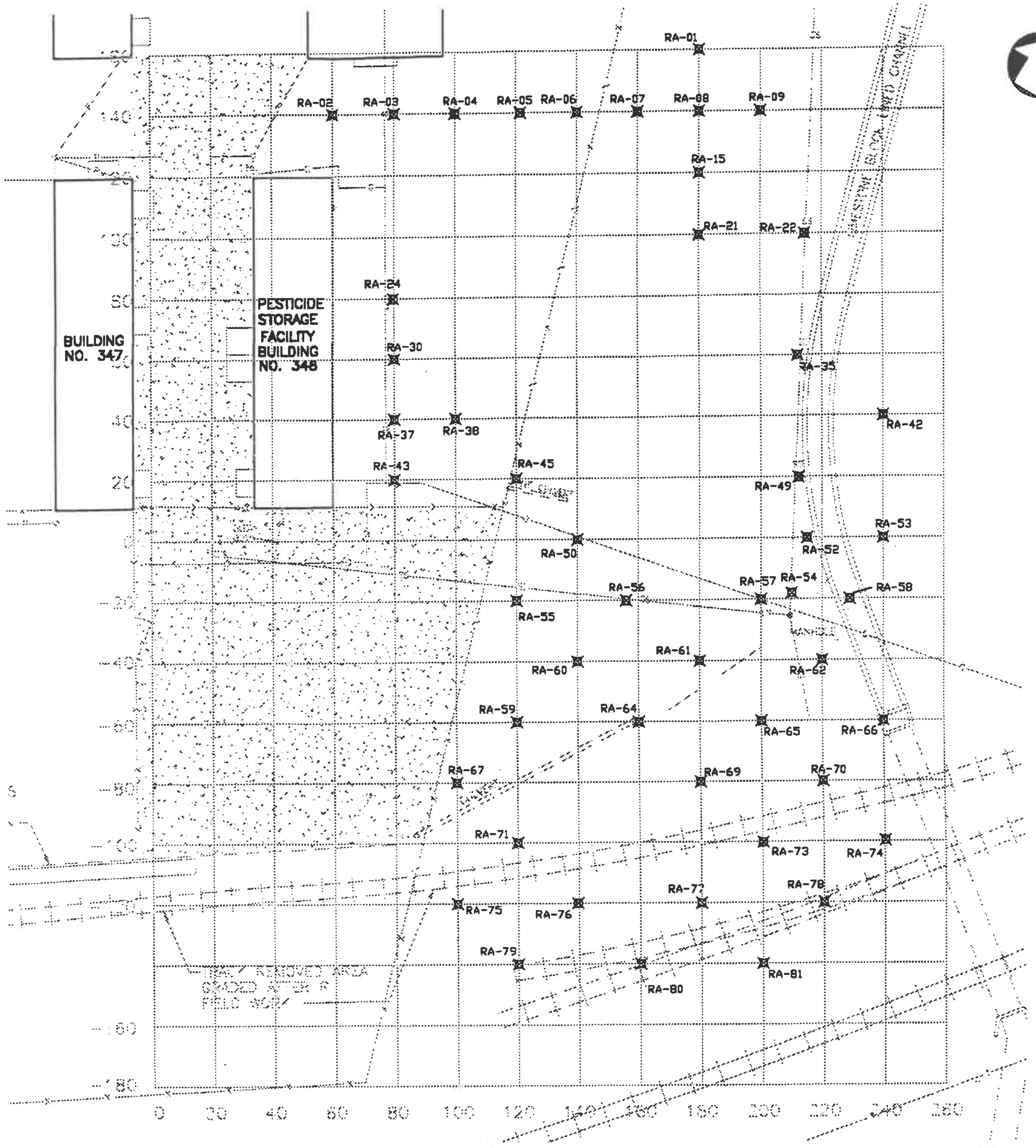
TABLE 4–1

REMAINING SURFACE SOIL ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES FOLLOWING THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and Metabolites* (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
140	−40	RA−60	03/07/94	1	<0.033	0.050	0.007	<0.007
180	−40	RA−61	03/07/94	1	<0.017	0.112	0.024	<0.003
220	−40	RA−62	03/07/94	1	0.072	0.288	0.022	<0.003
160	−60	RA−64	03/08/94	1	0.140	<0.003	0.014	<0.003
200	−60	RA−65	05/19/94	0	0.021	DDE 0.847 DDD 0.335 DDT 1.29	0.158	<0.001
240	−60	RA−66	03/08/94	1	<0.033	0.172	0.017	<0.003
100	−80	RA−67	03/08/94	1	0.151	0.143	0.032	<0.003
180	−80	RA−69	03/08/94	1	<0.033	0.091	0.017	<0.003
220	−80	RA−70	03/08/94	1	0.439	0.667	0.109	0.004
120	−100	RA−71	03/30/94	0	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.011
120	−100	RA−71	03/30/94	1	<0.034	DDT 0.378 DDE 0.188 DDD <0.003	0.082	<0.001
200	−100	RA−73	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
240	−100	RA−74	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
100	−120	RA−75	03/30/94	1	<0.034	DDD 0.164 DDE 0.111 DDT 0.327	0.054	<0.001
140	−120	RA−76	03/30/94	1	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	−120	RA−77	03/30/94	1	<0.034	DDE 0.040 DDT 0.079 DDD <0.002	<0.004	<0.001
220	−120	RA−78	03/30/94	1	<0.034	DDE 0.061 DDT <0.002 DDD <0.003	<0.004	<0.001
120	−140	RA−79	03/30/94	1	<0.034	DDT 0.379 DDD 0.163 DDE 0.254	0.107	<0.001
160	−140	RA−80	03/30/94	1	<0.034	DDE 0.036 DDT 0.075 DDD <0.003	<0.004	<0.001
200	−140	RA−81	03/30/94	1	<0.034	DDE 0.203 DDT 0.175 DDD 0.100	<0.004	<0.001

RA – Prefix samples from Removal Action.
* DDT metabolites (DDD and DDE) only reported for select samples.
Results for metabolites presented if analyzed.
(1) Detection limit not reported by laboratory.



LEGEND:

▲ SURFACE SOIL SAMPLE LOCATION (1992 RI)

☒ SURFACE SOIL SAMPLE LOCATIONS (1994 REMOVAL ACTION)

▨ ASPHALT

┼┼┼ RAILROAD

······G······ GAS LINES

······X······ FENCE

······SS······ SANITARY SEWER

······P······ OVERHEAD POWERLINE

MAP SOURCE: OHM, 1994

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

REMAINING SURFACE SOIL LOCATIONS SAMPLED DURING THE RI AND REMOVAL ACTION

PREPARED BY/DATE:	SEG/5-95	FIGURE NUMBER:	FILE DATE:	21.OCTOBER.94
CHECKED BY/DATE:	EFW/5-95	4-1	PLOT DATE:	05.FEB.97
APPROVED BY/DATE:	KAH/5-95		FILE NAME:	RIREM01.DWG

TABLE 4-2

COMPARISON OF POSITIVE ANALYTICAL RESULTS FOR EXISTING SURFACE SOILS WITH REMEDIAL GOALS ESTABLISHED FOR THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

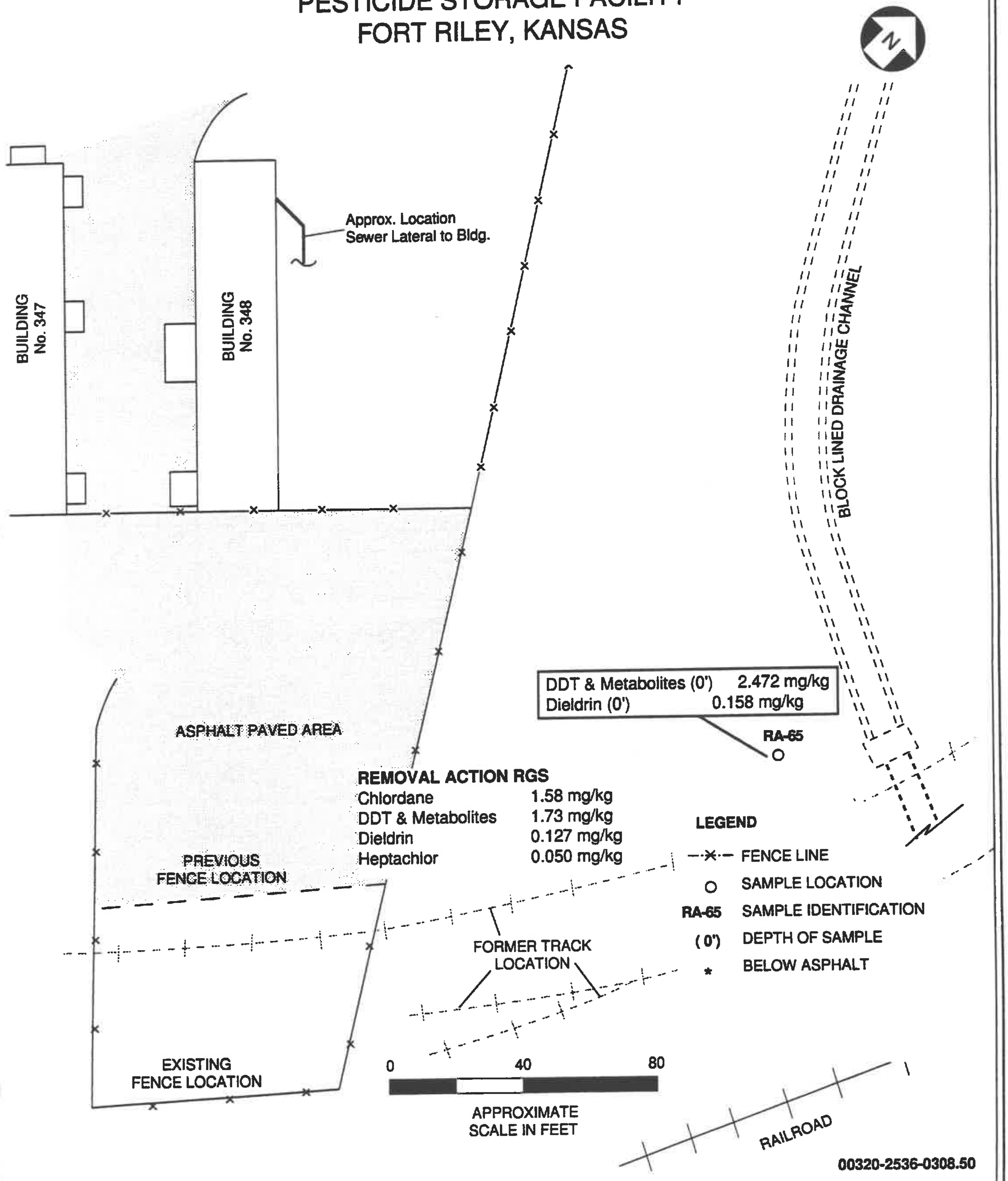
Parameter	Frequency of Detection	Percent Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Removal Action Remedial Goal (mg/kg)	Remedial Goal Exceedance Frequency
SURFACE SOIL SAMPLES:						
Chlordane	17/52	32%	0.0207	1.12	1.58	0/52
DDD	7/18	39%	0.0237	0.454	1.73(1)	0/18
DDE	12/18	67%	0.0356	0.847	1.73(1)	0/18
DDT	35/52	67%	0.012	1.29	1.73(1)	0/52
Dieldrin	20/52	38%	0.007	0.158	0.127	1/52
Heptachlor	2/52	4%	0.004	0.0093	0.050	0/52

(1) Removal Action RG established for DDT and metabolites

FIGURE 4-2

REMAINING SURFACE SOIL SAMPLES EXCEEDING REMOVAL ACTION REMEDIAL GOAL CONCENTRATIONS

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



DDT & Metabolites (0')	2.472 mg/kg
Dieldrin (0')	0.158 mg/kg

REMOVAL ACTION RGS

Chlordane	1.58 mg/kg
DDT & Metabolites	1.73 mg/kg
Dieldrin	0.127 mg/kg
Heptachlor	0.050 mg/kg

LEGEND

—×—	FENCE LINE
○	SAMPLE LOCATION
RA-65	SAMPLE IDENTIFICATION
(0')	DEPTH OF SAMPLE
*	BELOW ASPHALT

00320-2536-0308.50

The Removal Action RG for dieldrin was 0.127 mg/kg. The highest concentration of dieldrin was 0.158 mg/kg, found in a surface sample located at RA-65 (located approximately 100 feet east of the fence line). The location of this sample is shown on Figure 4-2. This concentration exceeds the Removal Action RG.

The Removal Action RG for heptachlor was 0.05 mg/kg, which was not exceeded in surface soil samples collected prior to the Removal Action. The highest concentration of heptachlor in existing soil was 0.009 mg/kg found in a 1-foot sample (sample RA-38). As shown in Table 4-2, heptachlor was only detected in two remaining surface soil samples.

4.1.2 Evaluation of Subsurface Soil Analytical Results

Table 4-3 presents results of subsurface soil samples for soils remaining at the PSF site and includes analyses for the pesticides chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin and heptachlor. As discussed in Section 4.1.1, DDT metabolites were only reported for select samples, and Table 4-3 presents results for these metabolites if analyzed. It should be noted that samples located under currently paved areas are considered subsurface. Figure 4-3 shows the locations of subsurface soil samples for soil still remaining at the site. Figures D-21 through D-30 in Appendix D-6 show the results of the analysis for these samples at various depth intervals. As in Section 2, samples collected from 1-foot depth increments were combined on each figure because the Removal Action excavations were carried out in 1-foot increments. Again, as observed for the surface samples, detectable levels of the pesticides are distributed throughout the PSF site. Generally, concentrations of the pesticides remaining in soils were relatively low. Table 4-4 presents minimum and maximum concentrations encountered for these pesticides in remaining soil, along with detection frequencies and Removal Action RG exceedance frequencies. Figure 4-4 shows the location of remaining subsurface soil samples exceeding Removal Action RGs. During the Removal Action, the RGs for surface soil exposure were used to guide subsurface soil excavation. Thus, it should be noted that comparisons of existing subsurface soil concentrations to Removal Action RGs are actually comparisons to surface soil RGs. The use of surface RGs to compare to subsurface soil concentrations is a conservative approach because people will not be exposed to subsurface soils as frequently as to surface soils. The RRA (Section 5.1) evaluates surface soil as well as subsurface soil exposures. Subsurface sample results for each pesticide are discussed below.

The highest concentrations of chlordane at the 2- to 3-foot depth interval were 5.35 mg/kg at 2 feet (sample RA-29, located against Building 348) and 5.89 mg/kg in a 2-foot sample (sample RA-47, located approximately 100 feet east of Building 348). At the 4- to 5-foot depth interval, the highest concentrations of chlordane were 8.71 mg/kg at 4 feet (sample RA-46, located 20 feet east of the fence line) and 10.2 mg/kg at 4 feet (sample RA-41, located approximately 55 feet east of the fence line). Thus, chlordane exists in soils at the PSF at concentrations greater than the Removal Action RG of 1.58 mg/kg. The highest concentration of depths of 6 feet and

TABLE 4–3

REMAINING SUBSURFACE SOIL ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES FOLLOWING THE REMOVAL ACTION
Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and[1] Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
180	160	RA–01	03/08/94	3	<0.017	<0.003	<0.003	<0.003
160	140	RA–07	03/08/94	3	<0.017	<0.003	<0.003	<0.003
180	140	RA–08	03/08/94	3	<0.017	<0.003	<0.003	<0.003
200	140	RA–09	03/08/94	3	<0.016	<0.003	<0.003	<0.003
40	120	RA–10	02/04/94	5	<0.050	<0.050	<0.005	<0.005
80	120	RA–11	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
80	120		03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	120	RA–13	03/30/94	2	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	120		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
160	120	RA–14	03/30/94	2	<0.028	DDT 0.036 DDD 0.023 DDE 0.020	<0.003	<0.0009
160	120		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
160	120		04/08/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
160	120		04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	120	RA–15	03/08/94	3	<0.017	<0.003	<0.003	<0.003
60	100	RA–16	04/08/94	2	2.67	DDT 0.509 DDD 0.218 DDE 0.132	0.020	0.129
80	100	RA–17	03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
80	100		03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009

TABLE 4-3

REMAINING SUBSURFACE SOIL ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES FOLLOWING THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
100	100	RA-18	03/30/94	5	<0.05	<0.05	<0.005	<0.005
100	100		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	100		03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	100	RA-20	03/30/94	2	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	100		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
180	100	RA-21	03/08/94	3	<0.016	<0.003	<0.003	<0.003
215	100	RA-22	03/07/94	3	<0.033	<0.003	<0.003	<0.003
60	80	RA-23	04/08/94	2	3.36	DDT 1.95 DDD 0.925 DDE 0.332	<0.004	<0.001
60	80		02/04/94	5	<0.05	<0.05	<0.005	<0.005
100	80	RA-25	05/19/94	2	0.048	DDT 0.051 DDD <0.003 DDE <0.009	<0.003	<0.0009
120	80	RA-26	02/04/94	5	<0.05	<0.05	<0.005	<0.005
140	80	RA-27	03/30/94	7	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	80		04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
160	80	RA-27.5	05/19/94	8	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
180	80	RA-28	03/30/94	2	0.298	DDT 0.035 DDD 0.029 DDE 0.033	<0.003	<0.0009
180	80		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
60	60	RA-29	04/08/94	2	5.35	DDT <0.002 DDD <0.003 DDE 0.034	<0.004	0.038

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Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
80	60	RA-30	03/30/94	3	0.049	DDT <0.002 DDD <0.003 DDE 0.018	<0.003	<0.0009
80	60		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	60	RA-31	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	60		03/30/94	5	<0.028	DDT 0.186 DDD 0.017 DDE 0.041	<0.003	<0.0009
140	60	RA-32	03/30/94	7	0.167	DDT 0.034 DDD <0.003 DDE 0.012	<0.003	<0.0009
140	60		04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
160	60	RA-33	02/04/94	5	<0.050	<0.050	<0.005	<0.005
160	60		03/30/94	5	0.272	DDT 0.105 DDD <0.0005 DDE 0.027	<0.0006	0.001
160	60		03/30/94	7	ND(1)	ND(1)	ND(1)	ND(1)
180	60	RA-34	03/30/94	2	2.98	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	0.008
180	60		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
65	40	RA-36	04/08/94	5	0.201	DDT 0.112 DDD 0.084 DDE 0.049	<0.004	<0.001
65	40		04/08/94	5	0.042	DDT <0.002 DDD 0.019 DDE <0.011	<0.004	<0.001
65	40		04/08/94	5	0.266	DDT 0.768 DDD 0.271 DDE 0.254	<0.004	<0.001
80	40	RA-37	03/30/94	3	<0.028	DDT 0.017 DDD 0.011 DDE 0.022	<0.003	<0.0009
80	40		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE 0.010	<0.003	<0.0009

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Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(f) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
100	40	RA–38	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	40		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
130	40	RA–39	03/30/94	5	<0.028	DDT <0.002 DDD 0.001 DDE <0.009	<0.003	<0.0009
140	40	RA–40	03/30/94	5	0.332	DDT 0.068 DDD 0.023 DDE 0.066	<0.003	<0.0009
140	40		04/08/94	5	0.623	DDT 0.221 DDD 0.081 DDE <0.011	<0.004	<0.001
140	40		04/08/94	7	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	40	RA–41	03/30/94	2	0.302	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
180	40		03/30/94	4	10.2	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
80	20	RA–43	03/30/94	3	0.087	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
80	20		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	20	RA–44	03/30/94	3	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
100	20		03/30/94	5	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.0009
140	20	RA–46	03/30/94	4	3.54	DDT 0.472 DDD 0.586 DDE 0.794	<0.003	0.008
140	20		04/08/94	4	8.71	DDT 0.917 DDD 0.513 DDE <0.011	<0.004	<0.001
140	20		05/19/94	4	0.059	DDT 0.016 DDD <0.003 DDE 0.036	<0.003	<0.0009

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Pesticide Storage Facility
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Coordinates		Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane	DDT and[f] Metabolites**	Dieldrin	Heptachlor
X	Y				(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
160	20	RA–47	03/30/94	2	5.89	DDT 0.715 DDD 0.365 DDE 0.666	<0.003	0.023
180	20	RA–48	03/30/94	2	0.325	DDT 0.039 DDD <0.003 DDE 0.043	<0.003	<0.0009
180	20		03/07/94	3	<0.033	<0.003	<0.003	<0.003
180	20		03/30/94	4	<0.028	DDT <0.002 DDD <0.003 DDE <0.009	<0.003	<0.009
215	20	RA–49	03/07/94	3	<0.033	<0.003	<0.003	<0.003
140	0	RA–50	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	0	RA–51	03/07/94	3	0.329	0.553	0.034	<0.003
180	0		03/30/94	5	0.562	DDT 0.144 DDD <0.003 DDE 0.126	<0.004	<0.001
215	0	RA–52	03/07/94	3	<0.033	<0.003	<0.003	<0.003
120	–20	RA–55	03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
156	–20	RA–56	03/08/94	3	<0.033	0.143	0.007	<0.003
200	–20	RA–57	03/08/94	3	<0.033	0.012	<0.003	<0.003
229	–20	RA–58	03/08/94	4	<0.017	<0.003	<0.003	<0.003
120	–60	RA–59	03/08/94	3	0.140	<0.003	<0.003	<0.003
120	–60		03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE 0.060	<0.004	<0.001
140	–40	RA–60	03/08/94	3	<0.017	<0.003	<0.003	<0.003
180	–40	RA–61	03/08/94	3	0.070	0.053	0.011	<0.003
160	–60	RA–64	03/08/94	3	<0.016	0.011	<0.003	<0.003
100	–80	RA–67	03/08/94	3	<0.017	<0.003	<0.003	<0.003
100	–80		03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

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REMAINING SUBSURFACE SOIL ANALYTICAL RESULTS FOR CHLORINATED PESTICIDES FOLLOWING THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
140	−80	RA−68	05/19/94	4	0.026	DDT 0.184 DDD 0.072 DDE 0.501	<0.003	<0.0009
140	−80		03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	−80	RA−69	03/08/94	3	0.080	0.109	0.022	<0.003
180	−80		03/30/94	5	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
220	−80	RA−70	03/08/94	3	0.081	0.044	0.009	<0.003
120	−100	RA−71	03/30/94	3	<0.034	DDT 0.153 DDD 0.044 DDE 0.251	0.066	<0.001
120	−100		03/30/94	5	<0.034	DDT 0.198 DDD 0.079 DDE 0.378	0.042	<0.001
160	−100	RA−72	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
160	−100		03/30/94	5	<0.034	DDT 0.098 DDD <0.003 DDE 0.053	0.023	<0.001
200	−100	RA−73	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
200	−100		03/30/94	5	<0.034	DDT 0.036 DDD <0.003 DDE <0.011	<0.004	<0.001
240	−100	RA−74	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
100	−120	RA−75	03/30/94	3	<0.034	DDT 0.154 DDD 0.051 DDE 0.076	<0.004	<0.001
140	−120	RA−76	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
180	−120	RA−77	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
220	−120	RA−78	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001

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Pesticide Storage Facility
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Coordinates		Sample	Sample	Sample Depth	Chlordane	DDT and[1] Metabolites**	Dieldrin	Heptachlor
X	Y	Location I.D.	Date	(feet)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
120	−140	RA−79	03/30/94	3	<0.034	DDT 0.070 DDD 0.044 DDE 0.089	<0.004	<0.001
160	−140	RA−80	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
200	−140	RA−81	03/30/94	3	<0.034	DDT <0.002 DDD <0.003 DDE <0.011	<0.004	<0.001
26.8	111.9	SB−2	04/07/92	0.5−1.5*	3.200	DDT 1.000 DDD <0.062 DDE 0.270	0.077	0.300
26.8	111.9		04/07/92	2.0−2.5	0.420	DDT 0.042 DDD <0.039 DDE <0.039	<0.039	0.045
26.8	111.9		04/07/92	4.0−4.5	0.320	DDT <0.370 DDD <0.370 DDE <0.370	<0.037	0.028
24.8	19.1	SB−4	04/07/92	2.0−2.5	0.181	DDT 0.140 DDD <0.016 DDE 0.031	<0.016	<0.008
24.8	19.1		04/07/92	4.0−4.5	0.125	DDT 0.096 DDD <0.016 DDE 0.021	<0.016	<0.008
89.3	55.9	SB−6	04/07/92	2.0−2.5	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
89.3	55.9		04/07/92	4.0−4.5	0.008	DDT 0.014 DDD <0.007 DDE <0.007	<0.007	<0.004
66.8	29.1	SB−8	04/07/92	2.0−2.5	0.070	DDT 0.440 DDD <0.043 DDE 0.110	<0.043	<0.021
66.8	29.1		04/07/92	4.0−4.5	0.012	DDT 0.150 DDD <0.008 DDE 0.020	<0.008	<0.004
150.9	13.9	SB−14	04/04/92	4.0−4.5	0.010	DDT 0.012 DDD <0.008 DDE <0.008	<0.008	<0.004
184.8	86.1	SB−15	04/04/92	4.0−4.5	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004

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Pesticide Storage Facility
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Coordinates		Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and[1] Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
X	Y							
200.9	95.6	SB–16	04/04/92	1.5–2.5	0.138	DDT 0.310 DDD <0.037 DDE <0.037	<0.037	<0.019
200.9	95.6		04/04/92	3.5–4.5	0.013	DDT 0.025 DDD <0.008 DDE <0.008	<0.008	<0.004
178.7	66.5	SB–17	04/06/92	4.0–4.5	0.016	DDT 0.025 DDD <0.007 DDE <0.007	<0.007	<0.004
197.0	58.0	SB–18	04/05/92	4.0–4.5	0.036	DDT 0.082 DDD <0.008 DDE 0.022	<0.008	<0.004
176.8	56.0	SB–19	04/04/92	4.0–4.5	0.025	DDT 0.036 DDD <0.008 DDE 0.022	<0.008	<0.004
190.6	24.7	SB–20	04/08/92	4.0–4.5	0.026	DDT 0.025 DDD <0.008 DDE 0.011	<0.008	<0.004
81.2	318.4	PSF92–01	04/28/92	15–17	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
81.2	318.4		04/28/92	21–25	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
124.1	94.7	PSF92–02	05/05/92	4–8	<0.004	DDT <0.007 DDD <0.007 DDE <0.007	<0.007	<0.004
124.1	94.7		05/05/92	8–12	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
124.1	94.7		05/05/92	14–16	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
124.1	94.7		05/05/92	20–22	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
105.8	18.5	PSF92–03	05/02/92	10–14	0.005	DDT <0.008 DDD <0.008 DDE <0.008	0.009	<0.004
105.8	18.5		05/02/92	20–22	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004

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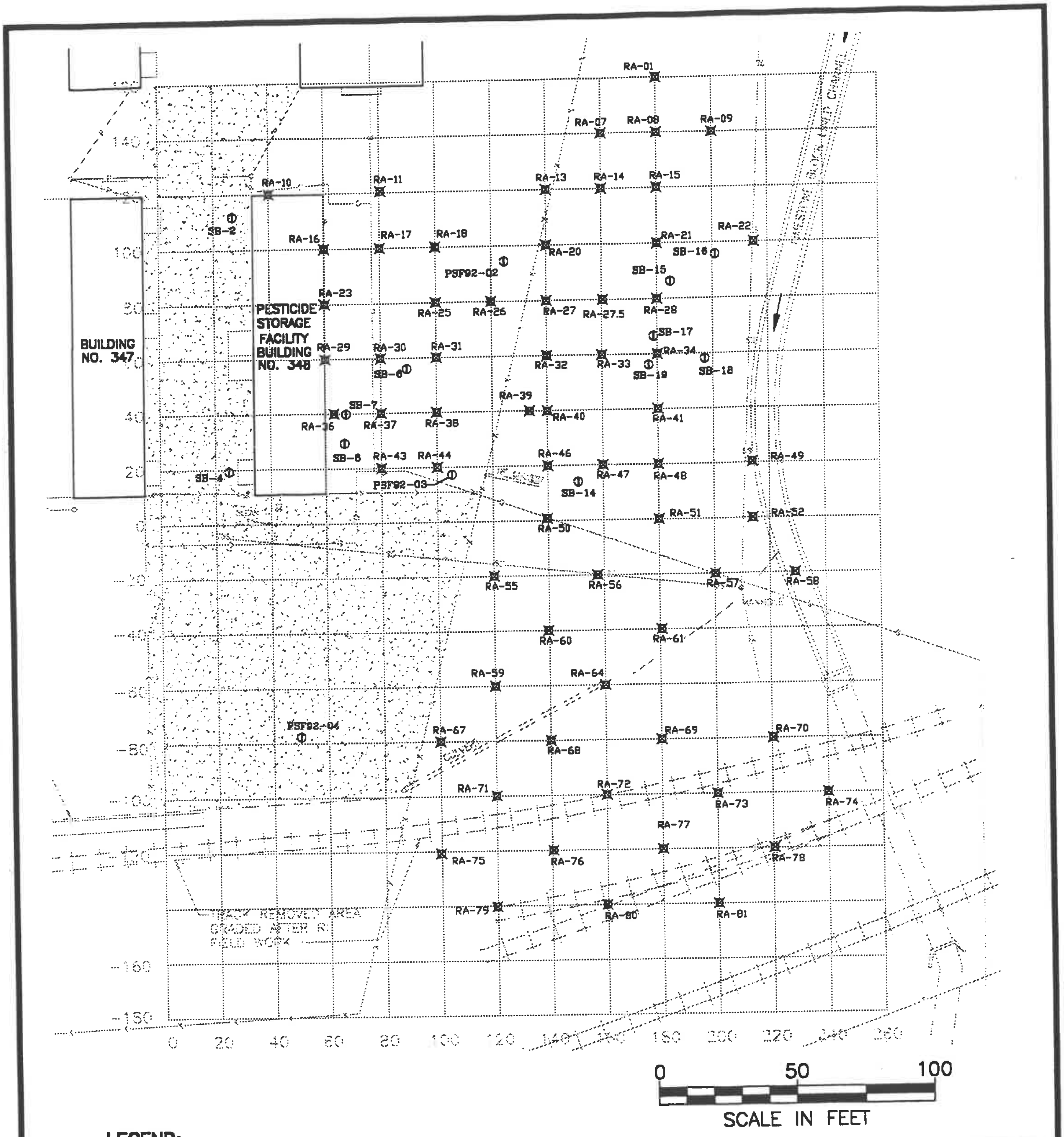
Coordinates X	Coordinates Y	Sample Location I.D.	Sample Date	Sample Depth (feet)	Chlordane (mg/kg)	DDT and(1) Metabolites** (mg/kg)	Dieldrin (mg/kg)	Heptachlor (mg/kg)
49.8	−77.9	PSF92−04	05/04/92	12−14	0.033	DDT <0.007 DDD <0.007 DDE 0.012	0.013	<0.004
49.8	−77.9		05/04/92	22−24	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
179.6	−233.4	PSF92−05	04/29/92	9−11	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004
179.6	−233.4		04/29/92	17−19	<0.004	DDT <0.008 DDD <0.008 DDE <0.008	<0.008	<0.004

RA – Prefix samples from Removal Action
SB and PSF92 – Prefix samples from RI (LAW, 1993a)
ND – Not detected
* Currently under asphalt, considered subsurface.
** DDT metabolites (DDD and DDE) only reported for select samples.
Results for metabolites presented if analyzed.
(1) Detection limit not reported by laboratory.



LEGEND:

ⓘ SOIL SAMPLE LOCATIONS COLLECTED 1992 (RI)

☒ SOIL SAMPLE LOCATIONS COLLECTED DURING REMOVAL ACTION (1994)

▨ ASPHALT

RAILROAD

GAS LINES

SANITARY SEWER (APPROX. LOCATION)

OVERHEAD POWER LINE

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

SUBSURFACE SOIL LOCATIONS SAMPLED DURING THE RI AND REMOVAL ACTION

PREPARED BY/DATE:	SEG/5-95	FIGURE NUMBER:	FILE DATE:	12-5-94
CHECKED BY/DATE:	EFW/5-95	4-3	PLOT DATE:	05.feb.97
APPROVED BY/DATE:	KAH/5-95		FILE NAME:	FR03.DWG

TABLE 4–4

COMPARISON OF POSITIVE ANALYTICAL RESULTS FOR EXISTING SUBSURFACE SOILS WITH REMEDIAL GOALS ESTABLISHED FOR THE REMOVAL ACTION

Pesticide Storage Facility
Fort Riley, Kansas

Sample ID	Frequency of Detection	Percent Frequency of of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Removal Action Remedial Goal (mg/kg)$^{(1)}$	Remedial Goal Exceedance Frequency
SUBSURFACE SOIL SAMPLES:						
Chlordane	46/133	35	0.0051	10.2	1.58	9/133
DDD	20/106	19	0.0013	0.925	1.73$^{(2)}$	0/106
DDE	35/106	33	0.0104	0.794	1.73$^{(2)}$	0/106
DDT	47/133	35	0.011	1.95	1.73$^{(2)}$	1/133
Dieldrin	12/133	9	0.007	0.077	0.127	0/133
Heptachlor	9/133	7	0.0012	0.3	0.050	2/133

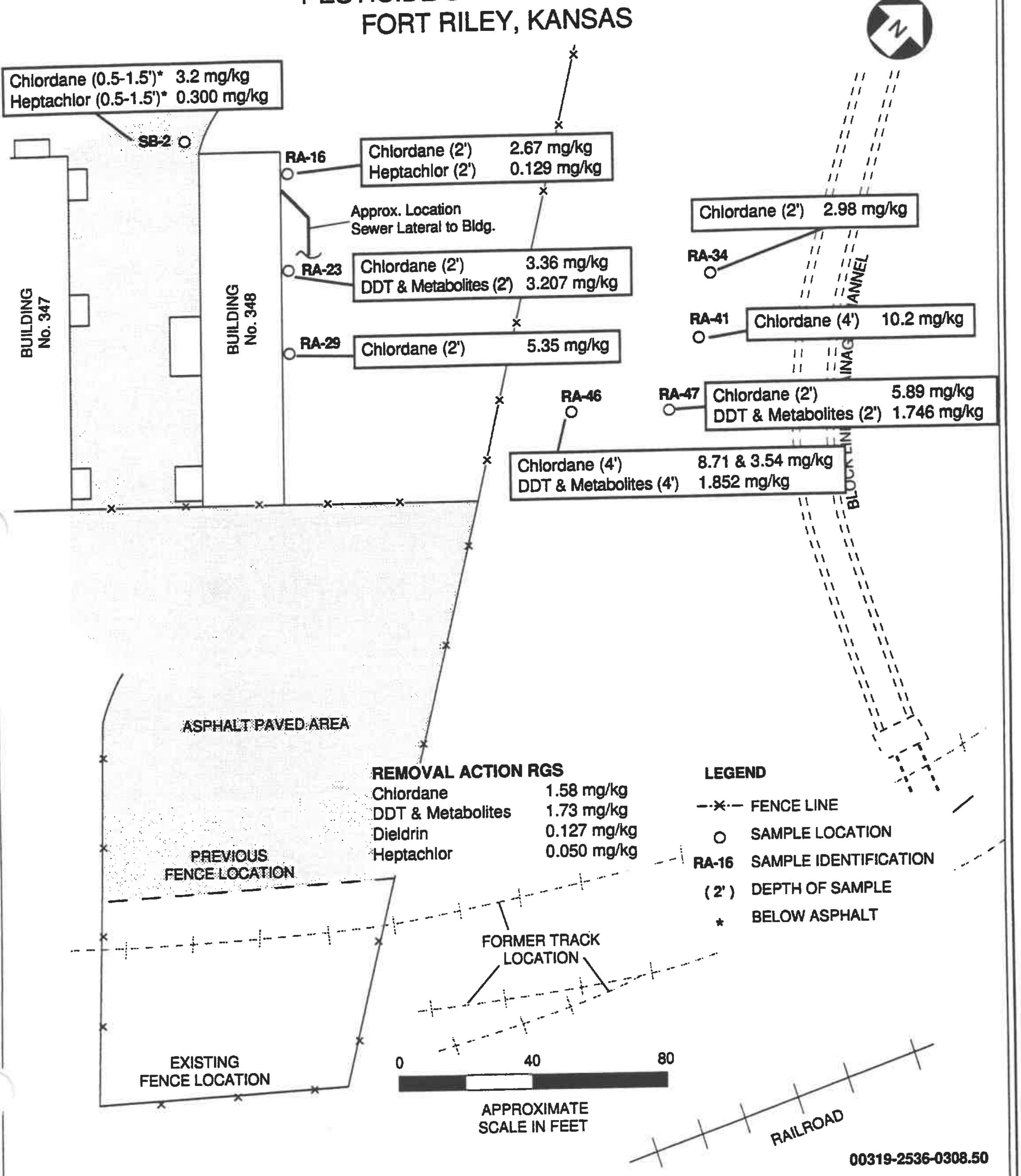
(1) Removal Action RG for surface soil

(2) Removal Action RG established for DDT and metabolites

FIGURE 4-4

REMAINING SUBSURFACE SOIL SAMPLES EXCEEDING REMOVAL ACTION REMEDIAL GOAL CONCENTRATIONS

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



00319-2536-0308.50

greater was 0.167 mg/kg. As shown in Table 4-4 and on Figure 4-4, 9 samples at 8 locations had concentrations of chlordane above the Removal Action RG.

The maximum concentration of DDT and its metabolites (added together) was 3.207 mg/kg in RA-23 (located adjacent to the east side of Building 348) at 2 feet which exceeds the Removal Action RG of 1.73 mg/kg for DDT and metabolites. At the 4- to 5-foot interval, the highest concentration was at RA-46 (located approximately 80 feet east of the southeast portion of Building 348) with 1.852 mg/kg at 4 feet. At 6 feet or deeper, the highest concentration of DDT and metabolites was detected in RA-32 at 0.046 mg/kg at 7 feet. As shown in Table 4-4, individually, only DDT exceeded the Removal Action RG once. As shown on Figure 4-4, when added together, DDT and metabolites exceeded the Removal Action RG in three samples.

As shown on Table 4-4, dieldrin was detected infrequently in subsurface soils which still exist at the site, and was not detected above the Removal Action RG of 0.127 mg/kg in soils remaining at the site.

The highest concentration of heptachlor at the site was detected at 0.300 mg/kg in sample SB-2 under the existing pavement near the northwest corner of Building 348. Heptachlor was detected in RA-16 (located adjacent to the east side of Building 348) at a concentration of 0.129 mg/kg at 2 feet, above the Removal Action surface soil RG of 0.050 mg/kg. At the 4- to 5-foot depth interval, the maximum concentration of heptachlor was found in SB-2 at a concentration of 0.028 mg/kg. Heptachlor was not detected at the PSF site in samples taken at 6 feet deep or below. Figure 4-4 shows the location of the two samples which exceeded the Removal Action RG for heptachlor.

Table 4-5 presents the "positive hits" results of soil samples collected during the RI field investigation for soils remaining at the site, and includes results for analyses of semi-volatile organic compounds, volatile organic compounds and total metals. Table 4-6 presents the frequencies of occurrence, and the minimum and maximum concentrations encountered for detected nonpesticide contaminants in the subsurface soils remaining at the PSF.

Six metals were detected in the subsurface samples which remain at the site (Table 4-5). Lead exhibited elevated concentrations at sample locations SB-8 (770 mg/kg at 2.0 to 2.5 feet and 130 mg/kg at 4.0 to 4.5 feet), SB-14 (100 mg/kg at 4.0 to 4.5 feet), and SB-15 (130 mg/kg at 4.0 to 4.5 feet). Arsenic, one of the target compounds for the Removal Action, exhibited a concentration range of 0.4 to 20 mg/kg, with the highest concentration occurring at sample location SB-2 at the 2.0- to 2.5-foot depth interval. Arsenic, barium and chromium were found in all the samples, while lead occurred in 80 percent of the samples (Table 4-5).

The RI background samples and background soil samples collected by the Removal Action contractor are included in Table 4-7. Table 4-7 was developed using information presented in Table 4-5, Table 4-6, and Appendix D. Although beryllium and nitrate were included in the analyses of background constituent concentrations during the Removal Action, these constituents

TABLE 4–5

POSITIVE ANALYTICAL RESULTS
REMAINING SUBSURFACE SOIL SAMPLES OTHER THAN PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER Sample Depth Date Collected	SB–02 (6–18") 04/07/92	SB–02 (2–2.5') 04/07/92	SB–02 (4–4.5') 04/07/92	SB–04 (2–2.5') 04/07/92	SB–04 (4–4.5') 04/07/92	SB–06 (2–2.5') 04/07/92	SB–06 (4–4.5') 04/07/92	SB–08 (2–2.5') 04/07/92	SB–08 (4–4.5') 04/07/92	SB–14 (4–4.5') 04/04/92	SB–15 (4–4.5') 04/04/92
SEMI–VOLATILE ORGANICS											
Benzo(a)anthracene, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	330	ND
Chrysene, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	290	ND
Diethylphthalate, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	530	ND
Phenanthrene, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	250	ND
Pyrene, µg/kg	ND	ND	ND	ND	ND	ND	ND	170 (I2)	ND	570	ND
bis(2–ethylhexyl)phthalate, µg/kg	ND	ND	ND	ND	ND	ND	1200	ND	ND	410	ND
VOLATILE ORGANICS											
Benzene, µg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride, µg/kg	24	19 (B2)	10 (B2)	19 (B2)	22	18 (B2)	17	9.5 (B2)	13 (B2)	38 (B2)	35 (B2)
Toluene, µg/kg	6.0 (I2)	ND	ND	ND	9.5	ND	ND	ND	ND	ND	38 (I2)
TOTAL ICP METALS											
Barium, mg/kg	35	97	82	100	98	77	39	160	130	100	130
Chromium, mg/kg	6.9	6.5	8.3	11	6.3	5.3	4.6	4.8	6.5	8.3	5.5
Lead, mg/kg	32	13	11	12	9.9	4.7	4.7	770	270	140	7.6
Silver, mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TOTAL FURNACE METALS											
Arsenic, mg/kg	16	20	4.3	6.2	1.9	1.6	1.1	3.3	2.5	3.0	1.6
TOTAL MERCURY											
Mercury, mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND Not detected
NA Not analyzed
* Removal Action data located at RA–39
NAV Not available

B2 Sample results are less than 10 times the amount detected in the method blank. Result is estimated.
I2 Low internal standard response and high surrogate recovery. Result is biased high.

TABLE 4-5

POSITIVE ANALYTICAL RESULTS
REMAINING SUBSURFACE SOIL SAMPLES OTHER THAN PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER Sample Depth Date Collected	SB-16 (1.5-2.5') 04/04/92	SB-16 (3.5-4.5') 04/04/92	SB-17 (4-4.5') 04/06/92	SB-18 (4-4.5') 04/05/92	SB-19 (4-4.5') 04/04/92	SB-20 (4-4.5') 04/08/92	PSF92-01 (15-17') 04/28/92	PSF92-01 (21-25') 04/28/92	PSF92-02 (4-8') 05/05/92	PSF92-02 (8-12') 05/05/92	PSF92-02 (14-16') 05/05/92
SEMI-VOLATILE ORGANICS											
Benzo(a)anthracene, µg/kg	ND	ND	ND	ND	ND	160	ND	ND	ND	ND	ND
Chrysene, µg/kg	ND	ND	ND	ND	ND	200	ND	ND	ND	ND	ND
Diethylphthalate, µg/kg	ND	ND	ND	ND	ND	430	ND	ND	ND	ND	ND
Fluoranthene, µg/kg	ND	ND	ND	ND	ND	310	ND	ND	ND	ND	ND
Phenanthrene, µg/kg	ND	ND	ND	ND	ND	230	ND	ND	ND	ND	ND
Pyrene, µg/kg	110	ND	ND	ND	ND	310	ND	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate, µg/kg	960	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
VOLATILE ORGANICS											
Benzene, µg/kg	ND	ND	ND	ND	ND	ND	6.6	5.9	ND	ND	ND
Methylene chloride, µg/kg	28 (B2)	34 (B2)	29	31	31 (B2)	15 (B2)	62 (B2)	46 (B2)	18	19	17
Toluene, µg/kg	8.9	18	5.9	9.8	ND	ND	ND	ND	ND	ND	ND
TOTAL ICP METALS											
Barium, mg/kg	47	120	71	110	100	88	61	120	60	83	100
Chromium, mg/kg	4.7	8.7	5.7	6.8	6.9	6.9	6.8	8.7	11	4.8	6.4
Lead, mg/kg	18	12	8.0	15	12	89	5.1	10	4.7	ND	ND
Silver, mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	0.9	ND	1.1
TOTAL FURNACE METALS											
Arsenic, mg/kg	1.9	1.6	0.9	1.6	1.4	1.9	1.0	2.5	1.7	1.7	2.4
TOTAL MERCURY											
Mercury, mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND	Not detected
NA	Not analyzed
*	Removal Action data located at RA-39
NAV	Not available

B2 Sample results are less than 10 times the amount detected in the method blank. Result is estimated.

I2 Low internal standard response and high surrogate recovery. Result is biased high.

TABLE 4–5

POSITIVE ANALYTICAL RESULTS
REMAINING SUBSURFACE SOIL SAMPLES OTHER THAN PESTICIDES
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	PSF92–02	PSF92–03	PSF92–03	PSF92–04	PSF92–04	PSF92–05	PSF92–05	SP–10–B*	SP–10–C*
Sample Depth	(20–22')	(10–14')	(20–22')	(12–14')	(22–24')	(9–11')	(17–19')	(5')	(7')
Date Collected	05/05/92	05/02/92	05/02/92	05/04/92	05/04/92	04/28/92	04/28/92	04/08/94	04/08/94
SEMI–VOLATILE ORGANICS									
Benzo(a)anthracene, µg/kg	ND	ND	ND	ND	ND	110	ND	NA	NA
Chrysene, µg/kg	ND	ND	ND	ND	ND	110	ND	NA	NA
Diethylphthalate, µg/kg	ND	ND	ND	ND	ND	ND	ND	NA	NA
Fluoranthene, µg/kg	ND	ND	ND	ND	ND	180	ND	NA	NA
Phenanthrene, µg/kg	ND	ND	ND	ND	ND	ND	ND	NA	NA
Pyrene, µg/kg	ND	ND	ND	ND	ND	180	ND	NA	NA
bis(2–ethylhexyl)phthalate, µg/kg	ND	ND	ND	ND	ND	ND	ND	NA	NA
VOLATILE ORGANICS									
Benzene, µg/kg	ND	ND	ND	ND	ND	ND	ND	NA	NA
Methylene chloride, µg/kg	11	19	22	21	20	70 (B2)	38 (B2)	NA	NA
Toluene, µg/kg	ND	ND	ND	ND	ND	ND	ND	NA	NA
TOTAL ICP METALS									
Barium, mg/kg	72	190	68	60	70	96	44	NA	NA
Chromium, mg/kg	7.1	11	6.1	20	6.0	10	6.6	NA	NA
Lead, mg/kg	ND	8.5	5.9	58	ND	30	5.9	NA	NA
Silver, mg/kg	1.2	ND	ND	ND	ND	ND	ND	NA	NA
TOTAL FURNACE METALS									
Arsenic, mg/kg	1.4	2.0	0.5	3.1	0.4	2.9	0.6	9.4	2.2
TOTAL MERCURY									
Mercury, mg/kg	ND	ND	ND	ND	ND	0.1	ND	NA	NA

ND	Not detected
NA	Not analyzed
*	Removal Action data located at RA–39
NAV	Not available

B2 Sample results are less than 10 times the amount detected in the method blank. Result is estimated.

I2 Low internal standard response and high surrogate recovery. Result is biased high.

TABLE 4-6

SUMMARY OF POSITIVE ANALYTICAL RESULTS - CONSTITUENTS OTHER THAN PESTICIDES FOR REMAINING SUBSURFACE SOIL SAMPLES
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Frequency of Detection	Percent Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration
SUBSURFACE SOIL SAMPLES:				
Metals (mg/kg):				
Arsenic	31/31	100	0.4	20
Barium	29/29	100	35	190
Chromium	29/29	100	4.6	20
Lead	25/29	80	4.7	770
Mercury	1/29	3	0.1*	0.1
Silver	3/29	10	0.9	1.2
Volatile Organics (mg/kg):				
Benzene	2/29	7	0.0059	0.0066
Methylene Chloride	13/29	45	0.011	0.031
Toluene	7/29	24	0.0059	0.038
Semi-volatile Organics (mg/kg):				
Benzo(a)anthracene	3/29	10	0.11	0.33
bis(2-Ethylhexyl)phthalate	3/29	10	0.41	1.2
Chrysene	3/29	10	0.11	0.29
Diethylphthalate	1/29	3	0.43*	0.43
Fluoranthene	3/29	10	0.18	0.53
Phenanthrene	2/29	7	0.23	0.25
Pyrene	5/29	17	0.11	0.57

* = Only one detection of this constituent, thus reported concentration is minimum and maximum detected concentration.

TABLE 4-7

COMPARISON OF RANGES FOR BACKGROUND METALS TO PSF SOIL CONCENTRATIONS

Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	BACKGROUND RANGE (mg/kg)	NUMBER OF BACKGROUND SAMPLES	PSF RANGE (mg/kg)	EXCEEDANCE FREQUENCY ABOVE MAXIMUM BACKGROUND CONCENTRATION(1)
Arsenic	1.2 - 7.1	25	0.4 - 20	3/31
Barium	31 - 200	25	35 - 190	0/29
Beryllium	<0.50-0.59	24	NAL	NA
Chromium	6.7 - 9.3	3	4.6 - 20	5/29
Lead	4.3 - 46	25	4.7 - 770	5/29
Nitrate	<1.0 - 3.9	22	NAL	NA
Thallium	<25	22	NAL	NA

NA Not applicable
NAL Not analyzed
(1) Number of samples exceeding the maximum background concentration/number of samples analyzed.

Sources: OHM, 1994 and LAW, 1993a

were not analyzed for the soils at the PSF. Three metals were detected above the high-end background concentration in the PSF soils. Arsenic was found to exceed the background concentration in three samples; both chromium and lead were found to exceed the background concentration in five samples. However, none of these metals individually were found to cause excessive risk in the Residual Risk Assessment (Section 5 of this report) performed for the PSF site soils. Barium was not found to exceed the high-end background concentrations, and beryllium was not analyzed in any on-site samples.

The volatile organic compound toluene was detected only at low concentrations, occurring in 7 of 29 samples (Table 4-6). It was usually found at depths greater than 3.5 feet (Table 4-5), with the exception of sample locations SB-02 (at 0.5 to 1.5 feet) and SB-16 (at 1.5 to 2.5 feet). Benzene was only found in the deeper samples, with its shallowest occurrence from the background monitoring well location (PSF92-01) at the 15- to 17-foot interval. The presence of methylene chloride was attributed to the laboratory analytical methods used. The QCSR (LAW, 1992) and Second Quarter QCSR (LAW, 1993d) provides supporting QC data which attributes methylene chloride detections to laboratory contamination, as discussed in the RI report (LAW, 1993a). Methylene chloride was found in preparation blanks associated with soil samples. Methylene chloride results in soil samples from the PSF less than 10 times the amount of methylene chloride found in the associated blank were qualified.

The semi-volatile organic compounds detected were primarily PAHs and were found infrequently. Pyrene showed the highest frequency of detection, occurring in 5 of 29 subsurface samples for which it was analyzed. Soil sample locations SB-14 and SB-20 showed the largest number of detected PAHs at the depth interval of 4.0 to 4.5 feet, and generally the highest concentrations of these compounds.

4.1.3 Evaluation of Soil Analytical Results for Soils Remaining On Site

This section presents an evaluation of the nature and extent of contamination in surface and subsurface soils remaining at the site based on data collected during the RI field activities and Removal Action sampling. The discussion in this section compares the analytical data to removal RGs. Section 5 presents a residual risk assessment for the soils remaining on site. As discussed in Section 2.2, subsurface soils were evaluated considering all depths at or below 2 feet, and not individual comparisons at each depth. Figures 4-2 through 4-4 presented location and analytical results for pesticides remaining in surface soil and subsurface soil, respectively, above Removal Action RGs. Tables 4-2 and 4-4 evaluated pesticide concentrations in surface and subsurface soils, respectively, and provided the number of RG exceedances for each pesticide. Using information obtained from these figures and tables, a summary of nature and extent of pesticide contamination at the site is provided below. Additionally, summary results for metals, volatile organic compounds, PAHs, and arsenic are provided.

The pesticides chlordane, DDT, DDD, DDE and dieldrin were distributed through the PSF site, at depths down to at least 4.5 feet bgs at relatively low concentrations. The presence of heptachlor was also detected, but on a much less frequent basis. In surface soil remaining at the site, only one sample remains with a pesticide concentration above the Removal Action RG (RA-65, located approximately 100 feet east of the fence line), with a dieldrin concentration of 0.158 mg/kg and a DDT and metabolite concentration of 2.472 mg/kg. This is shown on Figure 4-2. As noted in Section 4.1.2, Removal Action RGs for surface soil were used to guide subsurface soil excavation. However, as will be discussed in Section 5, these surface soil RGs were very conservative estimates. As shown in Table 4-4, 12 exceedances of the surface soil RGs were identified in subsurface soil (nine for chlordane, one for DDT, and two for heptachlor). Figure 4-4 shows the locations of the subsurface samples remaining at the site which exceeded the Removal Action RGs. The soil samples collected and analyzed for pesticides at the lateral and vertical limits of the Removal Action sampling did not exceed the Removal Action RGs at the 10^{-6} risk levels in surface and subsurface soils except for three samples These were at locations RA-16, RA-23, and RA-29 (see Figure 4-4) which were adjacent to the building foundation. These areas were not excavated because the structural stability of Building 348 would have been jeopardized by the additional excavations. No data gaps were, therefore, identified for pesticides.

Of the metals, lead was found to occur in subsurface samples at elevated concentrations at two locations. Chromium and lead were found to exceed the high-end Fort Riley background soil concentrations in some PSF soil samples. However, neither of these metals were found individually to cause excessive risk as determined by the Residual Risk Assessment discussed in Section 5.

As discussed in Section 2.1, background soil samples for arsenic at Fort Riley were detected in the range of 1.2 to 7.1 mg/kg. Arsenic detected in surface soils collected during the RI at the PSF and not under pavement did not exceed 4.6 mg/kg which was within the range of Fort Riley background concentrations. Shallow soil samples under pavement were considered as subsurface samples because the pavement prevents direct exposure. Because elevated levels of arsenic were not detected in the surface soils above the range of background concentrations, arsenic sampling results were not mapped. Additional surface soil samples were not analyzed for arsenic during the Removal Action because elevated levels of arsenic in surface soils were not detected during the RI in surface soils.

In subsurface soils following the Removal Action, two arsenic soil samples under existing pavement remained which exceeded background arsenic concentrations because paved areas were not excavated. These samples were located at SB-2 (see Figure 4-4), at a depth of 0.5 to 1.5 feet (16 mg/kg) and at a depth of 2 to 2.5 feet (20 mg/kg). At the 4- to 4.5-foot depth arsenic was detected at 4.3 mg/kg in this location, within background concentrations. No additional sampling data was collected under the asphalt; however, the data limitations are not considered significant because the area is under pavement which prevents direct exposure, and the depth of the elevated arsenic was limited. Elevated arsenic areas east of Building 348 were consistent with the areas of pesticide contamination, and were removed with pesticide contaminated soils during the Removal Action with one exception. At location RA-39 (shown on Figure 4-3) the arsenic sample at the 5-foot depth was 9.4 mg/kg, above the maximum background concentration of 7.1 mg/kg. The sample collected from this location at the 7-foot depth (2.2 mg/kg) was within the background range. The exceedance is minor and limited in depth, and not significant.

The only volatile organic compounds detected in the soil samples were toluene and benzene. Toluene was more frequently found at the shallower subsurface depths, while benzene was limited to deeper soils.

PAHs were detected in a small number of subsurface samples. The greatest number and highest concentrations of these compounds were found in two subsurface soil samples. The PAHs detected in subsurface soils during the RI field investigation occurred mostly in the areas where soil has been removed and replaced by clean fill during the Removal Action.

PAHs represented less than 2 percent of the estimated risk or hazard indices in surface soil in the BLRA, and therefore, were not considered contaminants of concern for the Removal Action or the Residual Risk Assessment. PAHs were not analyzed for during the Removal Action, and PAH-contaminated soils detected during the RI field investigation have mostly been removed and replaced with clean fill during the Removal Action, reducing exposure risks at the site below the levels estimated in the BLRA. The limited data gaps for PAHs are not considered significant.

4.2 GROUNDWATER DATA EVALUATION

This section provides a discussion of the groundwater results from the PSF site and background wells in the Building 354 area.

The RI report (LAW, 1993a) was approved in April 1994. General comments included in the approval indicated concerns pertaining to detected concentrations of arsenic, beryllium, nitrate, and thallium in some PSF groundwater samples, and additional sampling was recommended. Except for nitrate, these constituents were detected infrequently at concentrations of concern during RI sampling, and available data presented in the RI report (LAW, 1993a) relating the detected range of PSF concentrations to local Fort Riley background concentrations were inconclusive. The data from the first four rounds of groundwater samples collected from the five PSF site wells (baseline and first three quarters) were used in the RI report (LAW, 1993a). Additional groundwater sampling and analyses of the wells (one background and four downgradient) at the PSF and two additional wells at the Building 354 area was performed in September 1994 to further confirm the previous infrequent detections of the inorganics in the on-site and background wells. The Building 354 area wells were sampled to provide additional background data for comparison with the on-site wells. The September 1994 data further confirmed the previous results, and it was concluded based on professional judgement that the inorganics of concern similarly detected infrequently at low concentrations in the on-site and background wells represented background conditions. It was also concluded that nitrate was a contaminant of concern, because nitrate was consistently detected in some on-site wells at concentrations exceeding background levels.

Following a review by USEPA and KDHE, it was requested that additional monitoring at the site be performed and a statistical evaluation of background and on-site groundwater concentrations be conducted. In response to the request, the additional monitoring round was performed in December 1995, and samples were collected from the PSF wells and the two wells in the Building 354 area. This sixth round was collected to further confirm the previous sampling results, and to provide the additional data set needed for a statistical comparison of the concentrations in the on-site and background wells.

Section 4.2.1 presents a discussion of the groundwater sampling results for selected inorganics of interest since the RI report (LAW, 1993a) was completed in 1993. The RI data are also included to provide a complete discussion of the sampling results at the PSF. Groundwater concentrations are also compared to the MCLs and to upgradient background concentrations. Section 4.2.2 summarizes the statistical evaluation, and the complete data report is included in Appendix C. A discussion of site-specific hydrogeology using groundwater elevations data obtained through the September 1994 sampling event is presented in Section 4.3. Water levels measured in December 1995 were compared with the previous data only to confirm that the water levels decreased in the direction of the Kansas River, as expected from previous sampling data.

4.2.1 Constituent Concentrations in Groundwater for Selected Inorganics

This section discusses the groundwater sampling results from September 1994 and December 1995 for selected inorganics of interest identified in the RI report (LAW, 1993a). The RI data are also included to provide complete discussions and comparisons of the results. A summary of the results obtained from the baseline (July 1992) through third quarter (May 1993) sampling events was presented in Table 1-3. Appendix D-1 of this report provides a positive analytical results summary for the baseline and four subsequent rounds of sampling at the five PSF site wells and a positive hits summary from the December 1995 sampling. Appendix D-2 provides the positive analytical results for the Building 354 area wells.

Twelve potential constituents of concern (COCs) were identified in groundwater in the BLRA. These constituents were:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Manganese
- Nitrate
- Selenium
- Thallium
- Vanadium

Aluminum and selenium were minor contributors to the noncarcinogenic risk in the BLRA and the September 1994 samples were consistent with the previous results. These potential constituents are, therefore, not included in the following discussion. Although inorganic chloride and sulfate were not COCs in the BLRA they were sampled in 1994 for comparison with previous data. Table 4-8 lists the potential COCs and provides analytical results (total and

TABLE 4–8

ANALYTICAL DATA SUMMARY TABLE
POTENTIAL CONSTITUENTS OF CONCERN IN GROUNDWATER
SAMPLED IN SEPTEMBER 1994 AND DECEMBER 1995
Pesticide Storage Facility
Fort Riley, Kansas

TEST METHOD/PARAMETER	PSF92–01		PSF92–02			PSF92–03	
	27–SEP–94	16–DEC–95	26–SEP–94	DUPLICATE [(1)] 26–SEP–94	18–DEC–95	27–SEP–94	18–DEC–95
E300							
Nitrate as N	5.9	4.2	9.2 JL	9.1 JL	9.0	11	15.1
Inorganic Chloride	31	NS	44	44	NS	47	NS
Sulfate	160	NS	240	230	NS	160	NS
SW6010/SW3005 (Dissolved)/(Total)							
Barium	0.13/0.14	NS	0.042/0.040	0.041/0.042	NS	0.058/0.059	NS
Beryllium	<0.0050*	<0.001*	<0.0050*	<0.0050*	<0.001*	<0.0050*	<0.001*
Cadmium	<0.0050*	<0.001*	<0.0050*	<0.0050*	<0.001*	<0.0050*	<0.001*
Chromium	<0.0032*	<0.002*	<0.0032*	<0.0032*	<0.002*	<0.0032*	<0.002/0.005
Manganese	<0.015*	NS	<0.015*	<0.015*	NS	0.021/0.021	NS
Vanadium	<0.050*	NS	<0.050*	<0.050*	NS	<0.050*	NS
SW7041/SW3020 (Dissolved)/(Total)							
Antimony	<0.0050*	<0.003*	<0.0050*	<0.0050*	<0.003*	<0.0050*	<0.003*
SW7060/SW3020 (Dissolved)/(Total)							
Arsenic	<0.010*	<0.005*	<0.010*	<0.010*	<0.005*	<0.010*	<0.005*
SW7841/SW3020 (Dissolved)/(Total)							
Thallium	<0.0010/0.0024	<0.001*	<0.0010*	<0.0010*	<0.003*	<0.0010*	<0.001*

All units in mg/L.
dissolved concentration/total concentration
* = Detection Limits for dissolved and total analyses were equal to the value listed.
(1) = Duplicate was not sampled in December 199 5.

DATA QUALIFICATION FLAGS
JL = Estimated quantitation; possibly biased low or a false negative based on QC data.
NS = Not Sampled or not reported.

TABLE 4–8

ANALYTICAL DATA SUMMARY TABLE
POTENTIAL CONSTITUENTS OF CONCERN IN GROUNDWATER
SAMPLED IN SEPTEMBER 1994 AND DECEMBER 1995

Pesticide Storage Facility
Fort Riley, Kansas

TEST METHOD/PARAMETER	PSF92–04		PSF92–05		B354–01 (TS0292–02)		B354–02 (TS0292–01)	
	27–SEP–94	17–DEC–95	27–SEP–94	17–DEC–95	28–SEP–94	17–DEC–95	28–SEP–94	16–DEC–95
E300								
Nitrate as N	12	11.9	9.4	5.6	<1.0	<0.1	10	8.1
Inorganic Chloride	49	NS	62	NS	100	NS	100	NS
Sulfate	100	NS	100	NS	<5.0	NS	130	NS
SW6010/SW3005 (Dissolved)/(Total)								
Barium	0.086/0.093	NS	0.12/0.12	NS	1.2/1.1	NS	0.063/0.059	NS
Beryllium	<0.0050*	<0.001*	<0.0050*	<0.001*	<0.005*	NS/<0.001	<0.005*	NS/<0.001
Cadmium	<0.0050*	<0.001*	<0.0050*	<0.001*	<0.005*	NS/<0.001	<0.005*	NS/<0.001
Chromium	<0.0032*	<0.002*	<0.0032*	<0.002*	<0.0032*	NS/<0.004	<0.0032*	NS/0.007
Manganese	<0.015*	NS	<0.015/0.017	NS	0.58/0.52	NS	0.083/0.083	NS
Vanadium	<0.050*	NS	<0.050*	NS	<0.050*	NS	<0.050*	NS
SW7041/SW3020 (Dissolved)/(Total)								
Antimony	<0.0050*	<0.003*	<0.0050*	<0.003*	<0.005*	NS/<0.003	<0.005*	NS/<0.003
SW7060/SW3020 (Dissolved)/(Total)								
Arsenic	<0.010*	<0.005*	<0.010*	<0.005*	0.0039/0.039	NS/0.049	<0.010*	NS/<0.005
SW7841/SW3020 (Dissolved)/(Total)								
Thallium	<0.0010*	<0.001*	0.0011/<0.0010	<0.001*	0.0026/0.001	NS/<0.001	0.0025/0.0025	NS/<0.001

All units in mg/L.
dissolved concentration/total concentration
* = Detection Limits for dissolved and total analyses were equal to the value listed.
(1) = Duplicate was not sampled in December 199 5.

DATA QUALIFICATION FLAGS
JL = Estimated quantitation; possibly biased low or a false negative based on QC data.
NS = Not Sampled or not reported.

dissolved) for these constituents from the September 1994 and December 1995 sampling events. Table 4-9 summarizes the analytical results from the background wells for the groundwater constituents identified as potential COCs in the BLRA. Concentrations detected in background well PSF92-01 during the first four sampling rounds, and sampling results from well PSF92-01 and the two wells at the Building 354 area, B354-01 (also known as TS0292-02) and B354-02 (also known as TS0292-01) from September 1994 and December 1995 are included in Table 4-9. Inorganic chloride and sulfate concentrations are also reported in the table. These three wells are not considered to be downgradient from the PSF or any identified inorganic contaminant sources and, therefore, representative of local background conditions. The locations of these wells are shown on Figure 4-5. Table 4-10 presents for comparison the maximum concentrations of these constituents detected in these background wells, the frequency of constituents detected in the downgradient wells, the range of detected concentrations observed during the sampling periods and the Maximum Contaminant Levels (MCLs). In general, in comparing the September 1994 and December 1995 results with the previous RI data, the inorganics were consistently detected infrequently at low concentrations in the background and on-site wells.

Total and dissolved metals were analyzed for comparison and are reported on Table 4-8. Dissolved metals are more representative of a filtered drinking water, and are expected to have concentrations not exceeding total levels, which are affected by the turbidity in the sample. Total and dissolved concentrations were comparable, except that, in some instances at concentration levels near the detection limit, dissolved metals were detected when total metals were not. It is not uncommon to observe positive detections for dissolved metals near the method detection limit when total metals were not detected when using the graphite furnace method of analysis (e.g., USEPA Method 7841 for thallium). This uncertainty also can result in reported concentrations for dissolved metals at concentrations slightly higher than the total metal results. Normal uncertainties and variations inherent in the analysis method result in allowed variations of plus or minus 10 percent at concentration levels greater than five times the method detection limit. As the metal concentration approaches the method detection limit, however, the uncertainty associated with each measurement increases. In general, a variation of two times the method detection limit can be expected and is considered within acceptable tolerances of current methods. Professional judgment, however, must also be considered, especially when additional constituents are present in the sample at concentrations known to cause interferences and possibly bias the analysis results. A discussion of the sampling results follows. The dissolved metals were not analyzed in the third round (February 1993) samples.

4.2.1.1 <u>Antimony</u> - Total antimony was detected twice during the first four sampling rounds, once in the background well PSF92-01 at a concentration of 0.022 mg/L (2/3/93) and once in PSF92-05 at a concentration of 0.032 mg/L (2/3/93). Total antimony was not detected from any PSF site well during the September 1994 sampling event and was not analyzed for in the Building 354 area wells. Total antimony was analyzed utilizing USEPA Method 6010 for the first four sampling rounds. This method had a detection limit of 0.031 mg/L during the baseline event (July 1992) and a detection limit of 0.022 mg/L during the first through third quarter (November 1992 - May 1993). The MCL for antimony established on January 17, 1994, at

TABLE 4-9

ANALYTICAL DATA SUMMARY OF BACKGROUND GROUNDWATER CONCENTRATIONS
Pesticide Storage Facility
Fort Riley, Kansas

	July 1992 Baseline(1)	November 1992 First(1) Quarter	February 1993 Second(1) Quarter	May 1993 Third(1) Quarter	September 1994	December 1995
Total Metals (mg/L):						
Antimony	<0.031	<0.022	0.022	<0.0022	<0.005 (1)	<0.003 (2)
Arsenic	<0.002	<0.002	<0.002	ND	<0.010-0.039 (2)	<0.005-0.049 (2)
Barium	0.1	0.12	0.16	0.2	0.14-1.1 (2)	NS (2)
Beryllium	0.0014	0.002	0.002	0.002	<0.005 (1)	<0.001 (2)
Cadmium	<0.005	<0.005	<0.005	0.004	<0.005 (1)	<0.001 (2)
Chromium	0.01	<0.010	<0.010	ND	<0.0032 (1)	<0.002-0.007 (2)
Manganese	0.026	0.024	0.022	0.034	<0.015-0.52 (2)	NS (2)
Thallium	<0.100	<0.063	<0.063	<0.001	0.0024-0.0026 (2)	<0.001 (2)
Vanadium	0.0083	0.011	0.006	ND	<0.050 (1)	NS (2)
Wet Chemical Inorganics (mg/L):						
Nitrate (as N)	4.5	3.8	6.4	2.2	5.9-10.0 (2)	0.1-8.1 (2)
Inorganic Chloride	10.3	63.5	129	147	31-100 (2)	NS
Sulfate	84.7	70.8	52.2	52.9	130-160 (2)	NS

(1) Data from Well PSF92-01 only.

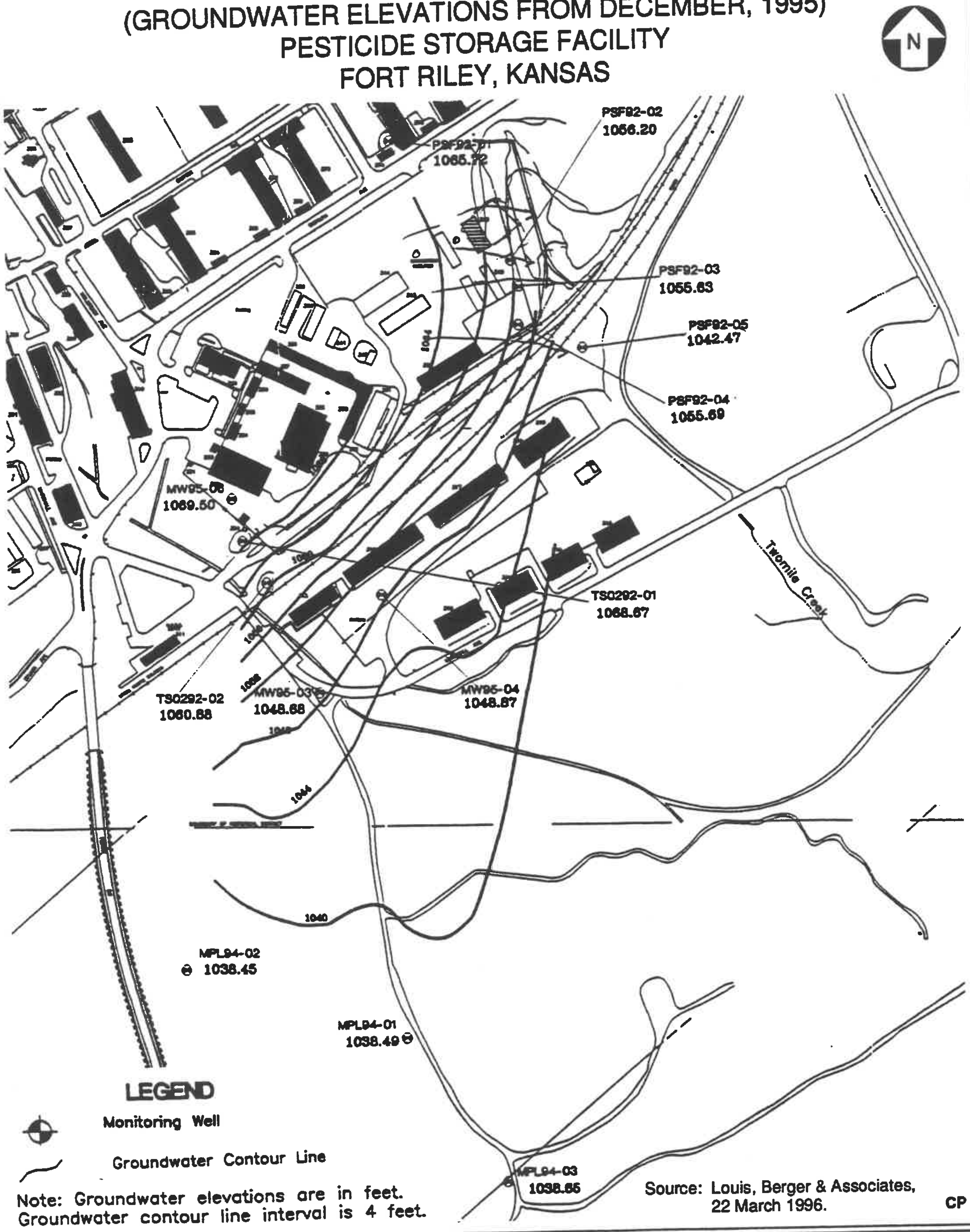
(2) Range includes samples from Well PSF92-01 and the Wells B354-01 (TS0292-02) and B354-02 (TS0292-01) sampled at Building 354 area.

NS Not sampled

FIGURE 4-5

LOCATION OF SITE AND BACKGROUND WELLS

(GROUNDWATER ELEVATIONS FROM DECEMBER, 1995)
PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



Note: Groundwater elevations are in feet.
Groundwater contour line interval is 4 feet.

Source: Louis, Berger & Associates, 22 March 1996.

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TABLE 4–10

SUMMARY AND COMPARISON WITH BACKGROUND AND MAXIMUM CONTAMINANT LEVELS
JULY 1992 THROUGH DECEMBER 1995 SAMPLES
Pesticide Storage Facility
Fort Riley, Kansas

		Background Wells	On–Site Wells		
Parameter	Method Detection Limit	Maximum Concentration Detected(a)	Frequency of Detection (b,c)	Range of Detected Concentrations(c)	MCL Concentration(e)
Total Metals (mg/L):					
Antimony	0.003–0.031	0.022	1/24	<0.003 – 0.03	0.006
Arsenic	0.002–0.010	0.049	5/24	< 0.002 – 0.01	0.05
Barium	0.005	1.1 (d)	20/20 (d)	0.042 – 0.13	2
Beryllium	0.001–0.005	0.002	15/24	< 0.001 – 0.00	0.004
Cadmium	0.001–0.005	0.004	2/24	< 0.001 – 0.006	0.005
Chromium	0.002–0.01	0.01	3/24	< 0.002 – 0.01	0.1
Manganese	0.015	0.52 (d)	18/20 (d)	<0.015 – 0.09	0.05 (s)
Thallium	0.001 – 0.100	0.0025	2/24	< 0.001 – 0.00	0.002
Vanadium	0.007 – 0.050	0.011 (d)	4/20 (d)	< 0.007 – 0.02	NE
Wet Chemical Inorganics (mg/L):					
Nitrate (as N)	0.1–0.2	10.0	23/24	<0.2 – 165	10
Inorganic Chloride	0.2 – 5	147 (d)	20/20 (d)	38.5 – 399	250 (s)
Sulfate	0.2 – 25	160 (d)	20/20 (d)	100 – 386	250 (s)

ND = Not detected at concentrations greater than or equal to the Method Detection Limit.
NE = MCL not established for this constituent.
(a) Includes concentrations detected in Well PSF92–01 during the six sampling rounds at the PSF and the Building 354 Wells B354–01 (TS029202) and B354–02 (TS029201) sampled September 1994 and December 1995.
(b) Frequency does not include the detections in the background wells PSF92–01 and TS0292–01 and TS02–92 at Building 354. Number of samples in which the chemical was positively detected divided by the number of samples available.
(c) Frequency and range of detected concentrations in Wells PSF92–02, PSF92–03, PSF92–04, and PSF92–05.
(d) This constituent was not sampled in December 1995.
(e) Drinking Water Regulations and Health Advisories, EPA 822–R–96–001, February 1996.
(s) Secondary Maximum Contaminant Level (MCL).

0.006 mg/L, and Method 6010 used previously, was changed to Method 7041 to provide a lower detection limit. During the September 1994 sampling event, USEPA Method 7041 was used which had a lower detection limit of 0.005 mg/L. In December 1995, USEPA Method 7041 was again used and resulted in a detection limit of 0.003 mg/L. Antimony was not detected in any PSF or background wells in December 1995. Antimony was not considered a COC in the BLRA presented in the RI report (LAW, 1993a). Antimony is reviewed further in this RI Addendum, because total concentration detected once in the background well and once in an on-site well exceeded the revised MCL. Because antimony has not been detected using USEPA Method 7041, the previous results are not considered significant.

Dissolved antimony was not detected during the baseline through second sampling rounds in the background well PSF92-01. Note that during the third sampling round (February 1993), total antimony was detected at 0.022 mg/L from well PSF92-01. Dissolved antimony was analyzed for using USEPA Method 6010 for the first three sampling rounds with the higher detection limit as for total antimony. Dissolved antimony was detected in well PSF92-03 at 0.028 mg/L during the third round, while total antimony was not detected from this well. The dissolved detection for antimony in the absence of a total detected concentration is not considered significant, because the 0.028 mg/L is near the method detection limit of 0.022 mg/L and such detections are not uncommon near the method detection limit. Additionally, antimony was detected at a similar total concentration in the background well, and was not detected in any site or background wells during the most recent sampling rounds which had a lower detection limit. Dissolved antimony concentrations detected in well PSF92-03 and once in well PSF92-05 only during the second round exceeded the revised MCL.

Dissolved antimony was detected at 0.036 mg/L from well PSF92-05 during the second round (February 1993), which is consistent with the total concentration (0.032 mg/L) result from this well. Dissolved antimony was not detected in September 1994 from any PSF wells, and was not analyzed for in the Building 354 area well samples. Dissolved antimony was not detected in any PSF or Building 354 area wells in December 1995. The September 1994 and December 1995 samples were analyzed using USEPA Method 7041, with resulting detection limits of 0.005 mg/L and 0.003 mg/L, respectively.

Antimony was not detected in the soil samples analyzed from the background well PSF92-01 pilot hole, and was not sampled in on-site soils.

4.2.1.2 Arsenic - Total arsenic concentrations detected in the site wells have decreased consistently from the baseline through third quarter sampling event. Total arsenic was only detected in well PSF92-05 during the baseline (July 1992), first quarter (November 1992) and second quarter (February 1993) samples at 0.016, 0.0044, and 0.0038 mg/L, respectively. The September 1994 data continued this decline, with all wells analyzing at nondetect. Consistent with the September 1994 data, total arsenic was not detected in the December 1995 PSF samples above the detection limit of 0.005 mg/L. Total arsenic was detected in background well B354-01 (TS0292-02) at 0.049 mg/L in December 1995. Total arsenic concentrations did not exceed the MCL (0.050 mg/L) in any samples.

Dissolved arsenic was only detected in well PSF92-05 during the baseline (July 1992), first quarter (November 1992) and second quarter (February 1993) sampling events. Dissolved concentrations were 0.015, 0.0043, and 0.0028 mg/L, respectively, and dissolved arsenic was not detected in any PSF wells during the September 1994 and December 1995 rounds. Total arsenic detections in well PSF92-05 exceeded dissolved concentrations during these three sampling events, and were reported at 0.016, 0.0044, and 0.0038 mg/L, respectively. Dissolved arsenic was detected in background well B354-01 (TS0292-02) in September 1994 at 0.039 mg/L, and the total arsenic concentration was also 0.039 mg/L. The dissolved arsenic concentration was not reported for this well in December 1994, and total arsenic was 0.049 mg/L.

In soils, arsenic exceeded the maximum background concentration (7.1 mg/kg) in 4 of 31 soil samples collected during the RI and Removal Action. The highest detected concentration was 20 mg/kg from a single sample. Soil from this area was removed during the Removal Action. Dissolved arsenic concentrations did not exceed the MCL (0.050 mg/L) in any samples.

4.2.1.3 Barium - Total barium was detected in the background and all downgradient wells during all five sampling rounds. As seen in Tables 4-9 and 4-10, background barium concentrations varied from 0.1 mg/L to 1.1 mg/L, and on-site well concentrations ranged from 0.042 mg/L to 0.13 mg/L. Concentrations of total barium remained consistent with background conditions and baseline concentrations. Barium was not analyzed in the December 1995 sampling event. Total barium concentrations did not exceed the MCL of 2.0 mg/L in any samples.

Dissolved barium concentrations were consistently detected as were total concentrations, and the analytical results were consistent with total barium concentrations. In the background wells, dissolved barium concentrations ranged from 0.063 mg/L to 1.2 mg/L. On-site concentrations varied from 0.041 mg/L to 0.140 mg/L. Dissolved barium concentrations were below the MCL in all samples.

Barium was consistently detected in the Fort Riley background soil samples. Barium levels in site soils were consistent with background conditions.

4.2.1.4 Beryllium - Total beryllium was detected in 15 of the 24 samples at concentrations ranging from 0.001 to 0.005 mg/L. Total beryllium exceeded the MCL (0.004 mg/L) in one sample (0.005 mg/L) collected from well PSF92-02 during the second round sampling event (February 3, 1993). Note that the duplicate sample had a concentration of 0.004 mg/L for this sample, equal to the MCL. Total beryllium concentrations from well PSF92-02 were consistently detected at concentration levels of 0.002 to 0.003 mg/L during the other four sampling events. During the September 1994 and December 1995 sampling events, beryllium was not detected in the background wells and not detected in any downgradient PSF wells above the detection limit (0.001 mg/L) resulting from USEPA Method 6010A. The background well

PSF92-01 had previous beryllium detections which varied from 0.0014 to 0.002 mg/L, with 0.002 mg/L being recorded in three of the six samples. These concentration levels detected in the background well were consistently comparable with the other detections observed from the on-site wells. Considering the narrow range of detected concentrations (small standard deviation), the single exceedance of the MCL and that beryllium was not detected in any wells in September 1994 or December 1995, beryllium can be attributed to natural background conditions.

Dissolved beryllium concentrations were generally consistent with total concentrations. Dissolved beryllium was not detected in well PSF92-01 during the baseline (July 1992) sampling event, while total beryllium was detected at 0.0014 mg/L. In six samples, dissolved beryllium concentrations slightly exceeded total concentrations; (e.g., dissolved beryllium was 0.003 mg/L while total beryllium was 0.002 mg/L in well PSF92-01 during the third quarter). The dissolved beryllium concentration in well PSF92-02 was equal to the total concentration (0.005 mg/L) during the second round. The duplicate sample also had 0.004 mg/L, equal to the total concentration. Beryllium concentrations recorded in all samples were close to the detection limit, and as discussed previously, these results are not uncommon under the circumstances. Dissolved beryllium exceeded the MCL concentration in the single sample from well PSF92-02.

Beryllium was not analyzed in soil samples at the site as sources relative to the past operational practices at the site were not identified, and contamination was not expected.

4.2.1.5 Cadmium - Total cadmium was only detected during the third quarter sampling event in wells PSF92-01 (background), PSF92-04, and PSF92-05 at concentrations of 0.004 mg/L, 0.004 mg/L, and 0.006 mg/L, respectively. Total cadmium was not detected during the September 1994 sampling round. The December 1995 samples were consistent with the 1994 results, that is, total cadmium was not detected in any PSF wells or background wells above the method detection limit of 0.001 mg/L. The single sample at 0.006 mg/L slightly exceeded the MCL concentration (0.005 mg/L).

Dissolved cadmium was not reported for the third quarter samples; therefore, comparisons with total concentrations are not available. Consistent with the total concentrations, dissolved cadmium was not detected in any samples from the PSF or Building 354 area wells during sampling rounds.

In soils cadmium was detected in 3 of 38 RI samples at a maximum concentration of 5 mg/kg.

4.2.1.6 Inorganic Chloride - Inorganic chloride exceeded the maximum detected background concentrations of 147 mg/L in three of the five samples collected from well PSF92-02 during the five sampling rounds. The maximum detected concentration was 399 mg/L in the third quarter (May 1993) samples. The maximum detected background concentration for inorganic chloride was not exceeded by samples collected from wells PSF92-03, PSF92-04, and PSF92-05 during the five sampling rounds. Inorganic chloride was not sampled in December 1995. Inorganic chloride was not analyzed in site soil samples.

4.2.1.7 Chromium - Total chromium was detected once in the background well PSF92-01 at 0.010 mg/L during the baseline sampling event and twice in downgradient well PSF92-02 during the first four sampling rounds. The detections were 0.012 mg/L during baseline, and 0.014 mg/L during the third quarter (May 1993) sample. Both of these detections were in the duplicate samples only. Total chromium was not detected during the September 1994 sampling round. In December 1995, total chromium was detected in well PSF92-03 at 0.005 mg/L. Total chromium was not detected in any other on-site wells in December 1995, but was detected in the background wells at Building 354 at comparable concentrations. In well B354-01 (TS0292-02) total chromium was detected at 0.004 mg/L. This metal was also detected at 0.007 mg/L in B354-02 (TS0292-01).

Dissolved chromium was not detected in any PSF or Building 354 area samples during any sampling rounds. These results, and the detections of total chromium only in the duplicate samples, suggest that the total chromium detections were related to the presence of solids in the samples.

In soils sampled for the RI, chromium exceeded the maximum detected background concentration (9.3 mg/kg) in 14 of 56 samples. The maximum detected concentration was 41 mg/kg, prior to the Removal Action. Concentrations in 12 of these samples did not exceed 15 mg/kg, and a single sample was detected at 20 mg/kg. These concentrations are slightly above the maximum background level and the exposure point concentration, prior to the Removal Action was 9.7 mg/kg in subsurface soil (LAW, 1993a). Soil was removed from the location where the 41 mg/kg sample was collected during the Removal Action.

4.2.1.8 Manganese - As discussed in Section 1.5.3, concentrations of total manganese in baseline through third quarter samples in the on-site wells were slightly above measured background concentrations, and the concentrations of total manganese were consistent between sampling events. Total manganese was detected in the September 1994 sampling event at concentrations consistent with baseline concentrations and the background conditions. In downgradient wells, total manganese was only detected at 0.021 mg/L in well PSF92-03; at 0.017 mg/L in well PSF92-05. In background wells, manganese exceeded the secondary MCL, at 0.52 mg/L in well B354-01 (TS0292-01); and at 0.079 mg/L in well B354-02 (TS0292-01). Total manganese was not detected in well PSF92-01 in September 1994, but was consistently detected in this well in the previous four rounds at concentrations from 0.022 mg/L to 0.0034 mg/L. As manganese has been consistently detected during the previous sampling events, manganese was not analyzed for in the December 1995 samples. Data available from five sampling rounds conducted at the PSF shows that manganese levels in downgradient wells were detected at concentrations less than 0.52 mg/L in 20 out of 20 samples, and only the baseline (July 16, 1992) sample from well PSF92-03, at 0.091 mg/L exceeded the 0.079 mg/L concentration. This data indicates that manganese levels observed at the PSF can be attributed to natural background levels. Baseline and third quarter samples from well PSF92-02 (0.056 and 0.052 mg/L, respectively) slightly exceeding the secondary MCL (0.05 mg/L) and baseline through second quarter samples from well PSF92-03, at 0.091 mg/L, 0.071 mg/L, and 0.070 mg/L, respectively, also exceeded the secondary MCL. No other samples in on-site wells exceeded the secondary MCL. Secondary MCLs are used to define the aesthetic quality of drinking water and are not enforceable standards.

Dissolved manganese detections were consistent with total manganese concentrations, and were usually equal to or slightly less than the total concentrations, as expected. In five samples dissolved manganese slightly exceeded total manganese, but the difference was not considered significant, for the reasons discussed previously. In the September 1994 sample total manganese was detected in well PSF92-05 at 0.017 mg/L, while dissolved manganese was not detected above the detection limit of 0.015 mg/L. In the Building 354 area background wells, dissolved manganese was detected at 0.58 mg/L in well B354-01 (TS029-02) and at 0.083 mg/L in well B354-02 (TS092-01). Dissolved manganese samples exceeded the secondary MCL consistent with the total concentration samples.

In soils, manganese was detected at 120 and 130 mg/kg in the PSF background well pilot hole soil boring. Manganese was not analyzed for in soils at the site.

4.2.1.9 Nitrate - First quarter, third quarter, and September 1994 nitrate concentrations were consistent with baseline concentrations. During the second quarter, nitrate showed an increase from two and one-half to five times in all samples except PSF92-01. However, as discussed in Section 1.5.3, discrepancies were noted for nitrate in one water sample, and the second quarter nitrate results were not confirmed by the Corps of Engineers - Missouri River Division (CEMRD) QA lab (CEMRD, 1993). A laboratory QA sample from this second quarter for nitrate was also reported at a concentration of less than 0.01 mg/L when the sample result was reported at 50.6 mg/L. Thus, uncertainty pertaining to these elevated second quarter results exists. The second quarter nitrate results are an anomaly not consistent with typical site conditions. The September 1994 results for nitrate confirmed that the high levels of nitrates observed during the second quarter (February 1993) are not consistently present in the PSF aquifer. The federal MCL for nitrate (10 mg/L as N) was exceeded by several PSF samples. Baseline through third quarter samples from well PSF92-02 at 33 mg/L, 20.3 mg/L, 165 mg/L, and 25 mg/L, respectively, exceeded the standard. In well PSF92-03, all samples, from baseline through December 1995 exceeded the standard, at 11.6 mg/L, 11.1 mg/L, 50.6 mg/L, 15.5 mg/L, 11 mg/L, and 15.1 mg/L. In well PSF92-04, nitrate was not detected in the baseline (July 1992) sample, but was detected at 13.8 mg/L, 65.6 mg/L, 12.2 mg/L, and 12 mg/L in first quarter through September 1994 samples, and at 11.9 mg/L in December 1995. In well PSF92-05, nitrate concentrations during baseline through third quarter samples were 18.4 mg/L 10.7, 45.9, and 10.6 mg/L. September 1994 results at 9.4 mg/L and December 1995 results, at 5.6 mg/L were less than the MCL. In summary the MCL was exceeded in 19 of 24 samples. Nitrate concentrations measured in the December 1995 samples were consistent with the previous sampling rounds (excluding the February 1993 data). One exception was the lower concentration recorded in PSF92-02 (9 mg/L). Nitrate was not detected in background well B354-01 (TS0292-02) above 0.1 mg/L, but was detected at 8.1 mg/L in well B354-02 (TS0292-01). These results are consistent with the September 1994 results, when nitrate was not detected in well 354-01 and was detected at 10 mg/L in well B354-02. Background well PSF92-01 nitrate concentrations ranged from 2.2 mg/L (third quarter, May 1993) to 6.4 mg/L (second quarter, February 1993). December 1995 results were 4.2 mg/L.

Nitrate was not analyzed for in the PSF soil samples, as sources relative to the past operational practices at the site were not identified, and contamination was not expected.

4.2.1.10 Sulfate - The maximum detected background concentration for sulfate was 160 mg/L collected from well PSF92-01 during the September 1994 sampling round. This background concentration was not exceeded by samples collected from PSF92-04 or PSF92-05 during the five sampling rounds. The maximum detected background concentration for sulfate was exceeded by five of five samples from PSF92-02 and four of five samples from PSF92-03. In well PSF92-02 concentrations ranged from 199 mg/L (third round May 1993) to 386 mg/L (baseline July 1992), while in well PSF92-03 concentrations varied from 148 mg/L (third round May 1993) to 197 mg/L (first round November 1992). Sulfate was not analyzed for in any of the December 1995 samples. Sulfate concentrations range from nondetect in well B354-01 (TS0292-02) to 160 mg/L in well PSF92-01. Baseline through second quarter sulfate concentrations in well PSF92-02 exceeded the secondary MCL (250 mg/L) at 356 mg/L, 336 mg/L, and 326 mg/L, respectively. No other samples taken from this or any other wells exceeded the secondary MCL.

4.2.1.11 Thallium - Total Thallium was analyzed utilizing USEPA Method 7060, with a detection limit from 0.063 to 0.100 mg/L, during the first three sampling rounds (baseline and first two quarters) and was not detected. After the second quarter samples were collected, the MCL for thallium was lowered to 0.002 mg/L, and the method of analysis for the third quarter was changed to USEPA Method 7841, with a detection limit of 0.001 mg/L. At this lower detection limit, total thallium was observed in two downgradient wells during the third quarter sampling event (PSF92-02 at 0.0029 mg/L and PSF92-03 at 0.0025 mg/L). In September 1994 total thallium was analyzed using USEPA Method 7841 with a detection limit of 0.001 mg/L and was detected in the background well PSF92-01 at a concentration of 0.0024 mg/L. Dissolved thallium was not detected in this well during the September 1994 sampling event. Total thallium was not detected in the four downgradient PSF wells; however, dissolved thallium was reported at 0.0011 mg/L in well PSF92-05, just above the laboratory reporting limit (0.001 mg/L). During September 1994, total thallium was not detected in well B354-01 (TS0292-02) while dissolved thallium was detected at 0.0026 mg/L in the sample from this well. Total thallium was also detected at 0.0025 mg/L in well B354-02 (TS0292-01). Total thallium was analyzed in December 1995 (sixth round) samples using USEPA Method 7841, as in 1994, with a method detection limit of 0.001 mg/L, and was not detected in any samples. These results indicated that total thallium was detected at similar concentrations and frequencies in the upgradient and downgradient wells at the site.

Dissolved thallium was only analyzed for in the baseline and first quarter samples from well PSF92-02 during the first three rounds, and not detected. Note that USEPA Method 7060 with the higher detection limits was used for the analyses, as for total thallium. USEPA Method 7841 with the lower detection limit was used for the fourth quarter, September 1994 and December 1995 samples. Dissolved thallium was not analyzed in third quarter samples, and dissolved comparisons to the total concentrations detected in wells PSF92-02 and PSF92-03 are not available. Dissolved thallium was not detected in well PSF92-01 (a background well) during September 1994, while total thallium was detected at 0.0024 mg/L. In well PSF92-05 dissolved thallium was detected at 0.0011 mg/L, slightly above the detection limit of 0.001 mg/L, while total thallium was not detected. As noted previously, dissolved thallium was also detected at 0.0026 mg/L in well B354-01 (TS0292-02) while total thallium was not detected. Dissolved thallium was also detected at 0.0025 mg/L in well B354-02 (TS0292-01) in September 1994, consistent with the total thallium detection. Dissolved thallium was not detected in any wells in December 1995.

Analysis for thallium is complicated by several additional factors including spectral and chemical interferences, as noted in Winge, et al. (1985). Thallium is typically analyzed at 276.79 nanometers (nm). At this wavelength, there are spectral interferences from iron (276.75 nm) and magnesium (276.85 nm). These interferences are very common components of soil and water and known to be prevalent in the Fort Riley area. The presence of these interferences may cause thallium results to be positively biased at concentrations near the detection limit. High levels of calcium, magnesium, and sodium may also indicate the presence of chloride which is a chemical interferant for thallium. Chloride may cause "smoke" during the analysis or other surface effects which could also produce positive bias for thallium results. At Fort Riley, interferences caused by high background levels of calcium (180 to 300 mg/L), magnesium (28 to 50 mg/L), and sodium (52 to 130 mg/L) were noted in the May 5-6, 1993 (third quarter) samples from wells PSF92-02 and PSF92-03. As stated in the September 10, 1993 case narrative letter provided in Appendix L of the RI report (LAW, 1993a), the well PSF92-02 and duplicate (PSF92-06) samples from this well were reported at 0.0029 and 0.0016 mg/L, respectively, during reanalysis of these samples. The original analyses of these samples were reported at 0.0017 mg/L and nondetect, respectively. Results from well PSF92-03 were reported at 0.0013 mg/L during reanalysis, and 0.0025 mg/L from the original analysis as discussed in the case narrative letter.

The best technology currently available for reduction of these interferences is the use of Zeeman background correction and innovative use of matrix modifiers. The classical modifier for thallium is sulfuric acid, but it does not yield the best results. In recent years, palladium or nickel nitrate have been found to guarantee better results. In 1993, the PSF samples were analyzed using sulfuric acid as the modifier. Samples from September were analyzed using a mixture of palladium and magnesium nitrate as a modifier for thallium. Therefore, the 1994 sampling results are likely to have less uncertainty than the 1993 analyses, due to better control of interferences. Interferences as discussed, however, still result in uncertainty and the results reported may be positively biased at levels near the detection limit.

Total thallium was detected in the background well during the September 1994 sampling event, at a concentration similar to the previous downgradient concentrations, thus indicating that thallium levels above MCLs may be naturally occurring background conditions at the PSF. Additional evidence of these background concentrations in Fort Riley groundwater was observed in groundwater sampling conducted at other areas of Fort Riley. Thallium was detected at comparable levels in three wells representing background conditions in the Southwest Funston Landfill area. These were at well SFL92-102 sampled October 28, 1994, with a dissolved thallium level of 0.0011 mg/L; well SFL92-303, sampled May 6, 1993, with a total thallium concentration of 0.0017 mg/L, and well AEHA-MW5, at 0.001 mg/L dissolved thallium, sampled on September 14, 1993. Thallium was also detected in the Building 354 area wells on September 28, 1994; well TS029201 at 0.0025 mg/L when sampled for both dissolved and total thallium, and well TS029202 at 0.0026 mg/L dissolved thallium. Thallium was not detected in any background or on-site wells in December 1995. These results further confirm that the thallium levels observed at the PSF area represent background conditions occurring at Fort Riley.

Thallium was not analyzed for in the PSF soil samples, as sources relative to the past operational practices at the site were not identified, and contamination was not expected. Thallium was not detected in Fort Riley background soil samples as noted in Section 2.1. No documented uses of thallium-based pesticide compounds (such as thallium sulfate) were identified at the PSF site, and thallium contamination was not expected at this site.

4.2.1.12 Vanadium - Total vanadium has been detected a total of eight times at the PSF with concentrations ranging from non-detect to 0.027 mg/L in downgradient wells during baseline through third quarter sampling events. Total vanadium was detected in background well PSF92-01 at 0.0083 mg/L during baseline, at 0.011 mg/L during first quarter, and at 0.006 mg/L during second quarter sampling events. Total vanadium was not detected in any samples from well PSF92-02. Total vanadium was also detected during the second quarter at 0.008 mg/L in well PSF92-03, third quarter at 0.009 mg/L from well PSF92-04, and in well PSF92-05 at concentrations of 0.027, 0.012, and 0.014 mg/L during baseline, first and second quarter sampling rounds, respectively. The 0.009 mg/L sample result was an estimated concentration, as vanadium was indicated in the method blank for this sample. Total vanadium was not detected in the background well PSF92-01 or any on-site wells during fourth quarter, September 1994, or December 1995 sampling rounds. Concentrations of total vanadium remained consistent with background conditions. Vanadium was not analyzed for the September 1994 or December 1995 samples from wells B354-01 (TS0292-02) and B354-02 (TS0292-01). An MCL for vanadium is not available for comparison with the on-site well concentrations, and this constituent is evaluated further in the RRA presented in Section 5.2.

Dissolved vanadium was detected in one sample from the background well PSF92-01 at 0.007 mg/L during the second quarter. Total vanadium was detected in this well during baseline, first, and second quarter sampling rounds as discussed previously. In well PSF92-04, dissolved vanadium was detected at 0.011 mg/L, which slightly exceeded the total concentration, which was estimated as discussed above. Dissolved vanadium results in well PSF92-05 were consistent with the total vanadium concentrations, and were 0.024 mg/L, 0.014 mg/L, and 0.007 mg/L, for baseline, first quarter, and second quarter samples, respectively. Dissolved vanadium was not analyzed in the September 1994 samples collected from the Building 354 area wells. Dissolved vanadium was not analyzed for in any December 1995 samples.

In soils, vanadium was detected at 13 and 15 mg/kg in the pilot hole soil boring samples at well PSF92-01. Vanadium was not analyzed for in PSF soils.

4.2.1.13 Pesticides - Pesticides were not detected in PSF groundwater above the laboratory reporting limit during any of the sampling rounds through the September 1994 sampling event. Pesticides were not sampled for in December 1995.

4.2.2 Statistical Comparison of Specific Inorganics in Groundwater to Background Concentrations

This section summarizes the results of a statistical comparison of the analytical data for specific inorganic compounds that were detected in the groundwater at the PSF to concentrations detected in background wells. The statistical evaluation was performed by the U.S. Army Corps of Engineers - Kansas City District, the results of which are provided in Appendix C. The purpose of the evaluation was to provide statistical evidence as to whether on-site concentrations of the specified compounds are equivalent to the detected background concentrations. Information pertaining to background concentrations are provided in Table 4-9 while information pertaining to on-site concentrations are provided on Table 4-10. The results of the evaluation are summarized in this section.

4.2.2.1 Background Information - The inorganic compounds included in the statistical comparison were antimony, arsenic, beryllium, cadmium, manganese, nitrate, and thallium. These seven inorganic compounds were included in the statistical comparison because they met one of the following criteria:

- A calculated hazard quotient that was greater than 1 (from results of the baseline risk assessment [RI report; LAW, 1993a]) (arsenic, manganese, nitrates, and thallium)
- A calculated risk that was greater than 1 X 10^{-6} (from results of the baseline risk assessment [RI report; LAW, 1993a]) (arsenic and beryllium)
- An exceedance of an MCL (antimony, beryllium, cadmium, nitrate, and thallium)

4.2.2.2 Evaluation Methodology - Six rounds of groundwater data were used in the statistical evaluation, with the first samples obtained in July 1992, and the most recent samples obtained in December 1995. Data for the seven inorganic compounds of interest from PSF wells PSF92-02 through PSF92-05 were statistically compared to background wells PSF92-01, B354-01, and B354-02. The data used to conduct the statistical evaluation is presented in Tables 4-11 through 4-17.

As per current risk assessment guidance, proxy concentrations of one-half the detection limit were used for nondetect results (USEPA, 1989a). Statistical calculations revealed that the total and dissolved concentrations in each well were equivalent; therefore, total and dissolved results were combined into one data set for each well.

The three background wells used in the statistical evaluation were selected based on the following criteria:

- Same hydrogeologic unit as the site wells
- Hydraulically isolated from the site
- Not hydraulically downgradient from known inorganic contaminant sources
- No evidence of past or present operations that would produce contamination at the specific well locations

The statistical evaluation was designed to test the hypothesis that the distribution of concentrations of inorganics in wells on site were the same as the distribution of concentrations in background wells. Because falsely rejecting the hypothesis that the concentrations detected in site wells are equivalent to the concentrations detected in the background wells (i.e., a false negative error) was a high priority for the statistical evaluation, the level of significance was chosen to be 0.01. That is, the design of the statistical evaluation was constructed so that the probability of incorrectly concluding that the concentrations of the inorganics detected in the site wells equivalent to the concentrations detected in the background wells was 1 percent (the definition of level of significance is found in Appendix C).

Several statistical tests were used in this evaluation. One test, the Kruskal-Wallis Test, was used to compare all wells simultaneously in order to determine if all wells were part of the same distribution. In other words, the Kruskal-Wallis Test was used to determine if the concentrations of inorganics in the on-site wells were the same (i.e., within the same "range") or different from those in the background wells. If concentrations detected in the on-site wells were shown to be statistically different from the background wells, then it might be reasonable to conclude that site-related conditions were contributing to elevated concentrations of inorganics in the groundwater.

The second statistical test used in this study, the Mann-Whitney Test, was used to compare the total (unfiltered) metals results with the dissolved (filtered) metals results for each well. The

TABLE 4-11

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility

Fort Riley, Kansas

ANTIMONY (µg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92	-	-	<31 TOT <31 DIS	<31 TOT DUP <31 DIS DUP <31 TOT <31 DIS	<31 TOT <31 DIS	<31 TOT <31 DIS	<31 TOT <31 DIS
11/5/92			<22 TOT <22 DIS	<22 TOT <22 DIS <22 TOT DUP <22 DIS DUP	<22 TOT <22 DIS	<22 TOT <22 DIS	<22 TOT <22 DIS
2/3/93			22 TOT <22 DIS	<22 TOT DUP <22 DIS DUP <22 TOT <22 DIS	<22 TOT 28 DIS	<22 TOT <22 DIS	32 TOT 36 DIS
5/6/93			<56 TOT	<56 TOT DUP <56 TOT	<56 TOT	<56 TOT	<56 TOT
9/27/94	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS <5 TOT DUP <5 DIS DUP	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
12/17-18/95			<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 6 µg/L

Source: USACOE, 1996.

TABLE 4-12

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

ARSENIC (µg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92	-	-	<2 TOT <2 DIS	<2 TOT DUP <2 DIS DUP <2 TOT <2 DIS	<2 TOT <2 DIS	<2 TOT <2 DIS	16 TOT 15 DIS
11/5/92	-	-	<2 TOT <2 DIS	<2 TOT <2 DIS <2 TOT DUP <2 DIS DUP	<2 TOT <2 DIS	<2 TOT <2 DIS	4.4 TOT 4.3 DIS
2/3/93			<2 TOT <2 DIS	2.7 TOT DUP <2 DIS DUP <2 TOT <2 DIS	<2 TOT <2 DIS		3.8 TOT 2.8 DIS
5/6/93			<2 TOT	<2 TOT DUP <2 TOT	<2 TOT	<2 TOT	3.8 TOT
9/27/94	39 TOT 39 DIS	<10 TOT <10 DIS	<10 TOT <10 DIS	<10 TOT <10 DIS <10 TOT DUP <10 DIS DUP	<10 TOT <10 DIS	<10 TOT <10 DIS	<10 TOT <10 DIS
12/17-18/95			<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 50 µg/L

Source: USACOE, 1996.

TABLE 4-13

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

BERYLLIUM (µg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92			1.4 TOT <1.0 DIS	2.8 TOT DUP 2.9 DIS DUP 3.0 TOT 3.0 DIS	1.5 TOT 1.6 DIS	1.4 TOT 1.6 DIS	1.6 TOT 1.5 DIS
11/5/92			2.0 TOT 1.0 DIS	3.0 TOT 2.0 DIS 2.0 TOT DUP 3.0 DIS DUP	2.0 TOT 2.0 DIS	1.0 TOT 1.0 DIS	2.0 TOT 2.0 DIS
2/5/93			2 TOT 3 DIS	4 TOT DUP 4 DIS DUP 5 TOT 5 DIS	2 TOT 3 DIS	2 TOT 2 DIS	3 TOT 2 DIS
5/6/93			2 TOT	3 TOT DUP 3TOT	2 TOT	<2 TOT	2 TOT
9/27/94	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS <5 TOT DUP <5 DIS DUP	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
12/17-18/95			<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 4 µg/L

Source: USACOE, 1996.

TABLE 4-14

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

CADMIUM (μg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92			<5 TOT <5 DIS	<5 TOT DUP <5 DIS DUP <5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5DIS	<5 TOT <5 DIS
11/5/92			<5 TOT <5 DIS	<5 TOT <5 DIS <5 TOT DUP <5 DIS DUP	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
2/3/93			<5 TOT <5 DIS	<5 TOT DUP <5 DIS DUP <5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
5/6/93			4 TOT	<4 TOT DUP <4 TOT	<4 TOT	4 TOT	6 TOT
9/27/94	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS <5 TOT DUP <5 DIS DUP	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
12/17-18/95			<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 5 μg/L

Source: USACOE, 1996.

TABLE 4-15

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

ANTIMONY (µg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92	-	-	<31 TOT <31 DIS	<31 TOT DUP <31 DIS DUP <31 TOT <31 DIS	<31 TOT <31 DIS	<31 TOT <31 DIS	<31 TOT <31 DIS
11/5/92			<22 TOT <22 DIS	<22 TOT <22 DIS <22 TOT DUP <22 DIS DUP	<22 TOT <22 DIS	<22 TOT <22 DIS	<22 TOT <22 DIS
2/3/93			22 TOT <22 DIS	<22 TOT DUP <22 DIS DUP <22 TOT <22 DIS	<22 TOT 28 DIS	<22 TOT <22 DIS	32 TOT 36 DIS
5/6/93			<56 TOT	<56 TOT DUP <56 TOT	<56 TOT	<56 TOT	<56 TOT
9/27/94	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS <5 TOT DUP <5 DIS DUP	<5 TOT <5 DIS	<5 TOT <5 DIS	<5 TOT <5 DIS
12/17-18/95			<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS	<3 TOT <3 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 6 µg/L

Source: USACOE, 1996.

TABLE 4-16

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

NITRATE (mg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/16/92			4.5	33 32	11.6	<1.0	18.4
11/5/92			3.8 20.2 DUP	20.3	11.1	13.8	10.7
2/3/93			6.4	165	50.6	65.6	45.9
5/5/93			2.2	24.7 25 DUP	15.5	12.2	10.6
9/27/94	<1.0	10.0	5.9	9.1 9.2 DUP	11.0	12.0	9.4
12/18/95			4.2	9.0	15.1	11.9	5.6

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 10 mg/L

* During the evalluation of the RI data, the second quarter sample result was considered anomalous.

Source: USACOE, 1996.

TABLE 4-17

GROUNDWATER CONCENTRATIONS OF PESTICIDE STORAGE FACILITY AND BACKGROUND WELLS

Pesticide Storage Facility
Fort Riley, Kansas

THALLIUM (μg/L)

Date	B35401	B35402	PSF92-01	PSF92-02	PSF92-03	PSF92-04	PSF92-05
7/14-16/92			<100 TOT <110 DIS	<100TOT DUP <110DIS DUP <100 TOT <110 DIS	<100 TOT <110 DIS	<100TOT <110DIS	<100 TOT <110 DIS
11/5/92			<63 TOT <63 DIS	<63 TOT <63 DIS <63 TOT DUP <63 DIS DUP	<63 TOT <63 DIS	<63 TOT <63 DIS	<63 TOT <63 DIS
2/3/93			<63 TOT <63 DIS	<63 TOT DUP <63 DIS DUP <63 TOT <63 DIS	<63 TOT <63 TOT	<63 TOT <63 DIS	<63 TOT <63 DIS
5/6/93			<1 TOT	<1 TOT DUP 17 TOT	2.5 TOT	<1 TOT	<1 TOT
9/27/94	<1 TOT 2.6 DIS	<1 TOT 2.5 DIS	2.4 TOT <1 DIS	<1 TOT <1 DIS <1 TOT DUP <1 DIS DUP	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT 1.1 DIS
12/17-18/95			<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS	<1 TOT <1 DIS

Note: TOT = Total (unfiltered) metals; DIS = dissolved (filtered) metals; DUP = duplicate sample.
MCL = 2 μg/L

Source: USACOE, 1996.

Mann-Whitney Test can be used for the both normal and non-normal distributions. It was used for all inorganic compounds for this comparison. Additionally, the Student's *t* Test (which can only be used for normal distributions) was used to make this comparison for the beryllium and manganese data because these distributions were normal. The results of the Mann-Whitney and the Student's *t* Test indicated that there was no statistical difference between the dissolved and total metals results for any of the seven inorganic compounds tested. Therefore, the dissolved and total metals results were combined before the Kruskal-Wallis Test was used to determine if all wells were part of the same distribution.

4.2.2.3 Results - The results of the statistical evaluation were that, for the seven inorganic compounds evaluated, only beryllium in well PSF92-02 was present in a single on-site well (PSF92-02) at concentrations not considered equivalent to background concentrations. The following briefly summarizes the results of the statistical evaluation for each of the seven inorganics:

- **Antimony** - Antimony was only detected in well PSF92-05. Using one-half the detection limit as a proxy concentration for all non-detect results, the results for well PSF92-05 were shown to be part of the same distribution as background (i.e., no statistical difference).

- **Arsenic** - The statistical evaluation showed that the distribution of arsenic concentrations in on-site wells was equivalent to that in the background wells.

- **Beryllium** - The statistical evaluation showed that the distribution of beryllium concentrations in on-site wells, with the exception of well PSF92-02, was equivalent to that in the background wells. The beryllium concentrations in PSF92-02, were shown to be outside the statistically-derived distribution for the background well. However, the beryllium concentrations in PSF92-02 were shown to be statistically less than the MCL of .004 mg/L.

- **Cadmium** - Cadmium was only detected in well PSF92-05. The statistical evaluation showed that the distribution of cadmium concentrations in on-site wells was equivalent to that in the background wells, assuming a proxy concentration of one-half the detection limit for all non-detected results.

- **Manganese** - The statistical evaluation showed that the distribution of manganese concentrations in on-site wells was equivalent to that in the background wells.

- **Nitrate** - The statistical evaluation showed that the distribution of nitrate concentrations in on-site wells was equivalent to that in the background wells.

- **Thallium** - The statistical evaluation showed that the distribution of thallium concentrations in on-site wells was equivalent to that in the background wells.

4.3 GROUNDWATER LEVELS AND WELL YIELD ESTIMATES

Site-specific hydrogeology based on groundwater data from December 1992 and presented in the RI report (LAW, 1993a) was discussed in Section 1.2.7.2. In September 1994, groundwater levels were measured, and based on the groundwater elevations in the five site wells, the calculated direction of flow was determined to be east-southeast with a gradient of approximately 0.07 ft/ft which is consistent with the baseline conditions. The direction of flow was derived by performing three point calculations on grouped wells PSF92-02, PSF92-04, and PSF92-05. This flow direction is toward the Kansas River and appears to follow the approximate slope of the bedrock surface and the general topographic trends. Groundwater elevations from September 1994 for the five site wells and gradient contours are presented on Figure 4-6.

A summary of the monitoring well water levels observed during the sampling events completed at the PSF is presented in Table 4-18 to show the water level variations recorded at the site. As seen in this table, differences in the water levels varied from a maximum 5.81 feet in well PSF92-05 to a minimum 1.62 feet in well PSF92-04. As seen from the data, recorded water levels consistently decreased in the direction toward the Kansas River which is east-southeast from the site.

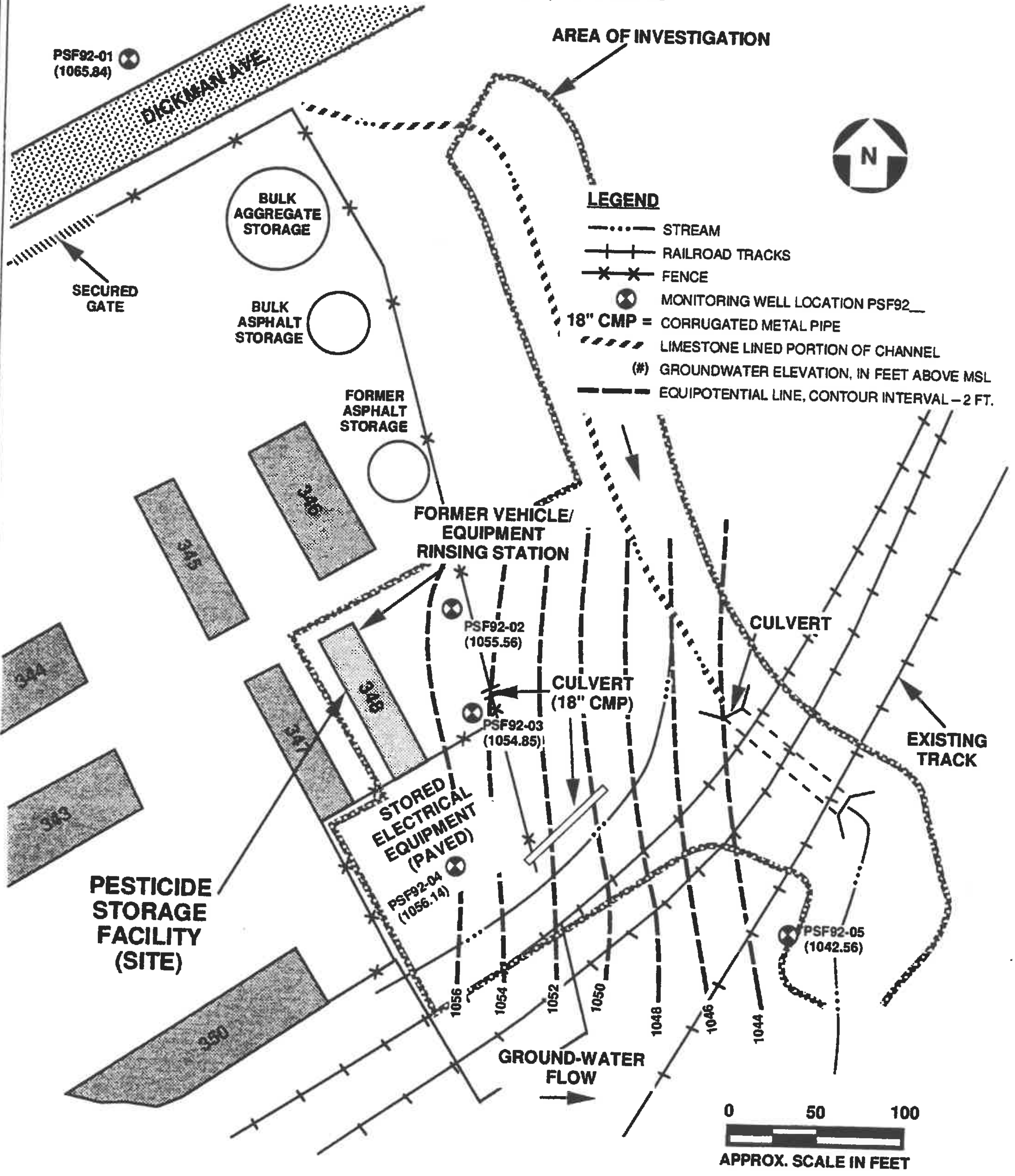
A range of estimated well yields in the uppermost aquifer at the PSF was also calculated using methods given in Driscoll, 1986. In addition to this range, the average estimated yield was calculated, using the average of the estimated hydraulic conductivity and assumed average aquifer thickness. The uppermost aquifer is the alluvial material overlying the limestone and shales encountered at the site. The information used in the calculation of estimated well yield was derived from the data gathered during the installation of the five groundwater monitoring wells at the PSF in 1992, and from well slug test data collected from the wells and interpreted during RI field activities. A pump test was not performed at the site. Therefore, the yield estimates were calculated by making assumptions and using the available data from the RI, as described below.

The depth to rock in the five PSF monitoring wells ranged from an estimated 38 feet in PSF92-01 to approximately 28 feet in wells PSF92-02, PSF92-03, and PSF92-05. The saturated thickness of the alluvial material encountered in the well borings ranged from approximately 12.27 feet at PSF92-01 to 5.53 feet at PSF92-02. The calculated hydraulic conductivities derived from the slug test data interpretations presented in the RI ranged from 1.17×10^{-4} ft/min to 1.03×10^{-3} ft/min.

FIGURE 4-6

POTENTIOMETRIC SURFACE MAP – SEPT. 1994

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



00278-2536-0308.50

TABLE 4-18

GROUNDWATER LEVELS MEASURED IN MONITORING WELLS
Pesticide Storage Facility
Fort Riley, Kansas

Well Identification	Groundwater Elevations Baseline (1) July 14-23, 1992	First Quarter (2) November 5, 1992	Second Quarter (3) February 3, 1993	Third Quarter (4) May 5-6, 1993	September 1994 (5) September 26-27, 1994	December 1995 (6) December 16-18, 1995
PSF92-01	1062.57	NA	1064.12	1065.57	1065.84	1065.72
PSF92-02	1055.33	NA	1056.51	1058.64	1055.56	1056.20
PSF92-03	1055.13	NA	1055.51	1057.29	1054.85	1055.63
PSF92-04	1054.92	NA	1055.43	1056.54	1056.14	1055.69
PSF92-05	1041.95	NA	1043.39	1047.76	1042.56	1042.47

NA - Data not available

(1) LAW, 1992. Quality Control Summary Report (Baseline) for Pesticide Storage Facility, Fort Riley, Kansas. Prepared for U.S. Army Corps of Engineers, Kansas City District. September 1992.

(2) LAW, 1993b. Quality Control Summary Report (First Quarter) for Pesticide Storage Facility, Fort Riley, Kansas. Prepared for U.S. Army Corps of Engineers, Kansas City District. January 1993.

(3) LAW, 1993c. Quality Control Summary Report (Second Quarter) for Pesticide Storage Facility, Fort Riley, Kansas. Prepared for U.S. Army Corps of Engineers, Kansas City District. April 1993.

(4) LAW, 1993d. Quality Control Summary Report (Third Quarter) for Pesticide Storage Facility, Fort Riley, Kansas. Prepared for U.S. Army Corps of Engineers, Kansas City District. July 1993.

(5) LAW, 1994c. Quality Control Summary Report (September 1994) for Residual Risk Assessment and Feasibility Study, Pesticide Storage Facility, Fort Riley, Kansas. Prepared for U.S. Army Corps of Engineers, Kansas City District, November 1994.

(6) Data Obtained by Louis Berger and Associates.

A range of estimated transmissivity of the alluvial material at the PSF was obtained by multiplying the range of observed saturated thickness (aquifer thickness) by the calculated hydraulic conductivities given above. The resulting transmissivities ranged from 0.93 ft^2/day to 18.2 ft^2/day. These values were used in conjunction with the observed aquifer thicknesses at the PSF to determine an estimated yield for a well installed in the PSF area. Well yield is the volume of water per unit of time discharged from a well, either by pumping or free flow (Driscoll, 1986). Assumptions made during the analysis included:

- Depth of water in well during pumping was 1 foot (conservative estimate; assumes almost total drawdown in well).
- Radius of well was assumed to be 0.25 feet (assumes a well diameter of 6 inches).
- The radius of the cone of depression at the pumping well was assumed to be 500 feet (this is a conservative estimate developed through the use of a sensitivity analysis of the effect of this value on well yield).
- Time of pumping was assumed to be 1 year of continuous pumping (conservative estimate, as most water wells are not pumped constantly).
- The uppermost alluvium was assumed to be unconfined; in accordance with Driscoll (1986), a storativity of 7.5×10^{-2} was used.

The range of well yield at the Fort Riley PSF site in gallons per minute (gpm) derived from the analyses was from approximately 0.12 to 5.2 gpm. These calculated yields are based on conservative assumptions, and may therefore be higher than would be observed if an aquifer test were performed in the uppermost alluvial deposits at the PSF.

To provide an estimate of the "average" well yield at the PSF site, using the available data, calculations were repeated using the average of hydraulic conductivities and aquifer thicknesses observed from the data. The "average" estimate of well yield calculated for the uppermost aquifer at the PSF site was 0.9 gpm, based on an estimated average hydraulic conductivity of 5.7×10^{-4} ft/min and an assumed average aquifer thickness of 7 feet. Well yields of 1 to 2 gpm were reported previously in the RI report (LAW, 1993a). These values are within the range predicted by this more rigorous analysis.

4.4 CONTAMINANT FATE AND TRANSPORT - GENERAL INFORMATION

Physical and chemical information concerning the transport and fate of contaminants is used to identify the potential migration routes for the environmental contamination. The fate and transport of constituents detected in site media was discussed in Section 5 of the RI report (LAW, 1993a). General information related to the fate and transport of constituents detected at the site are presented in the following paragraphs. Information about the physical/chemical properties, and other information related to fate and transport, are presented for organic and inorganic constituents on Tables 4-19 and 4-20, respectively.

In general, the primary constituents detected in the soil at the site (i.e., pesticides and PAHs), are expected to be relatively immobile in soil. This is because these constituents have low water solubilities and high K_{oc} values, which indicate a high affinity for binding to soil particles and a low potential for transfer to groundwater or surface water (ATSDR, 1987-1993; Howard, 1991). Almost without exception, the pesticides detected at the site bind strongly to soils, and resist displacement from soil particles even under prolonged leaching tests. This binding process appears to occur regardless of soil type (i.e., organic content of soil) and pH (ATSDR, 1987-1991; Howard, 1991). Similarly, the high K_{OC} values and low water solubilities of the PAHs detected at the site indicate that these constituents would also remain bound to soil. Therefore, the potential for the migration of constituents detected in the soil at the site is considered to be small.

The assumption that these compounds are immobile in soil is substantiated by the fact that no pesticides or PAHs were detected in the groundwater and surface-water samples collected from the site during the RI investigation. Pesticides in groundwater have not been confirmed at the PSF, including the September 1994 groundwater samples. Detectable concentrations of pesticides have been present in the soil at PSF for at least 20 years; the 1974 study performed by USAEHA confirmed the presence of pesticides within site soils. If leaching to groundwater was a significant transport pathway for these compounds, pesticides would have been detected in the site's groundwater samples.

Because pesticides and PAHs are likely to remain bound to soil particles, secondary transport pathways are limited to the transportation of adsorbed contaminants on soil particles by storm-water or surface-water run-off to sediments, and the subsequent transportation of these sediments to points downstream. In addition, surface soil particles containing sorbed contaminants may also be dispersed as airborne particulates.

The volatile organic compounds detected in site soils (toluene and benzene) are slightly water soluble. Therefore, the potential exists for leaching into the groundwater or, if present in the surface soil, volatilization into the atmosphere. However, the low levels detected in site soils are unlikely to affect the groundwater column to a great extent.

4.5 POST REMOVAL ACTION SITE CONDITIONS

Following the Removal Action, no further construction has been performed at the site. Current site conditions are described in this section. On September 29, 1994, the site was visited to observe the post Removal Action conditions. Land surfaces had been regraded to generally follow the land surfaces existing prior to the Removal Action. In some areas slope transitions had been modified to provide a more uniform slope. The land surfaces immediately around Building 348 consisted of graveled areas north and east of the building, and asphalted areas west

TABLE 4–19

ORGANIC CONTAMINANT FATE AND TRANSPORT DATA
Pesticide Storage Facility
Fort Riley, Kansas

CONSTITUENT	MOLECULAR WEIGHT (g/mole)	SOLUBILITY IN WATER (mg/L) (25 +/– 5° C)	ref.	VAPOR PRESSURE (atm) (25 +/– 5° C)	ref.	SPECIFIC GRAVITY (25 +/– 5° C)	ref.	HENRY'S LAW CONSTANT (atm–m^3/mole) (25 +/– 5° C)	ref.	LOG K_{oc}	ref.	LOG K_{ow}	ref.
VOLATILES:													
Benzene	78.11	1.80E+03	1	1.25E–01	1	0.87	1	5.48E–03	1	1.92	1	1.95	1
Carbon Disulfide	76.13	1.70E+03	1	4.74E–01	1	1.26	1	2.12E–02	1	2.47	1	1.84	1
1,2–Dichloropropane	112.99	2.70E+03	1	6.58E–02	1	1.56	1	2.94E–03	1	1.71	1	2.28	1
Methylene Chloride	84.93	1.67E+04	1	5.99E–01	1	1.33	1	2.18E–03	1	0.94	1	1.25	1
1,1,2,2–Tetrachloroethane	167.85	2.97E+03	1	1.05E–02	1	1.59	1	4.56E–04	1	2.56	1	2.56	1
Toluene	92.14	5.24E+02	1	2.89E–02	1	0.86	1	6.74E–03	1	2.06	1	2.50	1
Trichloroethene	131.39	1.10E+03	1	9.55E–02	1	1.46	1	9.10E–03	1	2.03	1	2.60	1
SEMI–VOLATILES:													
Acenaphthene	154.21	3.47E+00	1	2.04E–06	1	1.02(a)	1	7.92E–05	1	1.25	1	3.92	1
Alpha–chlordane	409.78	5.10E–02	1	3.00E–06	3	ND		ND		5.57	1	5.93	1
Anthracene	178.24	7.30E–02	1	2.24E–08	1	1.29	1	1.77E–05	1	4.27	1	4.45	1
Benzo(a)anthracene	228.30	9.40E–03	1	1.45E–10	1	1.27	1	2.29E–08	1	6.14	1	5.90	1
Benzo(b)fluoroanthene	252.32	1.20E–03	1	6.58E–10	1	ND		1.20E–05	1	5.74	1	6.57	1
Benzo(k)fluoroanthene	252.32	5.50E–04	1	1.26E–13	1	ND		1.04E–03	1	6.64	1	6.85	1
Benzo(g,h,i)perylene	276.34	2.60E–04	1	1.33E–13	1	ND		1.40E–07	1	6.89	1	7.10	1
Benzo(a)pyrene	252.32	3.80E–03	1	7.22E–12	1	1.35	1	2.40E–06	1	5.95	1	5.81	1
Bis(2–ethylhexyl)phthalate	390.00	4.00E–01	1	8.16E–11	1	0.99	1	1.10E–05	1	5.00	1	4.20	1
Chrysene	228.30	2.00E–03	1	8.29E–12	1	1.27	1	7.26E–20	1	5.39	1	5.61	1
4,4'–DDD	320.05	9.00E–02	1	1.34E–09	1	1.48	1	2.16E–05	1	4.64	1	5.99	1
4,4'–DDE	319.03	1.20E–02	1	8.54E–09	1	ND		2.34E–05	1	5.34	1	5.77	1
4,4'–DDT	354.49	3.10E–03	1	1.32E–10	1	1.56(b)	1	5.20E–05	1	5.38	1	5.98	1
Dibenzofuran	168.20	1.00E+01	1	ND		1.09(c)	1	ND		4.00	1	4.17	1
2,4–Dichlorophenol	163.00	4.50E+03	1	1.17E–04	1	1.38(b)	1	3.23E–06	1	2.94	1	3.15	1
Dieldrin	380.91	2.00E–01	1	2.37E–10	1	1.75	1	3.18E–05	1	4.08	1	4.66	1
Diethylphthalate	222.24	1.08E+03	1	2.18E–06	1	1.12	1	8.46E–07	1	1.84	1	2.47	1

TABLE 4-19

ORGANIC CONTAMINANT FATE AND TRANSPORT DATA

Pesticide Storage Facility
Fort Riley, Kansas

CONSTITUENT	MOLECULAR WEIGHT (g/mole)	SOLUBILITY IN WATER (mg/L) (25 +/- 5° C)	ref.	VAPOR PRESSURE (atm) (25 +/- 5° C)	ref.	SPECIFIC GRAVITY (25 +/- 5° C)	ref.	HENRY'S LAW CONSTANT (atm-m³/mole) (25 +/- 5° C)	ref.	LOG K_{oc}	ref.	LOG K_{ow}	ref.
SEMI-VOLATILES: (cont'd)													
Endrin Aldehyde	380.92	2.60E-01	1	2.63E-10	1	ND		3.86E-07	1	4.43	1	5.60	1
Fluoranthene	202.26	2.36E-01	1	6.58E-09	1	1.25(d)	1	1.69E-02	1	4.62	1	5.22	1
Fluorene	166.22	1.69E+00	1	1.36E-06	1	1.20(d)	1	2.10E-04	1	3.70	1	4.18	1
Gamma-chlordane	409.78	1.85E+00	3	3.90E-06	3	ND		ND	1	5.48	1	8.69	1
Heptachlor	373.32	5.60E-02	1	5.26E-07	1	1.66	1	2.30E-03	1	4.34	1	4.40	1
Heptachlor Epoxide	389.32	2.70E-01	1	3.42E-09	1	ND		3.20E-05	1	4.32	1	3.65	1
Indeno(1,2,3-cd)pyrene	276.34	6.20E-02	1	1.32E-13	1	ND		2.96E-20	1	7.49	1	5.97	1
Malathion	330.36	1.45E+02	2	5.26E-08	2	ND		1.20E-07	2	3.26	4	2.89	2
Methoxychlor	345.66	4.50E-02	1	ND		1.41	1	ND		4.90	1	4.40	1
2-Methylnaphthalene	142.20	2.46E+01	1	ND		1.01	1	ND		3.87	1	3.86	1
Phenanthrene	178.24	1.18E+00	1	8.95E-07	1	1.18	1	2.56E-05	1	4.36	1	4.46	1
Pyrene	202.26	1.32E-01	1	3.29E-09	1	1.27	1	1.09E-05	1	4.80	1	5.09	1
2,4,6-Trichlorophenol	197.45	1.20E+03	1	2.89E-05	1	1.68	1	1.76E-07	1	2.85	1	3.85	1

1. Montgomery and Welkom (1990).
2. Superfund Public Health Evaluation Manual (1986).
3. ATSDR, Toxicology Profiles (1988-91).
4. Rao and Hornsby (1989).

a. Data obtained at 90 +/- 4° C.
b. Data obtained at 15 +/- 4° C.
c. Data obtained at 99 +/- 4° C.
d. Data obtained at 0 +/- 4° C.
ND - No data

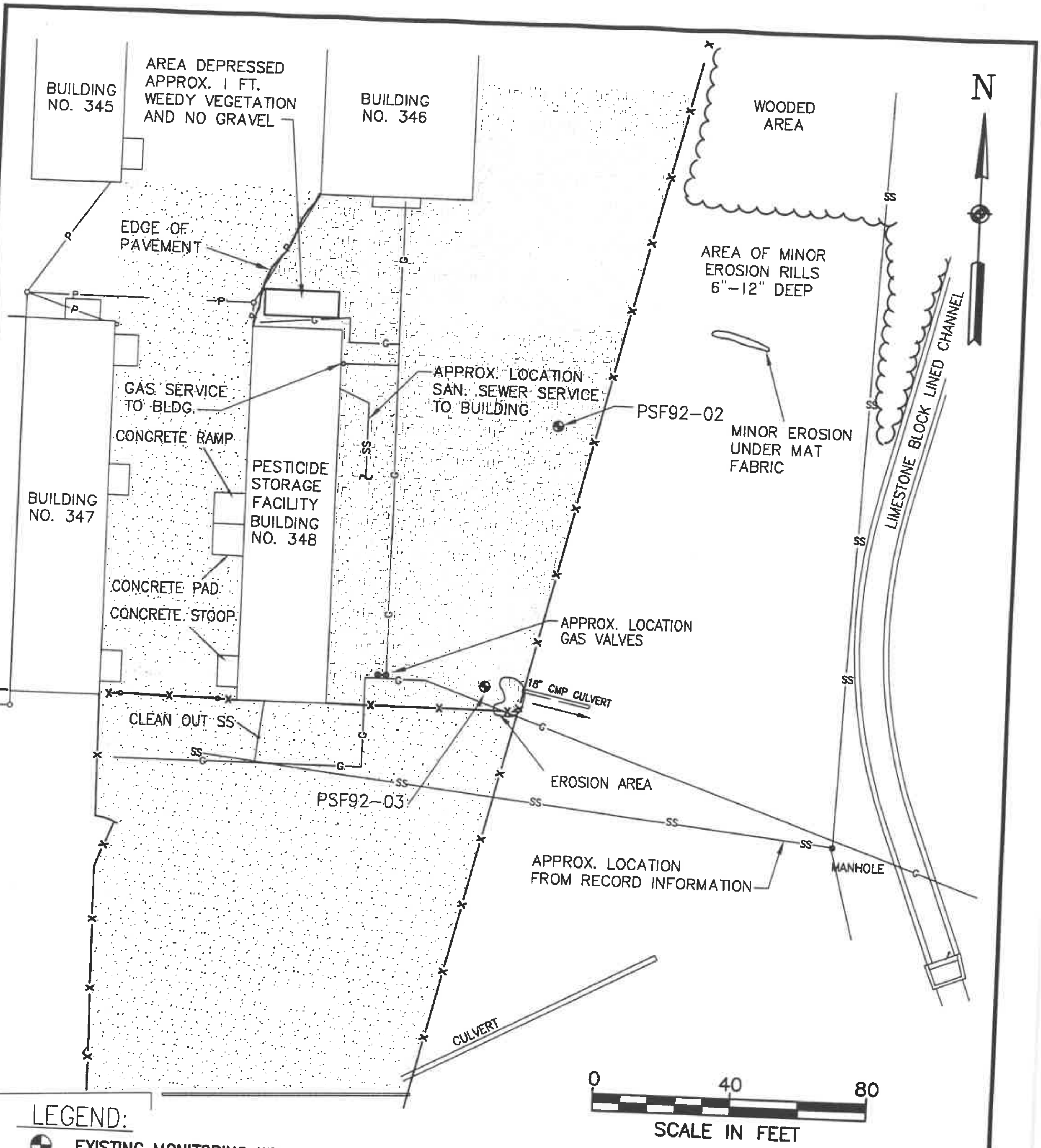
TABLE 4-20

METAL CONTAMINANT FATE AND TRANSPORT DATA
Pesticide Storage Facility
Fort Riley, Kansas

CONSTITUENT	MOLECULAR WEIGHT (g/mole)	AQUATIC BIOCONCENTRATION FACTOR (BCF)	ref.
Aluminum	26.98	ND	
Arsenic	79.92	4.40E+01	1
Barium	137.33	ND	
Beryllium	9.01	1.90E+01	1
Cadmium	112.40	8.10E+01	1
Calcium	40.08	ND	
Chromium	51.99	1.60E+00	1
Copper	63.55	2.00E+02	1
Iron	55.85	ND	
Lead	207.20	4.90E+01	1
Magnesium	24.31	ND	
Manganese	54.94	ND	
Mercury	200.59	5.50E+03	1
Nitrate	62	ND	
Potassium	39.10	ND	
Selenium	78.96	1.60E+01	1
Silver	107.87	3.08E+03	1
Sodium	22.99	ND	
Thallium	204	ND	
Vanadium	50.94	ND	
Zinc	65.37	4.70E+01	1

1. Superfund Public Health Evaluation Manual (1986)
ND – No data

and south of the building (Figure 4-7). Immediately north of the building was a 7-foot wide area depressed about 1 foot, with weeds and no gravel. At the time of the site visit, this area had not been backfilled after completion of the removal action in anticipation of possible repairs to be made to the portion of the gas line in the vicinity of this depressed area. This portion of the gas line had been damaged during the removal action. A small area of erosion (approximately 25 square feet) was present at the 18-inch corrugated metal pipe culvert inlet near the southeast corner of the fenced area. Drainage from the paved area south of the PSF site would flow northward to this culvert. Gas valves were present near the southeast corner of the building. Erosion rills, approximately 6 to 12 inches deep, were present along the northern boundary of the clearing limits east of the fence location. During storms, drainage from between Buildings 346 and 348 would be collected and flow through this area toward the east. Grass was growing in the area on which the removal action contractor had placed fabric and seeded. Some minor erosion had occurred in a few areas under the fabric near its northern limits. The approximate location of a sanitary sewer discovered during removal action excavations is shown on Figure 4-7. As previously stated in Section 2.3, potential soil contamination from the sewer was not identified.



LEGEND:

- ● EXISTING MONITORING WELL LOCATION
- ▨ ASPHALT
- ▨ GRAVEL
- ☐ SEEDED AND FABRIC MAT INSTALLED
- ┼┼┼ RAILROAD
- ○ POLE
- —T— TELEPHONE LINES
- —G— BURIED GAS LINES
- —X— FENCE–CHAINLINK
- —P— OVERHEAD POWER LINES
- —SS— SANITARY SEWER

UNITED STATES ARMY
FORT RILEY
FORT RILEY, KANSAS

PESTICIDE STORAGE FACILITY

OBSERVED SITE CONDITIONS SEPTEMBER 29, 1994

PREPARED BY:	SEG/5–95	FIGURE NUMBER:	FILE DATE:	23.OCTOBER.94
CHECKED BY:	EFW/5–95	4–7	PLOT DATE:	26.APRIL.95
APPROVED BY:	KAH/5–95		FILE NAME:	SITEMAP2.DWG

5.0 RESIDUAL RISK ASSESSMENT

This section presents the results of the residual risk assessment for the PSF at Fort Riley, Kansas. The risk assessment addresses the risk that remains at the site after completion of the Removal Action, and is an addendum to the December 1993 RI report (LAW, 1993a). This residual risk assessment includes a human health risk assessment and consideration of ecological risks due to potential exposures at the PSF site.

Because an extensive risk assessment has already been conducted for this site (LAW, 1993a), and in an effort to present only the risk information necessary to make informed decisions about the site, this residual risk assessment was conducted as a "streamlined" version of a baseline risk assessment (BLRA). To this end, information that has not changed from the RI report (LAW, 1993a) has been presented in summary form only in this residual risk assessment. For example, information presented in summary form only includes the fate and transport (Section 4) and toxicity assessment sections of the risk assessment. In addition, residual risks to human health have been calculated only for pathways for which risks were estimated to be equal to or greater than 1×10^{-6} (for carcinogens) or 1 (for noncarcinogens) in the RI report (LAW, 1993a). Because exposure point concentrations decreased as a result of the Removal Action (with a couple of minor exceptions), this approach is still considered to be conservative. (Based on the screening "points of departure," and the risks estimated in the BLRA, the pathways assessed in this current risk assessment represent approximately 90 to 99 percent of the risks at the site.) The residual risk assessment has been streamlined in this manner so that the assessment can be focused on the pathways with the greatest potential to result in adverse health effects.

The groundwater exposure scenarios and associated risks are presented in Section 5.2 for information purposes only. Potential risks to human health due to use of the uppermost aquifer beneath the site as a source of potable water are considered highly unlikely. Because an adequate existing water supply currently serves the area, the aquifer is not currently used as a water supply, and its low yield makes the uppermost aquifer an unlikely source of potable water in the future.

5.1 HUMAN HEALTH RISK ASSESSMENT - SOIL AND SEDIMENT

5.1.1 Introduction

The objective of this residual human health risk assessment is to examine the effects on exposed and potentially exposed populations following the soil Removal Action. The risk assessment approach used to evaluate potential impacts to human health as a result of soil and sediment contamination remaining at the PSF is consistent with the BLRA and with the approach presented in the USEPA "Risk Assessment Guidance for Superfund" document (USEPA, 1989a). The results of this residual human health risk assessment will be used to decide whether further remedial action is necessary at the PSF site.

The human health risk assessment consists of four steps, listed below. These four elements of the risk assessment are conducted in the following sections.

1. Identification of Chemicals of Concern
2. Exposure Assessment
3. Toxicity Assessment
4. Risk Characterization

5.1.2 Identification of Chemicals of Concern

For the purpose of this residual risk assessment, the chemicals remaining in the soil and sediment at the site have been retained as chemicals of concern (COCs) (Table 5-1). The results of the most recent soil sampling efforts were presented in Section 4. The soil and sediment data are from samples obtained during the Removal Action and from pre-removal site characterization activities. Areas that were excavated to a depth of 2 feet or more during the Removal Action, and then backfilled, have been considered subsurface soil in the residual risk assessment. Other areas (i.e., not excavated or excavated to a depth of less than 2 feet) are considered to be surface soil unless covered by pavement or concrete.

The soil and sediment data used have been evaluated, as follows, and are considered to be adequate for risk assessment purposes and to present a picture of current site conditions. The RI field data were subjected to a data quality evaluation as discussed in the RI report (LAW, 1993a). Removal Action soil data were analyzed using USEPA Method 8080 for pesticides, and reported detection limits were found to be less than the Removal Action remediation goal (RG) concentrations. Quality assurance samples during confirmation sampling conducted after excavations were completed during the Removal Action were evaluated by the Corps of Engineers, Missouri River Division Laboratory for compliance with Corps data quality standards (CEMRD, 1994). The QA samples met the Corps' HTW reporting requirements, and the information provided supported the quality of the data.

5.1.3 Exposure Assessment

An exposure assessment consists of the characterization of the exposure setting, identification of potential exposure pathways, and quantification of potential exposures to site-related contaminants of concern. As mentioned previously, only the exposure pathways for which risks

TABLE 5–1

CHEMICALS OF CONCERN IN SOIL SAMPLES
DETECTION FREQUENCIES AND CONCENTRATION RANGES
Residual Risk Assessment
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
SURFACE SOIL SAMPLES:			
Chlorinated Pesticides:			
Chlordane	17/52	0.0207	1.12
DDD	7/18	0.0237	0.454
DDE	12/18	0.0356	0.847
DDT	35/52	0.012	1.29
Dieldrin	20/52	0.007	0.158
Heptachlor	2/52	0.004	0.0093
SUBSURFACE SOIL SAMPLES:			
Metals:			
Arsenic	31/31	0.4	20
Barium	29/29	35	190
Chromium	29/29	4.6	20
Lead	25/29	4.7	770
Mercury	1/29	––	0.1
Silver	3/29	0.9	1.2
Chlorinated Pesticides:			
Chlordane	41/126	0.0051	10.2
DDD	16/100	0.0013	0.925
DDE	31/101	0.0104	0.666
DDT	42/126	0.011	1.95
Dieldrin	12/126	0.007	0.077
Heptachlor	8/126	0.0012	0.3
Volatile Organics:			
Benzene	2/29	0.0059	0.0066
Methylene chloride	13/29	0.011	0.031
Toluene	7/29	0.0059	0.038
Semi–Volatile Organics:			
Benzo(a)anthracene	3/29	0.11	0.33
bis(2–Ethylhexyl)phthalate	3/29	0.41	1.2
Chrysene	3/29	0.11	0.29
Diethylphthalate	1/29	––	0.43
Fluoranthene	3/29	0.18	0.53
Phenanthrene	2/29	0.23	0.25
Pyrene	5/29	0.11	0.57

Note: Information presented is based on site conditions following the removal action. Values reported are for total chlordane which includes the sum of alpha–chlordane and gamma–chlordane.

were greater than or equal to 1 x 10^{-6} (for carcinogens) or 1 (for noncarcinogens) in the RI (LAW, 1993a) were addressed in this residual risk assessment. However, a brief discussion of potentially exposed receptors is presented below.

Potentially Exposed Populations

The PSF site is located within the DEH yard. It is situated on an escarpment on the north side of the Kansas River Valley, approximately 2,000 feet west of the Kansas River, on the southeast edge of the Main Post cantonment area. The area immediately surrounding and including the PSF is moderately industrial/commercial in nature. The DEH yard includes areas used to perform vehicle and heavy equipment maintenance, and is also used for the storage of vehicles, equipment, and supplies. The DEH yard is enclosed by a fence and a gate that is locked after normal work hours.

Currently, the PSF site is inactive. Pesticides and related materials are now stored in the new pesticide building located approximately 1,500 feet from the site. Future land use is expected to be very similar to the current and historical uses. The portion of the Building 348 structure used for pesticide and herbicide storage will be examined and "closed" as appropriate. This action may or may not involve demolition of the structure and/or its floor slab and foundation. The demolition of Building 348 (with and without reconstruction) is also a future possibility.

On the basis of established land use patterns at the site, (an active military installation), residential land use of the site is extremely unlikely. Also, the site is elevated only 10 to 15 feet above the Kansas River flood plain and is not protected by a levee. Finally, Fort Riley's master plan does not include residential development of the PSF site or the surrounding area (DEH, 1993c). Therefore, an on-site residential scenario was not developed for the residual risk assessment.

The human populations that are potentially exposed to the residual contamination at the site are those persons who may come into contact with the soil or sediment at the site. Due to the industrialized nature of the PSF site, and the fact that the DEH yard is restricted (i.e., fenced and secured), utility workers, landscaping crews, or on-site workers are the most likely human receptors for exposure to the soils at the PSF site. Site workers or landscapers may also contact contaminated sediments while performing maintenance or landscaping activities in the lined channel located east of the site. Construction workers would be potentially exposed to subsurface soil during future activities related to the possible demolition of Building 348.

Base residential housing areas exist within 0.5 miles of the PSF site. However, it is unlikely that on-post residents would come in contact with site media during recreational activities (i.e., running or jogging) due to the restricted nature of the DEH yard and the overgrowth present in the contaminated areas outside the fence.

Similarly, children living in the nearby housing areas are unlikely to be exposed to site contamination during play or exploration activities because playgrounds are provided for the children's recreational use. The equipment present on these playgrounds include swing sets, a set of rings, see-saws, a slide, a tennis court, a basketball hoop, plus two activity centers. Therefore, it is unlikely that children would travel to the PSF site to play on a regular basis. Also, children have not been observed playing near the DEH yard. However, in order to conservatively estimate exposures at the site, a children's recreational scenario has been included for evaluation.

Risks for the receptors discussed above have been quantified for the appropriate media (i.e., soil or sediment). The exposure pathways for which residual risks will be estimated for each of the receptors and media are shown on Table 5-2. As described previously, these exposure scenarios are those for which risks were estimated to be equal to or greater than 1 x 10^{-6} (for carcinogens) or 1 (for noncarcinogens) in the RI report (LAW, 1993a).

Quantification of Exposure

Quantifying potential exposures requires estimating the magnitude, frequency, and duration of exposure for the populations and exposure pathways selected for quantitative evaluation. This step is typically conducted in two stages: first, exposure point concentrations are estimated; second, pathway-specific intakes are estimated. The exposure point concentrations and intake variable values are selected so that the combination of variables results in an estimate of reasonable maximum exposure (RME) for each pathway. An RME is the maximum exposure that is reasonably expected to occur at a site. The RME approach is designed to present exposure estimates that are "protective and reasonable," but not the worst possible case (USEPA, 1989a).

The exposure point concentrations used to estimate risks are the 95th percent upper confidence limit (UCL) on the arithmetic mean of the concentrations detected. If the UCL is greater than the maximum detected concentration, then the maximum detected concentration is used as the exposure point concentration (USEPA, 1989a).

For scenarios involving potential exposure to surface soil, the exposure point concentrations were calculated using data from samples obtained from a depth of less than 2 feet below original ground surface. Similarly, data from samples obtained from 2 feet or more below original ground surface were used to calculate exposure point concentrations for potential exposures to subsurface soils. The only exception to this is that the sample obtained from below the asphalt at the southwest corner of Building 348 (SB-02) was included in the subsurface soil data set even though it was obtained at a depth of less than 2 feet. This is because the soil at this location is not readily accessible, and it is reasonable to assume that exposure at this location would be associated with construction activities. The concentrations used to calculate potential risks due to exposure to surface soil, subsurface soil, and sediment are presented on Table 5-3.

TABLE 5–2

EXPOSURE PATHWAYS
Residual Risk Assessment
Pesticide Storage Facility
Fort Riley, Kansas

Medium	Receptor	Exposure Route
Surface Soil	Current Landscaper	Dermal Contact
	Current Site Worker	Dermal Contact, Incidental Ingestion
	Current Utility Worker	Dermal Contact
	Future Construction Worker	Dermal Contact, Incidental Ingestion
	Future Landscaper	Dermal Contact
	Future Recreational Child	Dermal Contact
	Future Site Worker	Dermal Contact, Inhalation of Fugitive Dust, Incidental Ingestion
	Future Utility Worker	Dermal Contact
Subsurface Soil	Current Landscaper	Dermal Contact
	Current Utility Worker	Dermal Contact
	Future Construction Worker	Dermal Contact
	Future Landscaper	Dermal Contact
	Future Utility Worker	Dermal Contact
Sediment	Future Site Worker	Dermal Contact

TABLE 5−3

ESTIMATED EXPOSURE POINT CONCENTRATIONS
Residual Risk Assessment
Pesticide Storage Facility
Fort Riley, Kansas

Medium	Exposure Pathway	Parameter	Exposure Concentration	Comments
Surface Soils	Incidental Ingestion, Inhalation of Fugitive Dust, Dermal Contact	Chlordane	0.12 mg/kg	From removal action surface soil analytical results (see UCL Tables in Appendix A) *When the 95% UCL exceeded the maximum detected concentration, the maximum concentration was used as the exposure point concentration. (1) Value is from Sample I.D. 18801−060. (2) Value is from Sample I.D. 19084−005.
		4,4'−DDD	0.45 mg/kg* (1)	
		4,4'−DDE	0.37 mg/kg	
		4,4'−DDT	1.3 mg/kg* (2)	
		Dieldrin	0.040 mg/kg	
		Heptachlor	0.0022 mg/kg	
Subsurface Soils	Dermal Contact	Chlordane	0.22 mg/kg	From removal action and RI subsurface soil analytical results (see UCL Tables in Appendix A.)
		4,4'−DDD	0.017 mg/kg	
		4,4'−DDE	0.033 mg/kg	
		4,4'−DDT	0.15 mg/kg	
		Dieldrin	0.0048 mg/kg	
		Heptachlor	0.0029 mg/kg	
		Benzene	0.0023 mg/kg	
		Methylene Chloride	0.019 mg/kg	
		Toluene	0.0067 mg/kg	
		Benzo[a]anthracene	0.11 mg/kg	
		bis(2−Ethylhexyl)phthalate	0.33 mg/kg	
		Chrysene	0.092 mg/kg	
		Diethylphthalate	0.24 mg/kg	
		Fluoranthene	0.13 mg/kg	
		Phenanthrene	0.11 mg/kg	
		Pyrene	0.12 mg/kg	
		Arsenic	4.6 mg/kg	
		Barium	110 mg/kg	
		Chromium	8.4 mg/kg	
		Lead	100 mg/kg	
		Mercury	0.054 mg/kg	
		Silver	0.46 mg/kg	

TABLE 5–3

ESTIMATED EXPOSURE POINT CONCENTRATIONS
Residual Risk Assessment
Pesticide Storage Facility
Fort Riley, Kansas

Medium	Exposure Pathway	Parameter	Exposure Concentration	Comments
Sediments	Dermal Contact	Chlordane	0.086 mg/kg	From RI sediment analytical results (see UCL Tables in Appendix A.)
		4,4'–DDD	0.059 mg/kg	
		4,4'–DDE	0.055 mg/kg	
		4,4'–DDT	0.096 mg/kg	
		Dieldrin	0.013 mg/kg	
		Benzo[a]anthracene	0.15 mg/kg	(Note: Samples SD1A and SD1B were not included in the statistical analysis for metals; these are background samples for inorganics.)
		Chrysene	0.18 mg/kg	
		Phenanthrene	0.21 mg/kg	
		Arsenic	2.8 mg/kg	
		Barium	120 mg/kg	
		Cadmium	1.8 mg/kg	
		Chromium	17 mg/kg	
		Lead	150 mg/kg	
		Mercury	0.24 mg/kg	

Note: Exposure point concentration calculations are presented in Appendix A.

Pathway-specific intakes were estimated by identifying a series of variables that describe the exposed population. These variables typically include contact rate (e.g., soil ingestion rate), exposure frequency, exposure duration, and body weight. The specific calculation procedures and variables used in this residual risk assessment to estimate pathway-specific intakes are the same as those in the RI report (LAW, 1993a). The variable values used to estimate intakes in the RI report (LAW, 1993a) for future exposure scenarios were reevaluated for this residual risk assessment. Because these variable values are based on an estimation of a reasonable worst-case scenario, and because the future use of the site is not certain, they have been judged to still be representative of the potential magnitude of future exposures. Because the site is currently inactive, the variable values used to estimate intakes for the "current" scenarios (retained in this residual risk assessment for consistency with the RI report [LAW, 1993a]) represent an overestimation of actual current exposures.

The dermal absorption factors used in this Residual Risk Assessment for pesticides detected in the soil differ from those used in the RI (LAW, 1993a), in which 100 percent was used. These new dermal absorption factors represent the upper bound proportion of the pesticides that would be retained in the skin (ATSDR, 1987-1993), and were approved for use in this residual risk assessment by USEPA Region VII (LAW, 1994b). The dermal absorption rates used for the chemicals of concern in the soil are:

- Inorganics (0.01, or 1 percent) - USEPA 1992b
- Volatile and semi-volatile organic compounds (1, or 100 percent)
- Chlordane and heptachlor (0.109, or 10.9 percent) - ATSDR 1989 and 1991, respectively
- DDD, DDE, and DDT (0.378, or 37.8 percent) - USEPA 1996
- Dieldrin (0.077, or 7.7 percent) - ATSDR 1989

The variable values used to estimate intakes were obtained from site-specific sources, when available (LAW, 1993a). These sources included the Senior Post Controller, Pesticide Workers, Materials Coordinator, DEH Chief of Maintenance, and the Grounds Foreman for the DEH at Fort Riley. When site-specific information regarding potential exposure-related activities was not available, standard default exposure values from the "Supplemental Guidance to the Human Health Evaluation Manual" (USEPA, 1991b) were used to calculate chemical-specific intakes. To estimate chemical-specific intakes for each pathway, the exposure variables were multiplied by the exposure point concentrations. The specific variable values used to estimate intakes are presented, by exposure pathway, in Appendix A. The chemical-specific intake estimates are also presented, by pathway, in Appendix A.

5.1.4 Toxicity Assessment

The toxicity assessment is an integral part of the risk assessment. For this residual risk assessment, the toxicity assessment consists of a summary of the applicable toxicity information for the chemicals of concern (Tables 5-4 and 5-5 for noncarcinogens and carcinogens, respectively). A discussion of the toxicology of the contaminants of concern is presented in the December 1993 RI report (LAW, 1993a). The hierarchy of sources used to obtain the toxicity information is that suggested by USEPA (USEPA, 1989a), and is listed below:

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Tables (HEAST)
- USEPA Environmental Criteria and Assessment Office (ECAO)
- USEPA Criteria Documents
- Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles

Toxicity information for the dermal exposure route is typically not available. Therefore, in accordance with USEPA Region VII guidance (USEPA, 1992a), oral reference doses (RfDs) and cancer slope factors (CSFs) were used directly as dermal toxicity values.

5.1.5 Risk Characterization

The risk characterization integrates the results of the exposure and toxicity assessments into quantitative and qualitative expressions of risk. To characterize potential noncarcinogenic risks, the estimated chemical intakes are compared to (i.e., divided by) the RfDs and reference concentrations (RfCs) for the COCs. To characterize potential carcinogenic risks, the estimated chemical intakes are multiplied by the chemical-specific slope factors for the COCs. These risk quantitation methods, and the results of the risk characterization, are discussed and presented in the following sections.

5.1.5.1 Noncarcinogenic Effects Characterization - Noncarcinogenic effects are characterized by comparing the estimated chemical intakes to the appropriate RfD or RfC value. The RfD and RfC values are, by definition, an estimate of a daily exposure level for the human population that is likely to be without appreciable risk of deleterious effects. Therefore, when the estimated chronic daily intake of a chemical exceeds the appropriate RfD/RfC, there may be a concern for

TABLE 5–4

TOXICITY VALUES FOR CHRONIC NONCARCINOGENIC EFFECTS
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Chronic RfD (mg/kg–day)	Confidence Level[a]	Critical Effect	Uncertainty Factor[b]	Source	Study[c]
Oral Route:						
Chlordane	6.0E–05	low	Regional liver hypertrophy in females	1000	IRIS	Velsicol Chem. Co., 1983
4,4'–DDD	no data				IRIS	
4,4'–DDE	no data				IRIS	
4,4'–DDT	5.0E–04	medium	Liver lesions	100	IRIS	Laug, 1950
Dieldrin	5.0E–05	medium	Liver lesions	100	IRIS	Walker, 1989
Heptachlor	5.0E–04	low	Liver weight increases	300	IRIS	Velsicol Chem. Co., 1955
Benzene	no data					
Methylene chloride	6.0E–02	medium	Histological alterations of the liver	100	IRIS	National Coffee Ass., 1982
Toluene	2.0E–01	medium	Changes in liver and kidney weights	1000	IRIS	NTP, 1989
Benzo[a]anthracene	no data				IRIS	
bis(2–Ethylhexyl)phthalate	2.0E–02	medium	Increased relative liver weights	1000	IRIS	Carpenter, 1953
Chrysene	no data				IRIS	
Diethylphthalate	8.0E–01	low	Altered organ weights	1000	IRIS	Brown, 1978
Fluoranthene	4.0E–02	low	Liver weight increases	3000	IRIS	USEPA, 1978
Phenanthrene	no data				IRIS	
Pyrene	3.0E–02	low	Kidney effects	3000	IRIS	USEPA, 1989
Aluminum	2.9E+00				EPA	
Arsenic	3.0E–04	medium	Hyperpigmentation, keratosis, vascular complications	3	IRIS	Tseng, 1977
Barium	7.0E–02	medium	Increased blood pressure	3	IRIS	Wones, 1990
Beryllium	5.0E–03	low	No adverse effects	100	IRIS	Schroeder & Mitchner, 1975
Cadmium	1.0E–03 (food) 5.0E–04 (water)	high	Significant proteinuria	10	IRIS	USEPA, 1985
Chromium	5.0E–03	low	No effects reported	500	IRIS	Mackenzie, 1958
Lead	no data				IRIS	
Manganese	1.4E–01 (food) 5.0E–03 (water)		Central nervous system effects	1	IRIS	WHO, 1973
Mercury	pending (3.0E–04)		Kidney effects	1000	HEAST	USEPA, 1988
Selenium	5.0E–03	high	Clinical selenosis	3	IRIS	Yang, 1989
Silver	withdrawn (5.0E–03)	low	Argyria	3	IRIS	Gaul & Staud, 1935
Thallium	7.0E–05	low	Increased levels of SGOT & LDH	3000	IRIS	USEPA, 1986
Vanadium	9.0E–03	low	Decreased hair cystine	100	IRIS	Stokinger, 1953
Nitrate	1.6E+00	high	Methemoglobinemia	1	IRIS	Walton, 1951

TABLE 5–4

TOXICITY VALUES FOR CHRONIC NONCARCINOGENIC EFFECTS
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Chronic RfD (mg/kg–day)		Confidence Level[(a)]	Critical Effect	Uncertainty Factor[(b)]	Source	Study[(c)]
Inhalation Route:							
Chlordane	pending					IRIS	
4,4'–DDD	no data					IRIS	
4,4'–DDE	no data					IRIS	
4,4'–DDT	no data					IRIS	
Dieldrin	no data					IRIS	
Heptachlor	no data					IRIS	
Benzene	1.4E–04					EPA	
Methylene chloride	8.6E–01			Liver toxicity	100	HEAST	Nitschke, 1988
Toluene	1.1E–01		medium	Neurological effects	300	IRIS	Foo, 1990
Benzo[a]anthracene	no data					IRIS	
bis(2–Ethylhexyl)phthalate	no data					IRIS	
Chrysene	no data					IRIS	
Diethylphthalate	no data					IRIS	
Fluoranthene	no data					IRIS	
Phenanthrene	no data					IRIS	
Pyrene	no data					IRIS	
Aluminum	no data					IRIS	
Arsenic	no data					IRIS	
Barium	pending	(1.4E–04)		Fetotoxicity	1000	HEAST	USEPA, 1984
Beryllium	no data					IRIS	
Cadmium	pending					IRIS	
Chromium	pending					IRIS	
Lead	no data					IRIS	
Manganese	1.4E–05		medium	Increased prevalence of respiratory symptoms and psychomotor disturbances	300	IRIS	Roels, 1992
Mercury	pending	(8.6E–05)		Neurotoxicity		HEAST	USEPA, 1990
Selenium	no data					IRIS	
Silver	no data					IRIS	
Thallium	no data					IRIS	
Vanadium	no data					IRIS	
Nitrate	no data					IRIS	

(a) Confidence Level (i.e., high, medium, or low) as reported in IRIS

(b) Uncertainty Factors (UF) are assigned by USEPA in multiples of 10 based on the following limitations in the database used to develop the RfC/RfD:

A – Animal to human extrapolation (UF of 10)
H – Variations in human sensitivity (UF of 10)
S – Extrapolation from a subchronic NOAEL instead of a chronic NOAEL (UF of 10)
L – Extrapolation from a LOAEL to a NOAEL (UF of 10)

Withdrawn – Withdrawn (from IRIS) as a result of further review
Pending – Under review by an EPA work group

Source: IRIS = Integrated Risk Information System (10/94)
HEAST = Health Effects Assessment Summary Tables (FY–1994 Annual)

(c) Study used to develop the RfD or RfC, as cited by IRIS and/or HEAST.

TABLE 5-5

TOXICITY VALUES FOR POTENTIAL CARCINOGENIC EFFECTS
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Slope Factor [a] (kg-day/mg)	Weight of Evidence Classification [d]	Type of Cancer	Source[e]	Study[e]
Oral Route:					
Chlordane	1.3E+00	B2	Liver tumors	IRIS	NCI, 1979
4,4'-DDD	2.4E-01	B2	Lung, liver, and thyroid tumors in rodents	IRIS	Tomatis, 1974
4,4'-DDE	3.4E-01	B2	Liver tumors, liver cancer, and thyroid tumors	IRIS	Rossi, 1983
4,4'-DDT	3.4E-01	B2	Liver tumors	IRIS	Cabral, 1982
Dieldrin	1.6E+01	B2	Liver cancer	IRIS	Walker, 1972
Heptachlor	4.5E+00	B2	Liver tumors	IRIS	NCI, 1977
Benzene	2.9E-02	A	Increased incidence of nonlymphocytic leukemia	IRIS	Wong, 1983
Methylene chloride	7.5E-03	B2	Increased incidence of hepatocellular neoplasms	IRIS	NTP, 1986
Toluene	no data			IRIS	
Benzo[a]anthracene	1.1E+00 *	B2	Tumors in mice via various routes	IRIS	Wislocki, 1986
bis(2-Ethylhexyl)phthalate	1.4E-02	B2	Increases in liver tumor responses	IRIS	NTP, 1982
Chrysene	2.9E-02 *	B2	Malignant lymphoma, skin cancers, in mice	IRIS	Wislocki, 1986
Diethylphthalate	no data			IRIS	
Fluoranthene	no data			IRIS	
Phenanthrene	no data			IRIS	
Pyrene	no data			IRIS	
Aluminum [b]	no data			EPA	
Arsenic	1.8E+00	A	Skin cancer	EPA	
Barium	no data			IRIS	
Beryllium	4.3E+00	B2	Lung cancer in rats/monkeys via inhalation	IRIS	Schroeder & Mitchener, 1975
Cadmium	no data			IRIS	
Chromium [c]	no data			IRIS	
Lead	no data	B2	Renal tumors, affects gene expression	IRIS	
Manganese	no data			IRIS	
Mercury	no data			IRIS	
Selenium	no data			IRIS	
Silver	no data			IRIS	
Thallium	no data			IRIS	
Vanadium	no data			IRIS	

TABLE 5-5

TOXICITY VALUES FOR POTENTIAL CARCINOGENIC EFFECTS
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Slope Factor [(a)] (kg-day/mg)	Weight of Evidence Classification [(d)]	Type of Cancer	Source[(e)]	Study[(e)]
Inhalation Route:					
Chlordane	1.3E+00	B2	Liver tumors	IRIS	USEPA, 1986
4,4'-DDD	no data			IRIS	
4,4'-DDE	no data			IRIS	
4,4'-DDT	3.4E-01	B2	Liver tumors	IRIS	USEPA, 1985
Dieldrin	1.6E+01	B2	Liver cancer	IRIS	USEPA, 1986
Heptachlor	4.6E+00	B2	Liver tumors	IRIS	USEPA, 1986
Benzene	2.9E-02	A	Increased incidence of nonlymphocytic leukemia	IRIS	Wong, 1983
Methylene chloride	1.6E-03	B2	Increased incidence of hepatocellular neoplasms	IRIS	NTP, 1986
Toluene	no data			IRIS	
Benzo[a]anthracene	no data			IRIS	
bis(2-Ethylhexyl)phthalate	no data			IRIS	
Chrysene	no data			IRIS	
Diethylphthalate	no data			IRIS	
Fluoranthene	no data			IRIS	
Phenanthrene	no data			IRIS	
Pyrene	no data			IRIS	
Aluminum [(b)]	no data			EPA	
Arsenic	1.5E+01	A	Lung cancer	IRIS	Lee-Feldstein, 1983
Barium	no data			IRIS	
Beryllium	8.4E+00	B2	Lung cancer in rats/monkeys (inh)	IRIS	Wagoner, 1980
Cadmium	6.3E+00	B1	Carcinogenic in mice by various routes	IRIS	Thun, 1985
Chromium [(c)]	4.2E+01	A	Lung cancer	IRIS	Mancuso, 1975
Lead	no data	B2	Renal tumors, affects gene expression	IRIS	
Manganese	no data			IRIS	
Mercury	no data			IRIS	
Selenium	no data			IRIS	
Silver	no data			IRIS	
Thallium	no data			IRIS	
Vanadium	no data			IRIS	
Nitrate	no data			IRIS	

No Data - No value listed in reference

(Values listed in parentheses are from HEAST, and are used in the absence of current IRIS values)

* CSF generated using toxicity equivalency factors, based on benzo[a]pyrene toxicity (see LAW, 1993)

(a) Slope factors provided in terms of unit risk are converted prior to input on this table as follows:
for oral route: UNIT RISK (L/ug) * 1,000 ug/mg * day/2 L * 70 kg = CSF (kg-day/mg)
for inhalation route: UNIT RISK (m^3/ug) * 1,000 ug/mg * day/20 m^3 * 70 kg = CSF (kg-day/mg)

(b) IRIS or HEAST listing not available for this chemical

(c) Value is for hexavalent chromium

(d) Weight of Evidence Classification:
A - Human Carcinogen
B1 - Probable human carcinogen; limited human data available
B2 - Probable human carcinogen; inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as to human carcinogenicity

Source: IRIS = Integrated Risk Information System (11/91)
HEAST = Health Effects Assessment Summary Tables (FY-1994 Annual)
EPA = Memorandum to Assistant Administrators. Recommended Agency Policy on the Carcinogenicity Risk Associated with the Ingestion of Inorganic Arsenic. USEPA, Office of the Administrator, Washington, D.C. June 21, 1988.

(e) Study used to develop slope factor, as cited by IRIS.

potential noncancer effects from exposure to that chemical. The ratio of the chronic daily intake to the chronic RfD/RfC is referred to as the "hazard quotient" (HQ). Because the USEPA assumes additivity of effects in evaluating potential noncarcinogenic effects from a mixture of chemicals, the chemical-specific HQs are summed. This summation yields an overall pathway risk called a hazard index (HI). If an HI exceeds 1, segregation of the chemicals by effect or mechanism should be considered (USEPA, 1989a).

A summary of the HI estimates, by pathway, is presented in Table 5-6. None of the exposure pathways evaluated had a HI estimate greater than 1, the standard point of departure below which adverse health effects are not expected. The chemical-specific hazard quotient and hazard index calculations are presented, by pathway, in Appendix A. Also presented in Table 5-6 are the pathway-specific HI estimates calculated in the BLRA. A comparison of the two sets of HI estimates shows that the residual risks that were calculated range from approximately 1 to 4 orders of magnitude less than the baseline risks.

5.1.5.2 Carcinogenic Risk Characterization - Chemical-specific cancer risks are estimated by multiplying the slope factor by the chronic daily intake estimates, and are interpreted as probabilities of excess cancers as a result of exposure to chemicals from the site. The carcinogenic slope factor correlates estimated total chronic daily intake to incremental cancer risk. The results of the risk characterization are expressed as upper-bound estimates of the potential carcinogenic risk for each exposure point.

To assess the overall potential for cancer effects posed by the mixture of chemicals present at the site, USEPA assumes additivity. Therefore, cancer risks are estimated for each chemical, then the chemical-specific risks are summed to yield an estimate of the overall pathway-specific cancer risk.

A summary of the cancer risk estimates, by pathway, is presented in Table 5-7. None of the exposure pathways evaluated had a risk greater than 1×10^{-6}, the most conservative (i.e., health-protective) point-of-departure typically used to assess unacceptable risk. Chemical-specific risk calculations are presented by pathway in Appendix A. Also presented in Table 5-7 are the pathway-specific cancer risk estimates calculated in the BLRA. A comparison of the two sets of cancer risk estimates shows that the residual risks that were calculated range from approximately 1 to 4 orders of magnitude less than the baseline risks.

Polynuclear aromatic hydrocarbons represented less than 2 percent of the estimated risk or hazard indices in surface soil in the BLRA, and PAH-contaminated soils were substantially removed and replaced with clean fill during the Removal Action. Therefore, they were not reassessed in the residual risk assessment. For subsurface soil, data from samples from monitoring well borings that included PAH information used in the BLRA and not excavated during the Removal Action were added to the data set used for the residual risk assessment.

TABLE 5–6

SUMMARY OF HAZARD INDICES
SOIL RESIDUAL RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX[(a)]	BASELINE HAZARD INDEX[(b)]
Current Site Worker	Incidental Ingestion of surface soil	0.002	0.02
Current Site Worker	Dermal contact with surface soil	0.01	9
Future Site Worker	Incidental ingestion of surface soil	0.003	0.06
Future Site Worker	Dermal contact with surface soil	0.02	30.0
Future Site Worker	Inhalation of fugitive dust	NA	0.0000004
Future Site Worker	Dermal contact with sediments	0.00003	0.02
Current Utility Worker	Dermal contact with surface soil	0.00002	0.04
Current Utility Worker	Dermal contact with subsurface soil	0.00001	0.02
Future Utility Worker	Dermal contact with surface soil	0.00007	0.2
Future Utility Worker	Dermal contact with subsurface soil	0.00004	0.07
Current Landscaper	Dermal contact with surface soil	0.00005	0.01
Current Landscaper	Dermal contact with subsurface soil	0.000009	0.02
Future Landscaper	Dermal contact with surface soil	0.00006	0.1
Future Landscaper	Dermal contact with subsurface soil	0.00004	0.1
Future Construction Worker	Incidental ingestion of surface soil	0.01	0.3
Future Construction Worker	Dermal contact with surface soil	0.007	20.0
Future Construction Worker	Dermal contact with subsurface soil	0.004	7
Current/Future Recreational Child	Dermal contact with surface soil	0.0009	2

NA – Not assessed because toxicity data for inhalation of the chemicals of concern (RfCs) were not available.

[(a)] Estimates based on post–removal site data and revised absorption factors for pesticides.

[(b)] Hazard Index estimates from the Baseline Risk Assessment (prior to the Removal Action).

TABLE 5–7

SUMMARY OF CANCER RISKS
SOIL RESIDUAL RISK ASSESSMENT
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIU	CANCER RISK(a)	BASELINE CANCER RISK(
Current Site Worker	Incidental ingestion of surface soil	2E–07	1E–06
Current Site Worker	Dermal contact with surface soil	1E–06	8E–04
Future Site Worker	Incidental ingestion of surface soil	3E–07	6E–06
Future Site Worker	Dermal contact with surface soil	1E–06	4E–03
Future Site Worker	Inhalation of fugitive dust	3E–10	1E–06
Future Site Worker	Dermal contact with sediments	8E–09	2E–06
Current Utility Worker	Dermal contact with surface soil	2E–09	4E–06
Current Utility Worker	Dermal contact with subsurface soil	1E–09	2E–06
Future Utility Worker	Dermal contact with surface soil	6E–09	2E–05
Future Utility Worker	Dermal contact with subsurface soil	5E–09	8E–06
Current Landscaper	Dermal contact with surface soil	1E–09	1E–06
Current Landscaper	Dermal contact with subsurface soil	1E–09	2E–06
Future Landscaper	Dermal contact with surface soil	6E–09	2E–05
Future Landscaper	Dermal contact with subsurface soil	5E–09	7E–06
Future Construction Worker	Incidental ingestion of surface soil	5E–08	1E–06
Future Construction Worker	Dermal contact with surface soil	3E–08	7E–05
Future Construction Worker	Dermal contact with subsurface soil	2E–08	4E–05
Current/Future Recreational Child	Dermal contact with surface soil	NA	NA

NA – Not assessed because cancer risks are not estimated for children.

(a) Estimates based on new site data and revised absorption factors for pesticides.

(b) Risk estimates from the Baseline Risk Assessment (prior to the Rapid Response Removal Action).

5.1.6 Uncertainties

There are a number of assumptions required in developing quantitative estimates of risk. These assumptions lend a certain amount of uncertainty to the risk assessment. The assumptions and/or uncertainties are briefly discussed below.

- The exposure point concentrations used in the calculations of risk for surface soil are greater than can be reasonably expected. This is because concentration data were not obtained from areas that were backfilled with clean soil after being excavated during the Removal Action. This bias in the surface soil data set will tend to cause an overestimation of potential risks due to exposure to surface soil.

- In evaluating risks from future exposures to soil and sediment contaminants, the assumption was made that future constituent concentrations will remain the same as current concentrations. Dilution, decay, degradation, and attenuation of constituents occurs naturally over time, and site contaminants would thus present a reduced risk in future scenarios.

- While the dermal absorption factors have been revised downward from those used in the RI report (LAW, 1993a), the use of the revised dermal absorption factors still results in a probable overestimation of exposure. This is because the current dermal absorption factors are derived from studies in which pesticides were dissolved in acetone prior to application; absorption factors derived from studies in which the pesticides were mixed with soil prior to application are approximately an order of magnitude (i.e., 10 times) less than the factors used in the residual risk assessment (ATSDR, 1987-1993).

- The risk estimates for the current scenarios are overestimations because the site is not being used at present. The estimations of risks for the future scenarios probably represent an overestimation because the exposure parameter values used comprise a worst-case scenario.

This risk assessment should not be viewed as an absolute quantitative measure of the risk to public health presented by site-specific contaminants. The assumptions and inherent uncertainties in the risk assessment process do not allow this level of confidence. This risk assessment provides a conservative indication of the potential for risk due to exposure to site-specific chemicals and should help guide the management of the site.

5.1.7 Summary of Soil Residual Risk Assessment

None of the exposure pathways for which risks were assessed in the Residual Risk Assessment exceeded a cancer risk of 1×10^{-6}. Similarly, none exceeded a hazard index of 1. Risk estimates for two pathways, however, were approximately equivalent to 1×10^{-6}. These were potential dermal exposure to surface soil by current and future site workers. Because the potential increased risk at the site resulting from exposure to site-related constituents (including soil, surface-water, and sediment pathways not reevaluated in this Residual Risk Assessment) is less than or equal to the most conservative point of departure used in risk assessment, risks at the site are considered to be within acceptable limits.

5.2 HUMAN HEALTH RISK ASSESSMENT - HYPOTHETICAL GROUNDWATER

5.2.1 Introduction

This section presents the results of the risk assessment for hypothetical exposures to the groundwater in the uppermost aquifer at the site. However, as stated in Section 5.0, these risk estimates are being provided for information purposes only and are not considered to be part of the RME scenarios for this site. This is because the uppermost aquifer at the site is not currently being used as a source of potable water - and because its future use for this purpose is considered highly unlikely because an adequate existing water supply currently serves the area, the uppermost aquifer is not currently used as a water supply, and its low yield makes the uppermost aquifer an unlikely source of potable water in the future.

The risk assessment approach used to evaluate the potential impacts to human health from the hypothetical use of the upper most aquifer as a potable water supply is consistent with the approach presented in the USEPA "Risk Assessment Guidance for Superfund" document (USEPA, 1989a) and with the risk assessment conducted as part of the RI report (LAW, 1993a).

5.2.2 Identification of Chemicals of Concern

The groundwater data used for this residual risk assessment include the data reported in the December 1993 RI report (LAW, 1993a), [i.e., baseline (July 1992) through third quarter (May 1993) sampling results], plus the results from the most recent sampling events (September 1994 and December 1995). Twelve inorganic compounds were included as COCs in the BLRA presented in the RI report (LAW, 1993a). However, based on the statistical evaluation and comparison to background concentrations summarized in Section 4.2.3 and presented in

Appendix C, six of these inorganic compounds are not considered COCs for this risk assessment because they were not statistically different from background concentrations. These six compounds are antimony, arsenic, cadmium, manganese, nitrate, and thallium.

The remaining compounds which have been selected as COCs in groundwater for their risk assessment are shown below.

- Aluminum
- Barium
- Beryllium
- Chromium
- Selenium
- Vanadium

Frequencies of detection along with minimum and maximum values for these COCs are presented in Table 5-8.

The elimination of inorganic chemicals which are present at the site at naturally occurring levels (i.e., background levels) from the quantitative risk assessment is consistent with USEPA guidance (USEPA, 1989a). It should be noted that pesticides were not detected in the groundwater during any previous sampling efforts at concentrations greater than the laboratory reporting limit.

5.2.3 Exposure Assessment

Typically, an exposure assessment is used to characterize the magnitude of potential exposures at a site. However, the groundwater beneath the PSF site is not currently used as a potable water supply. Fort Riley obtains its potable water from well fields approximately 1.8 miles upgradient from the PSF, and the city of Ogden obtains its water supply from wells located approximately 3 miles downgradient from the site. Therefore, it is unlikely that chemicals detected in the groundwater beneath the site currently have an impact on human populations.

In addition, the potential for future impacts on human populations is also considered to be limited. The PSF is presently supplied by the Fort Riley water system. According to the "Emergency Expansion Capability Report and Environmental/Analytical Assessment - Ft. Riley" (CEMRK, 1994), the safe available yield of water from the aquifer serving Fort Riley is estimated at 50 million gallons per day, which exceeds the combined requirements of Fort Riley and the surrounding communities. Fort Riley is currently served by a total of eight wells with a combined total well capacity of 8,400,000 gallons per day, which is reduced to approximately 7,900,000 gallons per day when adjusted for fire fighting requirements. In comparison, the actual daily use is approximately 3,400,000 gallons per day, or approximately 42 percent of the

TABLE 5–8

CHEMICALS OF CONCERN IN GROUNDWATER DETECTION FREQUENCIES AND CONCENTRATION RANGES

Residual Risk Assessment
Baseline through December 1995
Pesticide Storage Facility
Fort Riley, Kansas

PARAMETER	Frequency of Detection	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)
Metals:			
Aluminum*	10/20	0.11	0.8
Barium*	20/20	0.042	0.130
Beryllium	15/24	0.001	0.005
Chromium	3/24	0.005	0.014
Selenium	16/24	0.011	0.0036
Vanadium*	4/20	0.008	0.027

* = Not analyzed for in December 1995

total available system capacity. This also corresponds to 6.8 percent of the estimated safe available yield in the aquifer. Based on this, installation of new water supply wells is neither reasonable nor foreseeable. There are no records to indicate that water supply wells for either drinking water or other purposes have ever been installed at the site, and considering the available capacity, installation of a potable water well in proximity to the PSF site is not considered a reasonable possibility.

This above information, in conjunction with the low yield of the uppermost aquifer (estimated at 0.12 to 5.2 gpm in Section 4), render the installation of a water supply well in the uppermost aquifer at the site improbable. The limited yield is due to the soil type beneath the site (clays, instead of the characteristic silts and fine sands of the alluvial deposits). Therefore, the assessment of the potential (future) use of groundwater at the site is provided for information purposes only and not because exposure to groundwater is considered likely.

Risks due to hypothetical future exposures to groundwater in the uppermost aquifer will be calculated for adult and child residential receptors, via ingestion and dermal contact during typical household activities. The quantification of potential groundwater exposures will be performed using the same approach used for the soil residual risk assessment. That is, exposure point concentrations are estimated using 95th percent UCL or maximum detected concentration and intake variable values selected so that the resultant risk estimate represents a reasonable maximum value. The exposure point concentrations used in the groundwater risk assessment for the six COCs are presented on Table 5-9. The variable values selected for this risk assessment are standard default exposure values (USEPA, 1991b) and are the same as the values used in the RI report (LAW, 1993a). The chemical-specific intake estimates for each of the scenarios are presented in Appendix A.

5.2.4 Toxicity Assessment

Pertinent information related to the toxicity assessment of the COCs in the groundwater at the site have been presented previously in the RI report (LAW, 1993a) and in Section 5.1.4. Applicable toxicity information (i.e., RfDs and CSFs) were listed on Tables 5-4 and 5-5. Toxicity via dermal absorption of contaminants in groundwater is treated in a manner similar to soil-bound contaminants, except that the absorption factor (for exposure to contaminants in soil) is "replaced" by a permeability constant (PC) for groundwater exposures. The PC value for the COCs in the groundwater, which are all metals, is 0.001 cm/hour (USEPA, 1992b). The use of this value for PC is consistent with the value used in the RI report (LAW, 1993a). (Note: the oral RfD for aluminum has been revised by the USEPA since the RI report. The new value, which is 1.00 mg/kg-day (IRIS, 1996), has been used to assess potential effects due to exposure to groundwater.)

TABLE 5-9

ESTIMATED EXPOSURE POINT CONCENTRATIONS IN GROUNDWATER

Residual Risk Assessment
Pesticide Storage Facility
Fort Riley, Kansas

Medium	Exposure Pathway	Parameter	Exposure Concentration	Comments
Ground Water	Ingestion of Drinking Water, Dermal Contact	Aluminum	0.32 mg/L	Concentrations are the 95% UCL of measured concentrations in all ground water samples collected from the monitoring wells for the site (PSF92-02, PSF92-03, PSF92-04, and PSF92-05) (PSF92-01 is a background well, and was not included)
		Barium	0.10 mg/L	
		Beryllium	0.0028 mg/L	
		Chromium	0.0067 mg/L	
		Selenium	0.0025 mg/L	
		Vanadium	0.017 mg/L	

Note: Exposure point concentration calculations are presented in Appendix A.

5.2.5 Risk Characterization

5.2.5.1 Noncarcinogenic Effects Characterization - The HI estimates for the hypothetical use of the groundwater in the uppermost aquifer at the site are 0.2 and 0.8 for adults and children, respectively (Table 5-10). Of the two exposure routes that make up these scenarios (i.e., ingestion and dermal contact), ingestion comprises approximately 99.8 percent of the HI estimates. The chemical-specific hazard index calculations are presented, by pathway, in Appendix A.

5.2.5.2 Carcinogenic Risk Characterization - The cancer risk estimates for the hypothetical use of the groundwater in the uppermost aquifer at the site are 1×10^{-4} and 3×10^{-7} for the ingestion and dermal contact exposure routes, respectively (Table 5-11). Beryllium is the only carcinogenic COC identified in the groundwater at PSF. Chemical-specific risk calculations are presented by pathway in Appendix A. Note that cancer risk is not calculated for children (USEPA, 1989a).

5.2.6 Uncertainties

There are a number of assumptions required in developing quantitative estimates of risk.

- The major source of uncertainty in the risk assessment for potential exposure to groundwater is related to the assumption of the exclusive use of the groundwater beneath the site as a potable water source. Currently, a public supply of potable water is already available to serve the PSF. A well placed in the aquifer beneath the PSF site would have a limited yield estimated at 0.12 to 5.2 gpm. It is therefore, not reasonable to assume that a drinking water well would be installed in the vicinity of the PSF under continued Fort Riley operations. Therefore, evaluating risk on the basis of using site groundwater as a source of future potable water results in an overestimation of risk.

- The primary risk driver for the carcinogenic risk was beryllium. Beryllium was detected in one well at concentrations above the MCL (0.004 mg/L). The greatest concentration detected was 0.005 mg/L in well PSF92-02 during the February 1993 sampling episode. Beryllium was not detected in any well during the two most recent sampling episodes (September 1994 and December 1995). In addition, PSF92-02 was the only on-site well for which the detected

TABLE 5–10

SUMMARY OF HAZARD INDICES
HYPOTHETICAL GROUNDWATER USE
(For Information Only)
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	HAZARD INDEX[a]
Hypothetical Site Resident (Adult)	Ingestion of ground water	0.2
Hypothetical Site Resident (Adult)	Dermal contact	0.0003
Hypothetical Site Resident (Child)	Ingestion of ground water	0.8
Hypothetical Site Resident (Child)	Dermal contact	0.001

(a) Calculated using six rounds of groundwater data (July 1992 – December 1995).

TABLE 5–11

SUMMARY OF CANCER RISKS
HYPOTHETICAL GROUNDWATER USE
(For Information Only)
Pesticide Storage Facility
Fort Riley, Kansas

RECEPTOR	EXPOSURE ROUTE AND MEDIUM	CANCER RISK[a]
Hypothetical Site Resident (Adult)	Ingestion of ground water	1E–04
Hypothetical Site Resident (Adult)	Dermal contact	3E–07
Hypothetical Site Resident (Child)	Ingestion of ground water	NA
Hypothetical Site Resident (Child)	Dermal contact	NA

NA – Not assessed because cancer risks are not estimated for children.

(a) Calculated using six rounds of groundwater data (July 1992 – December 1995).

concentrations of beryllium were not considered equivalent to background. Therefore, the carcinogenic risk estimated for beryllium may be an overestimation.

5.2.7 Summary of Groundwater Risk Assessment

At the present time, risks due to exposure to the groundwater beneath the site do not exist because a complete exposure pathway does not exist. This is because potable water supply wells do not exist at the site for either residential or occupational uses. Risks due to groundwater use do not and are not expected to exist because the exposure pathway does not and is not expected to exist in the future. However, only if in the unlikely event that residential water supply wells were installed at the site in the future, the possibility of adverse human health effects may exist due to the presence of beryllium. It should be noted, however that the concentrations of beryllium were considered greater than background in only one well (PSF92-02) and that the exposure point concentration for beryllium (0.0028 mg/L) is below the MCL for drinking water of 0.004 mg/L. Both the total and dissolved concentrations of beryllium in well PSF92-02 in February 1993 were 0.005 mg/L; the beryllium concentration in the duplicates for these samples were 0.004 mg/L which is equal to the MCL.

5.3 ECOLOGICAL RISK ASSESSMENT

The Ecological Risk Assessment (ERA) for the PSF (LAW, 1993a) was conducted in accordance with the guidance provided in the "Risk Assessment Guidance for Superfund, Vol. II - Environmental Evaluation Manual" (USEPA, 1989b). The objective of the "residual" ERA was to reevaluate the ERA conducted for the RI based on site conditions after the Removal Action. A summary of the ERA is presented below, followed by a reevaluation of potential risks to ecological receptors.

5.3.1 Previous Ecological Risk Assessment Summary

In the ERA, potential receptors present in the vicinity of the PSF and the potential pathways by which these receptors might be exposed to chemicals of concern present in surface soils (specifically pesticides), surface water, and sediments were identified. Possible risks to environmental receptors arising from exposure to site contaminants were characterized. The objectives of the previous ERA (LAW, 1993a) were to:

1. Determine the value or uses of nearby natural resources (land, air, water, biota).
2. Identify potential environmental impacts.
3. Assess the significance of any environmental impacts.

The ERA comprised the following tasks:

- Ecological Receptor Identification
- Exposure Pathway Evaluation
- Selection of Relevant Exposures
- Toxicity Assessment and Identification of ARARs
- Risk Characterization

The potential ecological receptors that may be affected by contamination present at the PSF site are presented below. Most of the information presented here is taken from the "Survey of Threatened and Endangered Species on Fort Riley Military Reservation" (U.S. Fish & Wildlife Service [USFWS], 1992a) conducted by the U.S. Fish & Wildlife Service.

Terrestrial Vegetation - Fort Riley is located within the Flint Hills region of the Central Plains. The ecological region is known as a tall grass prairie. Terrestrial systems associated with the PSF and surrounding area consisted of two major habitat types: grassland/prairie habitats and riverain habitats. The grassland/prairie habitats include various grass species including switchgrass (*Panicum virginatum*), Indian grass (*Sorgastrum nutans*), thistle (*Canduus hataus*), Johnson grass (*Sorghum halepense*), and sunflower (*Helianthus* sp.). Vegetation typically noted in riverain and densely vegetated drainage habitats in the Fort Riley area include cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), and hackberry (*Celtis occidentalis*) as canopy cover and dominated by redbud (*Cercis canadensis*), dogwood (*Cornus* sp.), greenbrier (*Smilax* sp.), poison ivy (*Rhus radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and seedling overstory species.

The PSF site consists primarily of cleared areas, vegetated by grasses and other herbaceous vegetation intermixed with nonvegetated areas. A wooded area, located to the east of the site, can be classified as riparian woodland.

Terrestrial Wildlife - On the basis of site observations and literature information, the animal community considered to frequent the general area of the site includes many species of birds (rock doves, starlings, song birds, pigeons, wild turkey), insects, and small mammals (deer, an occasional bobcat, bats, raccoons, possums, rabbits, squirrels, and other rodents) (USFWS, 1992a; DEH, 1993d). The areas in the immediate vicinity of the PSF do not provide suitable habitats for most species, because these areas are industrialized "high traffic" areas (USFWS, 1992b). That is, the PSF area is within a vehicle compound area (the DEH yard), an area where there is a high frequency of movement and activity during the day. The daytime activities at the site should not affect the habits of nocturnal animals using the area. Therefore, although a variety of animals may pass through the PSF site and DEH yard during hunting/foraging activities, they are not thought to inhabit the immediate area of the DEH yard in significant numbers.

Endangered Species - A recent survey conducted by the U.S. Fish and Wildlife Service (USFWS, 1992a) provided much of the necessary background information regarding the potential for threatened and endangered species on site. According to this report, eight federally-listed threatened and endangered species along with twelve federal category 2 candidate species could potentially occur on Fort Riley. Category 2 candidate species are those which the U.S. Fish and Wildlife Service is seeking additional information regarding their biological status, in order to determine if listing of these species is warranted. A listing of the threatened and endangered species known to occur in the Fort Riley area, along with their typical habitats, is provided in Table 5-12.

As shown in Table 5-12, the PSF site does not provide a suitable habitat for most of the species listed. It is possible that the wooded area east of the site may be utilized although not inhabited by species favoring riparian forests (the bald eagle). The loggerhead shrike may similarly pass near the PSF, because this species favors manmade perches such as fence posts and power lines. Both the bald eagle and the loggerhead shrike have been sighted on various areas of Fort Riley. However, there are no confirmed sightings of these species at the PSF. And although the confluence of the drainage ditch to the east of the PSF and the Kansas River provides a suitable habitat for the sturgeon chub (USFWS, 1992b), a federal category 2 species, the summary report on threatened and endangered species states that the occurrence of the sturgeon chub at Fort Riley is very unlikely (USFWS, 1992a). Therefore, although threatened and endangered species are known to occur in the Fort Riley area, the actual habitation of these species on the PSF site and surrounding area is unlikely to occur.

Aquatic Species - Because of the intermittent flow within the drainage channel, aquatic organisms at the site are most likely limited both in quantity and species richness. However, benthic organisms may be supported by these intermittent streams. The drainage ditch could

TABLE 5-12

ENDANGERED AND THREATENED SPECIES (AND ASSOCIATED HABITATS) POTENTIALLY OCCURRING AT FORT RILEY AREA
Pesticide Storage Facility
Fort Riley, Kansas

SPECIES	HABITAT
Piping Plover	Open unvegetated beach or sandbar
Least Tern	Sparsely vegetated sandbars in a wide channel with good visibility
Bald Eagle	Near water bodies (rivers, lakes, etc.) utilizing riparian forest
Peregrine Falcon	Large river or waterfowl management areas, cropland, meadows and prairies, river bottoms, marshes, and lakes
Whooping Crane	Wetland, riverine base sandbars, shallow water, slow river flow
Eskimo Curlew	Wet meadows, fields, pastures, drier parts of salt and brackish marshes
Western Prairie Fringed Orchid	Tallgrass prairie and sedge meadow (fire adapted)
Prairie Mole Cricket*	Tallgrass prairie, ungrazed or unmowed native tallgrass with silt-sandy loam soils
Regal Fritillary Butterfly*	Prairie meadows (wet), moist tallgrass prairie, virgin grassland where violets act as host plants
Sturgeon Chub*	Areas of shallow strong currents and gravel bottoms, turbulent areas where shallow water flows across sandbars
Texas Horned Lizard*	Dry-flat areas with sandy, loamy, or rocky surfaces with little vegetation
Loggerhead Shrike*	Grassland or shrubby fields with scattered woody vegetation for perching and nesting
White-faced Ibis*	Small ponds with stands of cattail or bulrush
Western Snowy Plover*	Unvegetated riverine
Eastern Spotted Skunk*	Open level cultivated farmland, upland sites with preference for fallen logs and brushpiles
Topeka Shiner*	Turbulent areas in rivers where shallow water flows across sand bars
American Burying Beetle	Tallgrass prairie, ungrazed or unmowed native tallgrass with silt-sandy loam soils
Black Tern*	Wetland areas
Henslow's Sparrow*	Native grassland with few trees
Hairy False Mallow*	Rocky outcrops and dry areas in prairies

Source: U.S. Fish & Wildlife Service, 1992a

Underlined species are known to occur on Fort Riley.

* Candidate species for endangered and threatened status.

also potentially provide habitat and a drinking water source for amphibians and other bank dwelling species.

In summary, negative impacts to fauna and flora at the PSF site were not readily apparent during the site characterization phase of the RI. Terrestrial and aquatic life in the area of the drainage ditch may potentially suffer adverse effects from constituents detected in site surface-water and sediment samples. However, other (larger) sources of surface water are located nearby, and ecological receptors would probably favor these sources over the intermittent stream on site. Therefore, the environmental impact of the contamination detected in the surface water and sediment on site appears to be low. In addition, the contamination present in site surface water and sediment is not expected to impact downstream media because the natural character of the drainage ditch (i.e., its intermittent flow) does not consistently discharge surface water and flush sediments to downstream points.

Similarly, potential risks to environmental receptors due to exposure to soil at the site is considered to be minimal. The area most impacted by soil contamination prior to the Removal Action [the small stressed area of vegetation noted in the RI (LAW, 1993a)] was of very limited extent (approximately 20 feet by 20 feet), and there are areas adjacent to the site that provide suitable habitats and food supplies for animal species that may pass by or frequent the site. This area of stressed vegetation experienced regrowth during the 1993 growing season. Therefore, the effects of the (previous) soil contamination do not appear to be significant or long-lasting.

5.3.2 Re-evaluation of Ecological Risks Based on Current Conditions

Prior to the Removal Action, the ecological risks due to potential exposures at the site were judged to be minimal. The Removal Action replaced contaminated surface and subsurface soil with clean backfill and included the removal of soil from the area where stressed vegetation had been observed. Therefore, based on current site conditions, it is expected that ecological risks are not a concern at the PSF site.

6.0 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

While the RRA does not indicate unacceptable risk and the need for remediation is not triggered, applicable or relevant and appropriate requirements (ARARs) are analyzed in this section. All potential ARARs either do not apply to the site or are compliant under current or anticipated future conditions. To establish the need for remedial action, an evaluation of current site conditions for the purpose of identifing remedial action objectives (RAOs) consistent with NCP Section 300.430(e)(2)(i) is performed in this section. Protectiveness goals are being achieved for each exposure pathway and media of concern therefore, no RAOs are identified. RAOs specify the contaminants and media of concern, potential exposure pathways, and remediation goals (RGs) to be addressed by remedial actions at a site. RGs establish acceptable exposure levels for the COCs that are protective of human health and the environment, and are developed by considering the following:

- Risk-based remediation goal concentrations, using risk assessment-based calculations when applicable or relevant and appropriate requirements (ARARs) are not available, or are not sufficiently protective because of the presence of multiple contaminants or multiple pathways of exposure at the site.

- Maximum contaminant level goals (MCLGs) or maximum contaminant levels (MCLs) established under the Safe Drinking Water Act for ground or surface waters that are current or potential sources of drinking water, when the MCLGs or MCLs are relevant and appropriate under the circumstances of the release.

- ARARs under federal environmental, state environmental, or facility siting laws.

- Water quality criteria established under Section 303 or 304 of the Clean Water Act, where relevant and appropriate under circumstances of the release.

- Environmental evaluation to assess threats to the environment.

The NCP [NCP 300.430 (e)(2)(i)(D)] states: "In cases involving multiple contaminants or pathways where attainment of chemical-specific ARARs will result in cumulative risk in excess of 10^{-4}, criteria in paragraph 300.430 (e)(2)(i)(A) may also be considered when determining the cleanup level to be attained." This referenced criterion in NCP 300.430 (e)(2)(i)(A)(2) specifically addresses "concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect...incorporating an adequate margin of safety."

This section of the NCP also states: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}. The 10^{-6} risk level shall be used as the point of departure for determining remedial goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure."

These sections of the NCP allow risk levels of between 10^{-4} and 10^{-6} to be considered for establishing remedial goals to be attained by alternatives which consider multiple contaminants and pathways of exposure at the site. This intent is further stated in the preamble discussion to the NCP (Federal Register Vol. 55 No. 46) which describes the point of departure as a cumulative risk level "used as a starting point (or initial "protectiveness goal") for determining the most appropriate risk level that alternatives should be allowed to attain." The preamble to the NCP also states "preliminary and final remedial goals, i.e, target risk levels, however, may vary from the point of departure depending upon site-specific circumstances."

To identify the COCs at the PSF site, media-specific potential exposure pathways were identified, and risk estimates were calculated in the BLRA in the RI report (LAW, 1993a). Following the Removal Action, the exposure pathways previously identified in the BLRA with risk estimates exceeding 1 x 10^{-6} (for carcinogens) or a HI of 1 (for noncarcinogenic effects) were reevaluated in the RRA presented in Section 5.

> Soils and Sediment - Soils and sediment media exposure pathways were reevaluated in the RRA, and the carcinogenic risk estimates did not exceed 1 x 10^{-6}, and HI estimates for noncarcinogenic effects did not exceed 1. From the evaluations it is concluded that soil and sediment media do not present unacceptable risks at this site. RAOs addressing the sediment media are not needed, because protectiveness goals are being achieved at the site for the exposure scenarios considered. Similarly, soil exposure risks following the Removal Action do not exceed protectiveness goals at this site, and the identification of RAOs addressing soil media is not necessary. Although remedial action is not necessary, risk-based preliminary remediation goals (PRGs) concentrations are calculated for the receptors which represented the exposure pathways with the highest risks in the BLRA, and are presented as an informational comparison to residual soil concentrations to identify individual exceedances at the site. These risk-based PRGs are calculated for the COCs in the soils and are presented in Section 6.1.2.1.

> Surface water - Potential exposure pathways for surface water and associated risk estimates were evaluated previously in the December 1993 RI BLRA and are not reevaluated in the RRA. Calculated risk estimates did not exceed 1 x 10^{-6} for carcinogens nor did the HI exceed 1 for noncarcinogenic effects for any exposure pathway. Surface-water media does not present unacceptable risks at this site and it is unnecessary to identify RAOs addressing surface water, because protectiveness goals are being achieved at the site.

Air - Volatile organics were not identified as contaminants of concern at this site, and the metals and pesticides do not readily volatilize. Therefore, RAOs/RGs pertaining to air media are not developed.

Groundwater - The groundwater exposure pathway is currently incomplete at this site, and the future use of groundwater is very unlikely. An existing water supply system with adequate future capacity serves the site, and the on-site wells have a low yield, making their use for a water supply impractical. The groundwater exposure scenarios and associated risks were evaluated in the RRA for information only because the calculated risks are not expected to be realized at this site. Chemical constituents which were statistically evaluated (Section 4.2.2) and equivalent to background are not considered as COCs nor are they included in the risk estimates. The calculated noncarcinogenic hazard index for the hypothetical exposure scenario was less than 1. Therefore the COCs included in the noncarcinogenic risk calculation (presented in Section 5.2.5) are not of concern under a groundwater use scenario. The carcinogenic risk estimate was calculated to be 1×10^{-4}, due to beryllium which is the only COC included in the carcinogenic risk evaluation. The MCLG/MCL for beryllium is compared to the on-site concentrations for information only (see section 6.1.2.3). The groundwater use pathway is incomplete at this site under reasonable current and future land use scenarios.

ARARs are evaluated below considering current and likely future land uses. The PSF site is located in the Public Works equipment and material storage area and the land use is expected to remain as light industrial. An evaluation to identify potential ARARs for soil media is presented in Section 6.1. Under Section 303 of the Clean Water Act, states must develop water quality standards associated with designated uses identified for surface waters. Potential state ARARs are evaluated in Sections 6.1.1.7 and 6.1.1.8. Potential surface-water ARARs under Section 304 of the Clean Water Act were reviewed previously in the December 1993 RI Report. Under Section 304, the ambient water quality criteria were established for the protection of aquatic life. The ambient water quality criteria were not considered applicable nor relevant and appropriate at this site, because the intermittent stream does not support aquatic communities.

An environmental evaluation (e.g., ecological risk assessment) was previously conducted in the BLRA and was summarized in Section 5.3. Potential risks to ecological receptors were also reevaluated following the Removal Action. Ecological risks are not a concern at this site, therefore, consideration of remedial actions addressing environmental or ecological threats is not necessary at the PSF site.

6.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED (TBC) CRITERIA

CERCLA remedial response actions must address the requirements of the environmental laws which are determined to be "applicable" or "relevant and appropriate." The identification of ARARs involves the comparison of a number of factors, including the physical nature of the site (location-specific), the type of hazardous substances present (chemical-specific), and the types of remedial actions considered (action-specific), to the statutory or regulatory requirements of the relevant environmental laws. Two types of ARARs are addressed in the following sections: location-specific and chemical-specific.

Per the USEPA "CERCLA Compliance with Other Laws Manual: Interim Final" (USEPA, 1988b), a requirement under other environmental laws may be either "applicable" or "relevant and appropriate," but not both. Identification of ARARs must be performed on a site-specific basis and involves a two-part analysis. First, a determination whether a given requirement is applicable. If it is not directly applicable, a determination is made whether it is both relevant and appropriate.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. A state requirement must be promulgated to qualify as a potential ARAR. Promulgated requirements are found in state statutes and regulations that have been adopted by authorized state agencies. To qualify as an ARAR, a promulgated requirement must also be consistently applied and apply to a broader universe than Superfund sites (USEPA, 1988c, Chapter 6).

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

As stated earlier, the ARAR determination involves a comparison of a number of site-specific factors, including the characteristics of the remedial action, the hazardous substances present at the site, or the physical circumstances of the site, with those addressed in the statutory or regulatory requirement. As stated in the NCP, Section 300.400 (g)(2)(viii), the use or potential use of the affected resource shall be considered in the determination of relevant and appropriate requirements. In some cases, a requirement may be relevant, but not appropriate, given site-specific circumstances; such a requirement would not be an ARAR for the site. In addition, there is more discretion in the determination of relevant and appropriate; it is possible for only part of a requirement to be considered relevant and appropriate in a given case. When the analysis results in a determination that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

In addition to the ARARs, to be considered criteria (TBCs) may be identified during the process of determining remedial response objectives, in accordance with the NCP Section 300.400 (g)(3). The TBCs are nonpromulgated advisories or guidance criteria issued by the state or federal government that are not legally binding and thus do not have the status of potential

ARARs. TBCs are used, however, in conjunction with ARARs to aid in the determination of cleanup levels necessary to protect human health and the environment. Examples of TBCs include health advisories, guidance policy documents developed to implement regulations, and calculated risk-based levels such as contaminant-specific risk-based remediation goals.

6.1.1 Discussion of Potential Location-Specific ARARs and TBC Criteria

Location-specific ARARs are restrictions placed on the concentration of constituents or the activities to be performed at a site because the site occurs in a special location such as a floodplain, wetland area, historic places, and fragile ecosystems or habitats. Federal requirements that are evaluated for this site as potential ARARs are listed below:

- Endangered Species Act of 1973
- Fish and Wildlife Coordination Act
- Storm-Water Discharge Requirements National Pollutant Discharge Elimination System Requirements
- Federal Safe Drinking Water Act (Sections 303 and 304)
- Protection of Wetlands (Executive Order 11990)
- Floodplain Management Requirements (Executive Order 11988)
- National Historic Preservation Act (16 U.S.C. 469)

An additional State of Kansas regulation that has been evaluated is:

- State of Kansas Regulations in Article 16, Section 28, titled Water Pollution Control (K.A.R. 28-16-28b to K.A.R. 28-16-28e)

Currently, there are no location-specific TBC requirements under examination for this site. The potential location-specific ARARs are summarized below with descriptions of reasons for the applicability of a given location-specific ARAR to this site.

6.1.1.1 Endangered Species Act of 1973 (50 CFR 17) - These regulations protect or conserve endangered or threatened species. Fort Riley falls within an area that eight federally endangered species and thirteen additional candidate species for the federal endangerment listing are likely to inhabit. Of these 21 total species, two federally endangered species and eight candidate species are known to occur on Fort Riley. Examples of these species include the bald eagle, the peregrine falcon, the prairie mole cricket, and Henslow's sparrow. The PSF does not provide a suitable habitat for most of the threatened and endangered species at Fort Riley. Both the bald eagle and loggerhead snake have been sighted on various areas of Fort Riley, but there have been no confirmed sightings of these species at the PSF site. Bald eagles have been sighted in riparian areas in the vicinity of the PSF. Eagles may pass through the PSF area, but are unlikely to inhabit the PSF site due to the limited areas of woodlands and the frequent human activities in the area. Considering that no confirmed sightings have been made at the PSF site, the available habitat areas are limited, and the frequent activities in the PSF area, the Endangered Species Act of 1973 is not considered an ARAR.

6.1.1.2 Fish and Wildlife Coordination Act (33 CFR 320-330; 40 CFR 6.302) - This act conserves fish and wildlife when remedial actions result in the modification of a body of water; it is potentially applicable to this site because several different species of animals have been identified at Fort Riley, including the American burying beetle, the Texas horned lizard, the loggerhead shrike, and the regal fritillary butterfly.

6.1.1.3 Storm-Water Discharge Requirements National Pollutant Discharge Elimination System (CWA 40 CFR 122) - The PSF is located approximately one-half mile north of the Kansas River; an ephemeral drainage way, draining toward the Kansas River, is located east of the PSF. The federal Storm-Water Discharge Requirements and National Pollution Discharge Elimination System requirements, therefore, potentially apply to this site, because storm water may drain off the site, acquiring chemical contaminants by contact with contaminated surface soils, into the Kansas River. This drainage would constitute a surface-water discharge.

6.1.1.4 Protection of Wetlands (Executive Order 11990) - Federal requirements for protection of wetlands (Executive Order 11990) regulate action involving management of property in wetland areas to avoid adverse effects, minimize potential harm, and preserve and protect wetlands to the extent possible; these requirements do not apply because no formally delineated wetlands appear to exist at the site. The Corps of Engineers has conducted a wetlands delineation survey (CEMRK, 1993). Results generated from this survey indicated that no jurisdictional wetlands areas exist within the limits of the PSF site, and Executive Order 11990 is not an ARAR for the PSF site.

6.1.1.5 Flood Plain Management (Executive Order 11988) - Federal requirements for floodplain management (Executive Order 11988) regulate action that will occur within a floodplain to avoid adverse effects due to flooding. This ARAR is potentially applicable because portions of the PSF site are located within the 50-year floodplain. The 50-year flood peak in this region has been estimated at 1,067 feet above mean sea level (msl). Portions of the site are located on land situated within the confines of the floodplain. This requirement does not apply to existing conditions, but could apply if remedial action was considered for this site.

6.1.1.6 National Historic Preservation Act (16 U.S.C. 469) - These regulations were enacted to protect and preserve significant artifacts and historic properties. The historical and archaeological significance of Ft. Riley, in addition to its inclusion on the National Register of Historic Places, makes this ARAR potentially applicable to the PSF site, since the Main Post Area, encompassing the DEH yard, is identified. The PSF area has been extensively altered by filling, grading, and construction of the limestone channel during the past 60 years. Building 348, constructed in 1941, has not been identified as a historical structure. Considering these past activities, it is likely that any historic or cultural resources at the PSF site have been disturbed. Therefore, this ARAR is not relevant or appropriate to the PSF, as no concerns within the study area have been identified. This ARAR is applicable, but not expected to have a significant impact on actions at the site. Proposed actions, if initiated at the site, would have to be reviewed per Section 106 and activities may have to be monitored.

6.1.1.7 Kansas Regulations: Water Pollution Control (K.A.R. 28-16-28 to K.A.R. 28-16-28e) - The State of Kansas has promulgated water pollution control regulations under Agency-28, Department of Health and Environment. These regulations pertain to surface waters of Kansas. The regulations in Article 16, Water Pollution Control, are evaluated as potential ARARs for the PSF site.

> Definitions as used in these regulations, are stated in K.A.R. 28-16-28b, titled Definitions. K.A.R. 28-16-28b(c) defines an "alluvial aquifer" as sediment that is associated with, and deposited by, a stream and that contains water capable of being produced from a well. The site is located on terrace deposits above the current alluvial plain of the Kansas River. The average yield for the PSF on-site wells has been calculated to be 0.9 gpm. If the terrace deposits are considered to be associated with the Kansas River and if the groundwater is considered to contain water capable of being produced from a well, then this definition applies.
>
> K.A.R. 28-18-28b(ww) defines "Surface waters" to mean all "streams,...including sloughs, draws, arroyos, canals...and any alluvial aquifers associated with these surface waters." The lined channel adjacent to the site would meet the definition of surface water. As previously stated, the groundwater at this site, if considered to fall within the K.A.R. 28-16-28b(c) definition of considered "surface water" if the definition for "alluvial aquifer" applies to the groundwater at the site.
>
> "Classified surface water" is defined in K.A.R. 28-16-28b(m) as surface water that meets the criteria for classification in K.A.R. 28-16-28d(b). Under K.A.R. 28-16-28d(b)(1),

> classified streams shall include all streams with a summer base flow exceeding 0.003 cubic meters per second, or streams providing pooling of water during periods of zero flow providing important refuge for aquatic life permitting biological recolonization. The lined channel has an intermittent flow and during dry periods does not support significant aquatic life. The channel is not a classified surface water; therefore, provisions applicable to classified surface waters are not ARARs for the PSF site.
>
> K.A.R. 28-16-28b(q) defines "designated use" as any of the beneficial uses specifically attributed to surface waters in K.A.R. 28-16-28d. "Existing use" in K.A.R. 28-16-28b(u) means any of the beneficial uses described in K.A.R. 28-16-28d known to have occurred in or have been made in a surface water after November 28, 1975.
>
> "Pollution" is defined in K.A.R. 28-16-28b(mm) as contamination or other alteration....which may create a nuisance or render such waters harmful, detrimental, or injurious to public health....or other beneficial uses, or any discharge that will or is likely to exceed state effluent standards predicated upon technologically-based effluent limitations.

K.A.R. 28-16-28c, titled: General provisions, implements K.S.A. 65-165 and K.S.A. 65-171d. The provisions in K.A.R. 28-16-28c(a) require that levels of water quality be maintained in surface waters of the state to protect existing and designated uses. Water in the lined channel adjacent to the site has been tested and shown to exhibit levels of water quality necessary to protect existing uses and not result in pollution causing harmful effects on populations of any threatened or endangered species. The groundwater quality at the site, if considered to fall within the K.A.R. 28-16-28b(c) definition of an alluvial aquifer, is also protective of existing and designated uses in that all chemicals of concern are statistically equivalent to background or statistically below the MCL.

K.A.R. 28-16-28d, titled Surface-water use designation and classification, implements K.S.A. 65-165 and K.S.A. 65-171d. The lined channel is not a classified stream, as discussed above. To be assigned a "designated use," a stream must be a classified stream. Therefore, K.A.R. 28-16-28d is not applicable to the PSF site. Neither is it relevant and appropriate, because the stream does not support significant aquatic life nor has sufficient flow to sustain any of the designated uses listed in K.A.R 28-16-28d.

Surface-water quality criteria are presented in K.A.R. 28-16-28e. In K.A.R. 28-16-28e(b) the general criteria for surface waters are stated. Surface waters are to remain free from artificial polluting substances, such as toxic chemicals, infectious microorganisms from livestock, rubbish, debris, oil and grease, or other pollutants from direct discharges and from nonpoint sources that jeopardize public health, terrestrial or aquatic wildlife. These general criteria may be applicable to the lined channel, since the channel is defined as "surface water," as these criteria apply to all surface waters, regardless of classification. These general criteria also apply to the groundwater, if considered to fall within the K.A.R. 28-16-28b(c) definition of an alluvial aquifer. The groundwater is considered free of pollutants in that all chemicals of concern are statistically equivalent to background or statistically below the MCL. The criteria for designated uses of surface waters are presented in K.A.R. 28-16-28e(c). These criteria are not applicable nor relevant and appropriate to the lined channel since the channel is not classified and a designated use cannot be applied.

6.1.1.8 Kansas Statutes: Water Supply and Sewage (K.S.A. 65-161 to K.S.A. 65-171) - The State of Kansas has promulgated statutes (K.S.A. 65-161 to K.S.A. 65-171 titled Water Supply and Sewage) which were evaluated as potential ARARs for the PSF site. These statutes establish provisions for water sources within state boundaries which could be used to supply public water systems.

> Definitions as used in these regulations are stated in K.S.A. 65-161, titled Definitions. In K.S.A. 65-161(a) "Waters of the State" are defined as "all bodies of surface and subsurface waters within the boundaries of the state." This broad definition sets forth the indivisibility of surface and subsurface bodies of water as waters of the state. K.S.A. 65-161 presents definitions for "discharges," into waters of the state.
>
> K.S.A. 65-162(b) defines a "public water supply system" as a system for the provision to the public of piped water for human consumption, if such a system has at least 10 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. (This definition is similar to the Safe Drinking Water Act definition for a public water system). The water at the PSF site (channel or groundwater) clearly does not yield sufficient water to provide for a public water supply system as defined.

K.S.A. 65-163 is titled: Public Water Supply Systems: regulation; permits; complaints, investigations, orders, judicial review; system of fees for inspection and regulation; advisory committee. K.S.A. 65-163 et al. sets forth these requirements for public water supplies and are not applicable nor relevant and appropriate to the PSF site.

K.S.A. 65-164 is titled: Sewage; definition; complaints; investigations, orders; judicial review. "Sewage" as defined in K.S.A. 65-164(b) has a broad definition which includes "chemical or other wastes from domestic, manufacturing or other forms of industry." The Statute also sets out in K.S.A. 65-164(c) the Secretary of Health and Environment's role in investigating "the pollution or the polluted condition" of any waters of the state whenever the secretary "has reason to believe that any waters of the state are being polluted in a manner prejudicial to the health of any of the inhabitants of the state." These investigative requirements were satisfied by this investigation, and it was concluded from the investigation that the surface and groundwater at the PSF site are not prejudicial to the health of any inhabitants of the state.

K.S.A. 65-165 is titled: Permit for discharge of sewage; general permits; revocation or modification of permit. These statutes allow for the permitted discharges of sewage (as defined in K.S.A. 65-165[b]) into waters of the state which would not detract from the quality of the waters of the state for their beneficial uses, and establish administrative procedures for issuing discharge permits. The permitted discharge requirements are not applicable to the PSF site, because the site is landlocked within the confines of the Fort Riley military reservation, and site discharges remain on the federal property and do not directly enter waters of the state with a designated beneficial use. The requirement that discharges do not detract from beneficial uses may be relevant and appropriate because a beneficial use in downstream waters (e.g. Kansas

River) could be impacted by pollutants in surface waters from this site. The investigations at the PSF site have shown that the levels of contaminants found in the surface and groundwater discharges from the site do not adversely impact beneficial uses in the Kansas River, and these discharges comply with these requirements.

K.S.A. 65-166, titled: Application for permit to discharge sewage, and K.S.A. 65-166(a): fees for administering water pollution control permit systems; expiration of permits; reissuance;disposition of moneys, require that plans and specifications for sewer system extensions and fees for administrative costs associated with permitting be submitted to the State. These sections also present the requirements for issuing and renewing discharge permits. These provisions are not applicable nor relevant and appropriate to the site, as no sewer system improvements are being proposed.

K.S.A. 65-167 is titled: Sewage discharge; penalties for willful or negligent discharge of sewage without a permit or in violation of terms of permit. This section describes the penalties (fines) for discharges in violation of State requirements and is not applicable nor relevant and appropriate to the PSF site, because the site is within the confines of the Fort Riley military installation, and the discharges from the site are not impacting the beneficial uses of the waters of the State.

6.1.2 Discussion of Potential Chemical-Specific ARARs and TBC Criteria

Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Constituents that have the potential for causing adverse human health and environmental effects have been detected at the site.

The COCs in soils are the pesticides chlordane, DDT and metabolites, dieldrin, and heptachlor. For soils, no federal or State of Kansas requirements were identified for evaluation as potential chemical-specific ARARs. The following TBCs are identified and are evaluated below:

- Risk-based preliminary remediation goals (PRGs) are calculated for comparison with on-site concentrations
- Kansas Department of Health and Environment (KDHE) Remediation Interim Soil Cleanup Standards, August 1993

The risk evaluation for the hypothetical groundwater use identified beryllium as the only COC. For groundwater, the following federal and State of Kansas requirements are identified and evaluated as potential ARARs for this site:

- Federal Safe Drinking Water Act (40 CFR 141, Subpart B)
- State of Kansas Statutes titled Water Supply and Sewage (K.S.A. 65-161 to K.S.A. 65-171)

A TBC identified and evaluated is the NCP expectation for groundwater restoration found in Section 300.430(a)(1)(iii)(F). Potential chemical-specific ARARs are summarized below.

6.1.2.1 Calculation of Risk-Based Remediation Goals for Soils - Remediation goals (RGs) establish acceptable exposure levels that are protective of human health and the environment [NCP 300.430 (e)(2)(i)]. Appropriate RGs are determined by identifying chemical concentrations available in ARARs and from the consideration of risk-based RGs when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure [NCP 300.430 (e)(2)(i)(A)(2)]. During the RI/FS phase, preliminary remediation goals (PRGs) are developed while final RGs are determined when a remedy is selected. PRGs are calculated and presented here as an informational comparison to post-Removal Action site conditions (since the RRA does not indicate unacceptable risk and therefore does not trigger remedial action requirements).

Risk-based RGs are concentrations developed using risk assessment-based calculations. The calculations result in concentration limits for the COCs under specific exposure conditions. Ecological effects may also be considered when appropriate to develop RGs. At the PSF ecological impacts were not evident and were not considered in the development of the PRGs.

Risk-based PRGs for the COCs in the soil at the PSF site were developed following guidance available from USEPA (USEPA, 1989a; USEPA, 1991b). The contaminant-specific toxicity values used in the PRG calculations were obtained from the USEPA's Integrated Risk Information System (IRIS) data base. This method involves estimating exposure for reasonable scenarios at the PSF site. The exposure variable values used for calculating the PRGs for the PSF site are consistent with the values used in the RRA presented in Section 5.1 of this report. For surface soil, PRGs have been developed for future workers at the site. For subsurface soil, PRGs have been developed for future construction workers at the site. These evaluations have been conducted in a manner that is consistent with the BLRA and RRA, and incorporate the potential cumulative effects of exposure via ingestion, dermal contact, and inhalation. Therefore, this represents a conservative approach to the development of the PRGs (i.e., protective of human health). The soil PRGs developed herein differ from those used during the Removal Action in the following ways:

- More realistic dermal absorption factors were used for the pesticides that were identified as COCs in soil.

- Surface and subsurface soils are considered separately in developing the current PRGs (the PRGs used during the Removal Action were based on surface soil exposure only, and, therefore, were conservative).

- A target risk level of 10^{-5} was used to develop the current PRGs (versus 10^{-6} during the Removal Action).

This 10^{-5} target risk level was established considering NCP requirements, conservative assumptions incorporated into the calculations, and site-specific conditions. Risk-based preliminary remedial goal concentrations calculated at the 10^{-5} risk level incorporate consideration of the presence of multiple contaminants and routes of exposure. The current and probable future use of the PSF site as a light industrial area, used by workers, makes it unlikely that sensitive subgroups of the population would be exposed to site contaminants. The receptors are likely to be healthy adults and not sensitive populations (such as children and the elderly). These sensitive subgroups were considered in the development of the cancer slope factors by the USEPA which are included in the calculation methods used for the PRGs (USEPA, 1989a). Absorption factors used in the PRG calculations for pesticides were derived from studies which used pesticides dissolved in acetone prior to application. Absorption factors derived from studies using pesticides mixed with soil prior to application were approximately 10 times less than the factors used in the calculated PRGs (ATSDR, 1987-1993). These factors result in calculated PRG concentrations which are conservative. From these considerations, the 10^{-5} risk level is appropriate for the PSF site.

Tables 6-1 and 6-2 present the PRGs for surface and subsurface soil for the COCs at the PSF site. Risk-based PRGs were calculated using a carcinogenic risk range of 1×10^{-5} and a noncarcinogenic HI of 1.0. The lowest of the two calculated values for the carcinogenic risk level and HI was used as the risk-based PRG for each contaminant. For surface soils, (Table 6-2) the risk-based PRGs were based on carcinogenic risks, while for the subsurface soils, (Table 6-3) the PRGs were based on noncarcinogenic risks, because of the limited exposure duration in the future construction worker exposure scenario. The derivation of the risk-based PRG equations and the calculation of the risk-based PRGs are provided in Appendix B.

6.1.2.2 KDHE Remediation Interim Soil Cleanup Standards - The KDHE Bureau of Environmental Remediation issued interim soil cleanup standards in August 1993 (KDHE, 1993a) for the purpose of providing guidance for establishing soil cleanup standards. Constituents included in these standards did not include the pesticides which were COCs at the site, and are therefore not TBCs for soil at this site.

6.1.2.3 Federal Safe Drinking Water Act (40 CFR 141 Subpart B) - In accordance with the Safe Drinking Water Act, the USEPA has established MCLs and MCLGs for a number of constituents (Federal Register, 1987). The MCLs define the maximum levels of various

TABLE 6-1

RISK-BASED PRELIMINARY REMEDIATION GOALS - SURFACE SOILS (SITE WORKER)

Pesticide Storage Facility
Fort Riley, Kansas

FUTURE SITE WORKER

Constituent	Dermal Absorption Factor (unitless) [a]	Reference Dose (oral) (mg/kg-day)	Reference Dose (inhalation) (mg/kg-day)	Preliminary Remediation Goals (mg/kg) Non-cancer Effects[b]	Cancer Slope Factor (oral) $(mg/kg-day)^{-1}$	Cancer Slope Factor (inhalation) $(mg/kg-day)^{-1}$	10^{-5} Risk Preliminary Remediation Goals Carcinogenic Effects (mg/kg)	Risk-Based (Lowest) Preliminary Remediation Goal (mg/kg)
Pesticides:								
Chlordane	0.109	6.00E-05	--	3.38E+01	1.30E+00	1.30E+00	1.23E+01	1.23E+01
4,4'-DDD	0.378	--	--	--	2.40E-01	--	2.40E+01	2.40E+01
4,4'-DDE	0.378	--	--	--	3.40E-01	--	1.69E+01	1.69E+01
4,4'-DDT	0.378	5.00E-04	--	1.01E+02	3.40E-01	3.40E-01	1.69E+01	1.69E+01
Dieldrin	0.077	5.00E-05	--	3.58E+01	1.60E+01	1.60E+01	1.27E+00	1.27E+00
Heptachlor	0.109	5.00E-04	--	2.82E+02	4.50E+00	4.60E+00	3.56E+00	3.56E+00

a - Absorption factors are percentages expressed as numerical values (i.e. chlordane 10.9% / 100 = 0.109).
b - Preliminary remedial goal concentrations calculated using H.I. = 1.0.

TABLE 6-2

RISK-BASED PRELIMINARY REMEDIATION GOALS - SUBSURFACE SOILS (CONSTRUCTION WORKER)

Pesticide Storage Facility
Fort Riley, Kansas

FUTURE CONSTRUCTION WORKER

Constituent	Dermal Absorption Factor (unitless) [a]	Reference Dose (oral) (mg/kg-day)	Reference Dose (inhalation) (mg/kg-day)	Preliminary Remediation Goals (mg/kg) Non-cancer Effects[c]	Cancer Slope Factor (oral) $(mg/kg-day)^{-1}$	Cancer Slope Factor (inhalation) $(mg/kg-day)^{-1}$	10^{-5} Risk Preliminary Remediation Goals Carcinogenic Effects (mg/kg)	Risk-Based (Lowest) Preliminary Remediation Goal (mg/kg)
Pesticides:								
Chlordane	0.109	6.00E-05	--	2.09E+01	1.30E+00	1.30E+00	1.89E+02	2.09E+01
4,4'-DDD	0.378	--	--	--	2.40E-01	--	6.69E+02	6.69E+02
4,4'-DDE	0.378	--	--	--	3.40E-01	--	4.73E+02	4.73E+02
4,4'-DDT	0.378	5.00E-04	--	1.14E+02	3.40E-01	3.40E-01	4.73E+02	1.14E+02
Dieldrin	0.077	5.00E-05	--	1.86E+01	1.60E+01	1.60E+01	1.64E+01	1.64E+01
Heptachlor	0.109	5.00E-04	--	1.74E+02	4.50E+00	4.60E+00	5.46E+01	5.46E+01
Volatile Compounds:								
Benzene	1	--	e 1.43E-04	4.99E+05	2.90E-02	2.90E-02	3.08E+03	3.08E+03
Methylene chloride	1	6.00E-02	h 8.60E-01	7.61E+03	7.50E-03	1.64E-03	1.19E+04	7.61E+03
Toluene	1	2.00E-01	1.14E-01	2.54E+04	--	--	--	2.54E+04
Semi-Volatile Compounds:								
Benzo[a]anthracene	1	--	--	--	1.10E+00	--	8.12E+01	8.12E+01
bis(2-Ethylhexyl)phthalate	1	2.00E-02	--	2.54E+03	1.40E-02	--	6.38E+03	2.54E+03
Chrysene	1	--	--	--	2.90E-02	--	3.08E+03	3.08E+03
Diethylphthalate	1	8.00E-01	--	1.01E+05	--	--	--	1.01E+05
Fluoranthene	1	4.00E-02	--	5.07E+03	--	--	--	5.07E+03
Pyrene	1	3.00E-02	--	3.80E+03	--	--	--	3.80E+03
Metals:								
Arsenic	0.01	3.00E-04	--	1.30E+02	1.75E+00	1.50E+01	1.74E+02	1.30E+02
Barium	0.01	7.00E-02	h 1.40E-04	2.85E+04	--	--	--	2.85E+04
Chromium	0.01	5.00E-03	--	2.16E+03	--	4.20E+01	5.85E+04	2.16E+03
Lead	0.01	--	--	--	--	--	--	1.00E+03[b]
Mercury	0.01	3.00E-04	h 8.57E-05	1.30E+02	--	--	--	1.30E+02
Silver	0.01	p 5.00E-03	--	2.16E+03	--	--	--	2.16E+03

a - Absorption factors are percentages expressed as numerical values (i.e. chlordane 10.9% / 100 = 0.109).
b - OSWER Directive #9355.4-02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, September 1989.
c - Preliminary remediation goal concentrations calculated using H.I. = 1.0.
e - Value is from EPA-ECAO
h - Value is from HEAST (1994)
p - IRIS lists toxicity value as pending; value listed here is obtained from HEAST (1992).

TABLE 6–3

COMPARISON OF BERYLLIUM IN ON–SITE GROUNDWATER WITH REGULATORY CRITERIA
Pesticide Storage Facility
Fort Riley, Kansas

Parameter	Maximum Detected Concentration (mg/L)	Calculated 95% UCL Concentration (mg/L)	Mean Concentration (mg/L) [a]	Standard Deviation (mg/L) [a]	Median Concentration (mg/L) [a]	Federal Maximum Contaminant Level [b] (mg/L)	Federal Maximum Contaminant Level Goal [b] (mg/L)	Kansas Maximum Contaminant Level [c] (mg/L)
Beryllium (all wells)	$\boxed{0.005^{d}}$	0.0027 [d]	N/A	N/A	N/A	$\boxed{0.004}$	$\boxed{0.004}$	$\boxed{0.004^{e}}$
Well PSF92–02	$\boxed{0.005}$	N/A	0.00284	0.00115	0.00295	$\boxed{0.004}$	$\boxed{0.004}$	$\boxed{0.004^{e}}$
Well PSF92–03	0.003	N/A	0.00174	0.00082	0.00200	0.004	0.004	0.004 [e]
Well PSF92–04	0.002	N/A	0.00136	0.00081	0.00140	0.004	0.004	0.004 [e]
Well PSF92–05	0.003	N/A	0.00174	0.00082	0.00200	0.004	0.004	0.004 [e]
Background Wells	0.003 [f]	N/A	0.00169 [f]	0.00078 [f]	0.00200 [f]	0.004	0.004	0.004 [e]

Note: Data from Baseline through December 1995 samples (6 rounds) is included in this Table.

[a] Statistical data taken from Remedial Investigation Report Addendum, CEMRK, 1996.

[b] Drinking Water Regulations and Health Advisories; USEPA Office of Water, January 1996.

[c] Kansas Drinking Water Rules (KAR 28.15), last amended January 9, 1995.

[d] Value reported is based on data from Wells PSF92–02, PSF92–03, PSF92–04, PSF92–05.

[e] MCL shall apply only to community and nontransient, noncommunity public water supply systems [KAR 28.15.13(b)(4)].

[f] Value reported is based on data from Baseline through December 1995 samples (6 rounds) from Well PSF92–01 and September 1994 and December 1995 samples (2 rounds) from Wells TS0292–01 and TS0292–02 at Building 354.

N/A Not Applicable

☐ Boxed values indicate detected concentrations which exceeded regulatory criteria, and the regulatory criteria which were exceeded.

constituents allowed in "public water systems," defined as systems which provide piped water for human consumption with at least 15 service connections, or serving at least 25 persons. By definition, MCLGs equal to zero are nonenforceable health goals while the MCLs are the enforceable standards which must be set as close to the MCLGs as feasible. The Safe Drinking Water Act is not applicable to the site because the PSF groundwater is not directly provided to a public water supply system. State water regulations (K.A.R. 28.15) which set state MCLs for constituents detected on the site generally reflect the federal MCLs. However, discussions with the Kansas Department of Health and Environment, Bureau of Water Protection, indicated that the State of Kansas has not set different values, therefore Kansas is required to enforce the federally established MCLs (KDHE, 1992). The NCP Section 300.430 (e)(2)(i)(B) sets forth the goal that nonzero MCLGs or MCLs (when the MCLG is zero) established under the Safe Drinking Water Act be attained by remedial actions for groundwaters or surface waters that are current or potential sources of drinking water where relevant and appropriate to the circumstances of the release. The ARAR determination is based on the consideration of use or potential future use of the groundwater at the site, as discussed above. As stated previously, future use of the on-site aquifer was not considered a reasonable possibility considering the available water system, low yield, and future operations at Fort Riley. Therefore, the Safe Drinking Water Act is not relevant or appropriate at the site because there is no actual, planned, or reasonable expectation of future use of groundwater as a potable water source (USEPA, 1988c, pgs. 1-68 to 1-69).

The MCLG/MCL concentrations were compared to the on-site well concentrations for information only, and exceedances were minor and infrequent. Complete results of the comparisons and results from the statistical comparisons are listed below; however, beryllium was the only COC identified in the informational groundwater risk evaluation.

- Antimony exceeded the MCL (0.006 mg/L) in a single background well sample (0.022 mg/L) and in one on-site well (0.032 mg/L) during the same sampling round. Antimony was not consistently detected at the site and was not detected in September 1994 nor in December 1995 in any on-site or background wells using USEPA Method 7041 with the lower detection limits of 0.005 and 0.003 mg/L, respectively. Antimony concentrations in on-site wells were evaluated in the statistical comparison and were statistically equivalent to background concentrations.

- Beryllium exceeded the MCL (0.005 mg/L) once, in a single on-site well, at 0.006 mg/L when beryllium was also detected in the background well at 0.004 mg/L. Beryllium was detected at 0.005 mg/L in the duplicate sample evaluated for the on-site well. Beryllium was also consistently detected at concentrations up to 0.003 mg/L in the background wells during previous sampling rounds. From the statistical comparison, beryllium in the on-site wells except for well PSF02-02 was statistically equivalent to background. It was also concluded from the statistical comparison that beryllium in all the on-site wells is below the MCL concentration.

- Cadmium was only detected during a single round in two wells at the site, and exceeded the MCL (0.005 mg/L) once at 0.006 mg/L. Cadmium concentrations in on-site wells were evaluated in the statistical comparison and were statistically equivalent to background concentrations.

- Nitrate concentrations frequently exceeded the MCL concentration (10 mg/L) in the on-site wells. Nitrate was also frequently detected in the background wells at concentrations less than the MCL, and concentrations varied in the on-site and background samples. From the statistical comparison it was concluded that nitrate concentrations in the on-site and background wells were statistically equivalent and background related.

- Thallium exceeded the MCL (0.002 mg/L) two times in on-site samples, with a maximum detected concentration of 0.0029 mg/L. Thallium was not consistently detected in any on-site wells. Thallium was detected in September 1994 in the PSF and the Building 354 area background wells at a maximum concentration of 0.0025 mg/L, and was not detected in any downgradient wells. Similar detections for thallium have been observed in background wells at other areas of Fort Riley, such as the Southwest Funston Landfill site. From the statistical comparison of on-site and background wells it was concluded that the on-site thallium concentrations in all wells were statistically equivalent to background concentrations. Remedial alternatives are not warranted under these circumstances.

Beryllium was the only COC identified which contributed to a significant risk under the groundwater use scenario evaluated for information only. Beryllium concentrations in the on-site wells are compared to background concentrations and to the MCLG and MCL concentrations in Table 6-3. The maximum detected beryllium concentration in Well PSF92-02 slightly exceeded the MCLG/MCL, as depicted in the table. No other beryllium samples from the on-site wells exceeded the MCLG/MCL. The 95 percent UCL concentration in the on-site wells was less than the MCLG/MCL. As discussed in Section 4.2.2, it was concluded from the statistical evaluation with a high level of confidence that the beryllium concentrations in the on-site wells, except for Well PSF92-02, were statistically equivalent to the background concentration. It was further concluded that the beryllium concentrations in the on-site wells were statistically below the MCL, including Well PSF92-02. Statistical parameters from the evaluation for the on-site and background wells are included in Table 6-3 and compared to the MCLG and MCL.

6.1.2.4 NCP Expectations for Groundwater Restoration - Expectations for remedial alternatives identified in the NCP include the restoration of groundwater, wherever practicable, to allow for potential future beneficial uses when the groundwater is usable, given the circumstances of the site [NCP 300.430 (a)(1)(iii)(F)]. Evaluation of groundwater remedial alternatives is not appropriate and restoration is not practicable given the circumstances at this site, that is, infrequent detections of metals and inorganics in background and on-site wells at low concentrations, and minor exceedances of the MCL concentrations.

6.2 COMPARISON OF PRELIMINARY REMEDIATION GOALS TO RESIDUAL CONTAMINANT CONCENTRATIONS

In this section, contaminant levels in soils are compared with PRGs to identify exceedances. For soils, risk-based PRGs are compared to the remaining contaminant concentrations at the site following the Removal Action.

Risk-based remediation goals were presented in Tables 6-1 and 6-2 for surface and subsurface soils, respectively. Tables 6-4 and 6-5 present summaries of the current detections of COCs in surface soils and subsurface soils, respectively, and comparisons of the detected concentrations of these contaminants to the calculated PRG concentration ranges to identify exceedances. The 10^{-5} risk level is considered appropriate for this industrial area, as discussed in Section 6.1.2.1. Both the 10^{-5} and 10^{-6} risk levels are presented in Tables 6-4 and 6-5 for information and comparison. Graphical comparisons of the PRG concentrations calculated at the 10^{-6} risk level to the residual soil sample concentrations and calculated 95 percent UCL concentrations for surface soil COCs are presented in the histograms shown on Figures 6-1 to 6-5, and the subsurface soils comparisons are presented on Figures 6-6 to 6-10. In Figures 6-7 through 6-9, the calculated PRGs greatly exceeded the sampled concentrations, and are not shown to scale. As seen on these figures, PRG concentrations calculated at the 10^{-6} risk level for pesticides were exceeded by a single sample of dieldrin in surface soils. Histograms for heptachlor in surface and subsurface soils and arsenic were not drawn due to the infrequent detections at levels significantly below the PRG. A single arsenic sample in subsurface soil at 20 mg/kg under existing pavement slightly exceeded the PRG concentration at the 10^{-6} risk level which was 17.4 mg/kg. The locations of these samples are shown on Figure 6-11. Exposure point concentrations for dieldrin and arsenic were below the calculated PRGs as shown on Tables 6-4 and 6-5.

Considering the PRGs and Post-Removal Action site conditions, the extent of remaining contamination at the PSF is limited, as shown on Figure 6-11. At the 10^{-5} risk level, no surface or subsurface soil sample exceedances were noted. At the 10^{-6} risk level, a single surface soil sample analyzed for dieldrin (0.158 mg/L) exceeds the PRG concentration (0.127 mg/L). One subsurface soil sample under existing pavement exceeds the arsenic PRG of 17.4 mg/kg at 20 mg/kg. No other detected concentrations of the COCs in the PSF soil samples exceeded contaminant-specific PRGs. Exposure point concentrations were less than the PRGs at the 10^{-6}

risk level for these constituents. The selection of risk level has a very minor impact on the evaluation and results.

The soil from the stressed vegetation area, including the location of surface soil sample SS-04 discussed in the RI report (LAW, 1993a), had been excavated to a depth of approximately 4 to 7 feet during the Removal Action. Clean fill was placed in this area. PAHs detected in soils at depths from the surface to 4.5 feet during the RI were substantially excavated and removed from the site during the Removal Action, thus significantly eliminating the exposure risks.

TABLE 6-4

CONTAMINANTS OF CONCERN DETECTION SUMMARY - SURFACE SOILS AND COMPARISON TO RISK-BASED PRELIMINARY REMEDIATION GOALS

Pesticide Storage Facility
Fort Riley, Kansas

Pesticide Constituent	Detection Frequency[a]	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	10^{-5} Risk-Based Preliminary Remediation Goal (mg/kg)	10^{-6} Risk-Based Preliminary Remediation Goal (mg/kg)	10^{-5} Risk Exceedance Frequency[b]	10^{-6} Risk Exceedance Frequency
Chlordane	17/52	1.12	0.12	12.3	1.23	0/52	0/52
4,4'-DDD	7/18	0.454	0.45	24.0	2.4	0/18	0/18
4,4'-DDE	12/18	0.847	0.37	16.9	1.69	0/18	0/18
4,4'-DDT	35/52	1.29	1.29	16.9	1.69	0/52	0/52
Dieldrin	20/52	0.158	0.04	1.27	0.127	0/52	1/52
Heptachlor	2/52	0.0093	0.0022	3.56	0.356	0/52	0/52

[a] Number of times the analyte was detected/number of times the analyte was sampled.

[b] Number of times the analyte concentration exceeded the preliminary remediation goal concentration/number of times the analyte was sampled.

TABLE 6–5

CONTAMINANTS OF CONCERN DETECTION SUMMARY – SUBSURFACE SOILS AND COMPARISON TO GOVERNING RISK–BASED PRELIMINARY REMEDIATION GOALS

Pesticide Storage Facility
Fort Riley, Kansas

Constituent	Detection Frequency [a]	Maximum Detected Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	10^{-5} Risk–Based Preliminary Remediation Goals (mg/kg)	10^{-6} Risk–Based Preliminary Remediation Goal (mg/kg)	10^{-5} Risk Exceedance Frequency[b]	10^{-6} Risk Exceedance Frequency
Pesticides:							
Chlordane	41/126	10.2	0.220	20.9	18.9 (d)	0/126	0/126
4,4'–DDD	16/100	0.925	0.017	669	66.9	0/100	0/100
4,4'–DDE	31/101	0.666	0.033	473	47.3	0/101	0/100
4,4'–DDT	42/126	1.95	0.150	114	47.3 (d)	0/126	0/126
Dieldrin	12/126	0.077	0.0048	16.4	1.64	0/126	0/126
Heptachlor	8/126	0.3	0.0029	54.6	5.46	0/126	0/126
Volatile Compounds:							
Benzene	2/29	0.0066	0.0023	3080	308	0/29	0/29
Methylene chloride	13/29	0.031	0.019	7610	1,190 (d)	0/29	0/29
Toluene	7/29	0.038	0.0067	25,400 (d)	25,400 (d)	0/29	0/29
Semi–Volatile Compounds:							
Benzo[a]anthracene	3/29	0.33	0.1	81.2	8.12	0/29	0/29
bis(2–Ethylhexyl)phthalate	3/29	1.2	0.33	2540	638 (d)	0/29	0/29
Chrysene	3/29	0.29	0.092	3080	308	0/29	0/29
Diethylphthalate	1/29	0.43	0.24	101,000	10,100	0/29	0/29
Fluoranthene	3/29	0.53	0.13	5,070	507	0/29	0/29
Pyrene	5/29	0.57	0.12	3,800	380	0/29	0/29
Metals:							
Arsenic	31/31	20	4.6	130	17.4 (d)	0/31	1/31
Barium	29/29	190	105	28,500	2,850	0/29	0/29
Chromium	29/29	20	8.4	2,160 (d)	2,160 (d)	0/29	0/29
Lead	25/29	770	99.5	1,000 (c)	1,000 (c)	0/29	0/29
Mercury	1/29	0.1	0.054	130 (d)	130 (d)	0/29	0/29
Silver	3/29	1.2	0.46	2,160 (d)	2,160 (d)	0/29	0/29

a – Number of times the analyte was detected / number of times the analyte was sampled.
b – Number of times the analyte concentration exceeded the remedial goal / number of times the analyte was sampled.
c – OSWER Directive #9355.4–02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, September 1989.
d – Preliminary remediation goal based on hazard index of 1.0.

risk level for these constituents. The selection of risk level has a very minor impact on the evaluation and results.

The soil from the stressed vegetation area, including the location of surface soil sample SS-04 discussed in the RI report (LAW, 1993a), had been excavated to a depth of approximately 4 to 7 feet during the Removal Action. Clean fill was placed in this area. PAHs detected in soils at depths from the surface to 4.5 feet during the RI were substantially excavated and removed from the site during the Removal Action, thus significantly eliminating the exposure risks.

FIGURE 6-1

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED CHLORDANE IN SURFACE SOILS
Pesticide Storage Facility
Fort Riley, Kansas

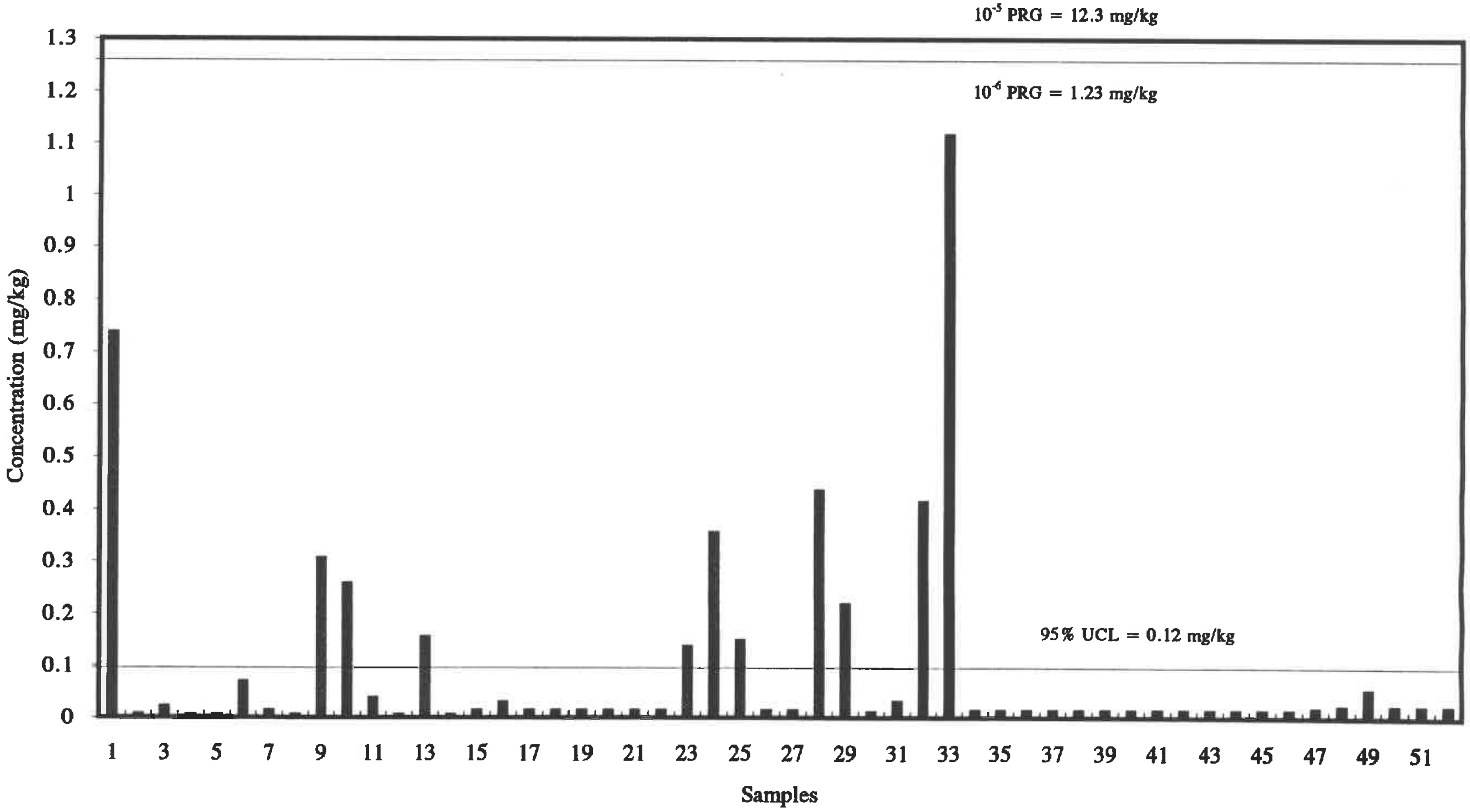


FIGURE 6-2

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDD IN SURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

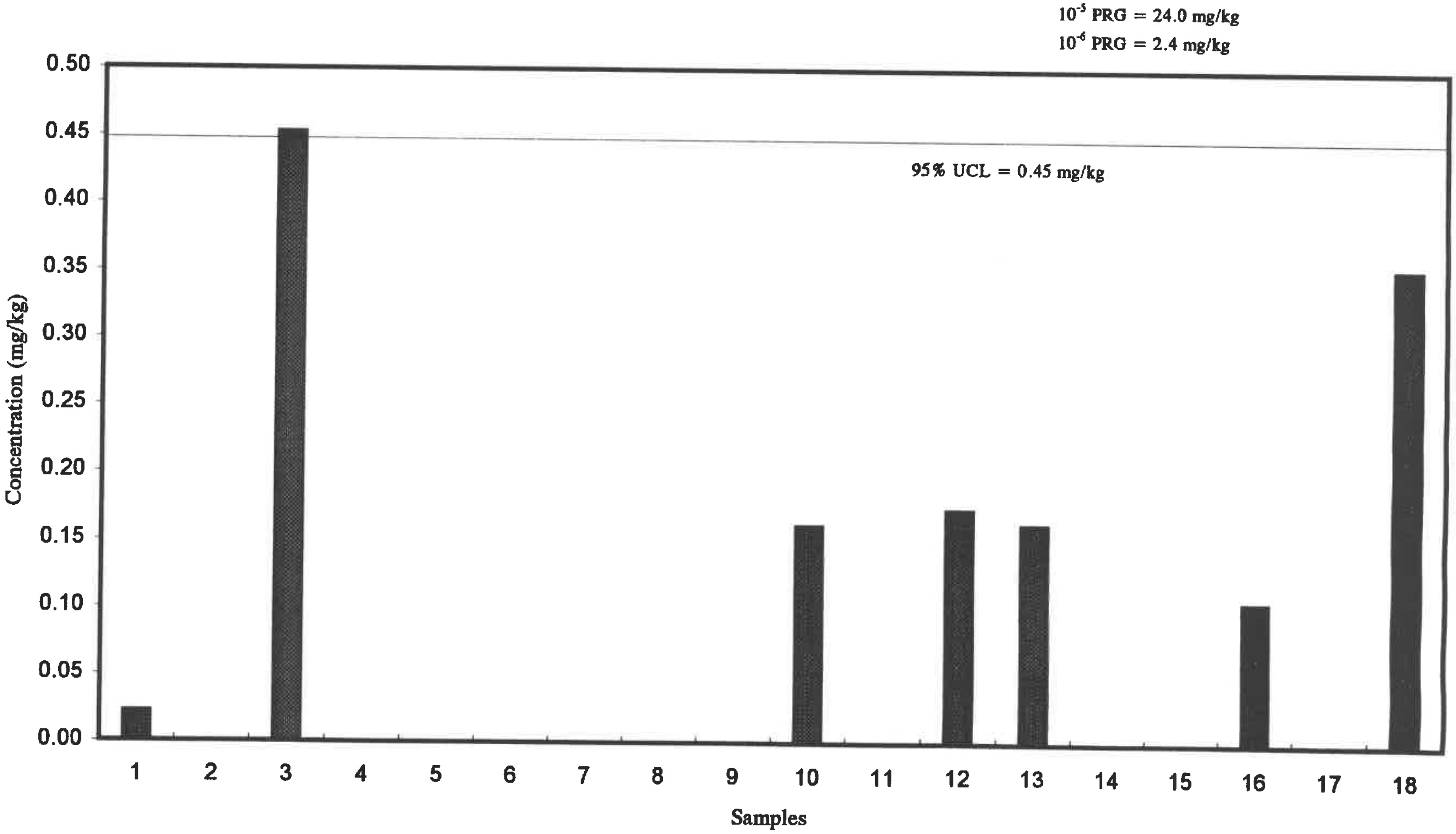


FIGURE 6-3

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDE IN SURFACE SOILS
Pesticide Storage Facility
Fort Riley, Kansas

10^{-5} PRG = 16.9 mg/kg
10^{-6} PRG = 1.69 mg/kg

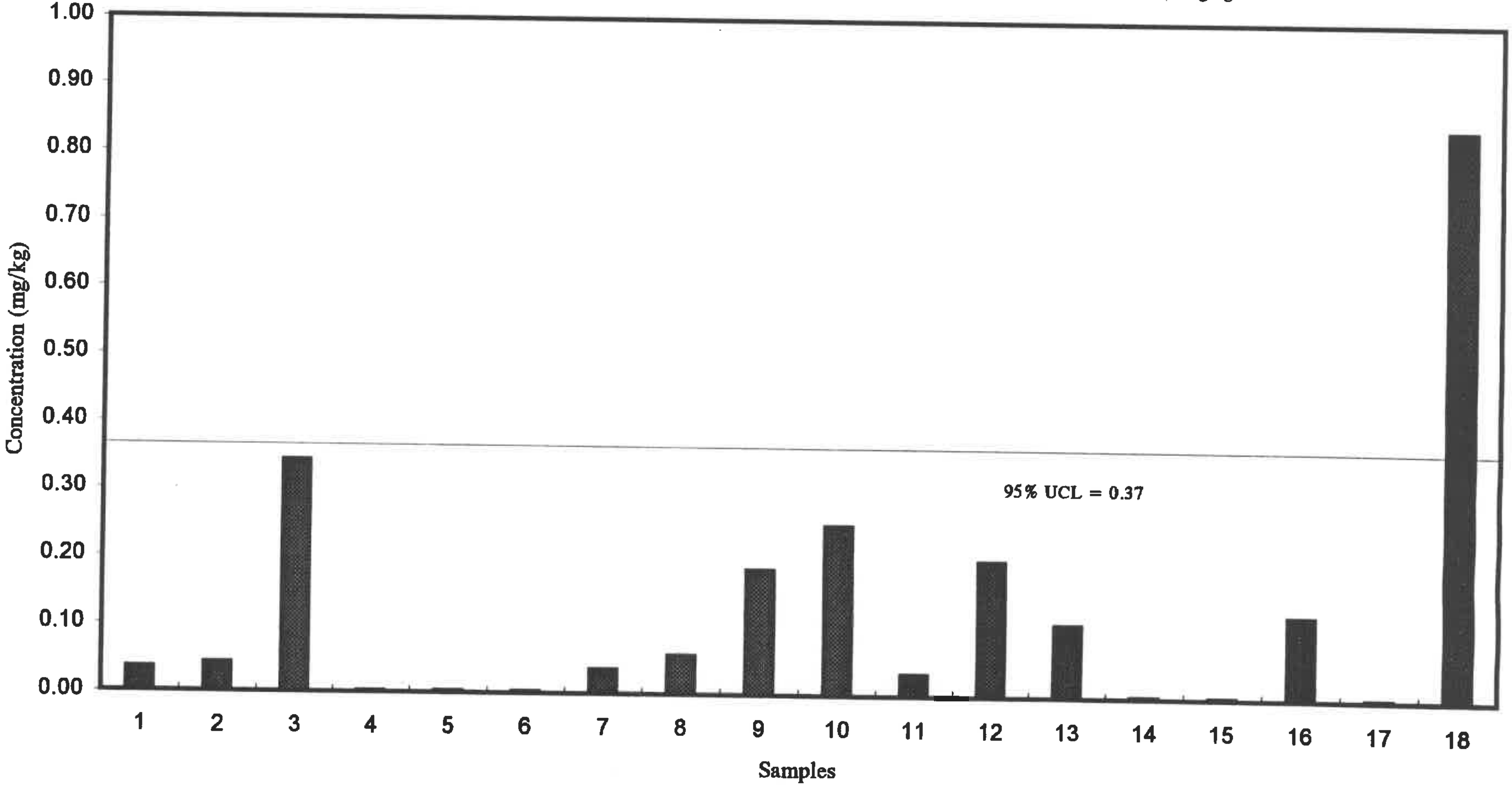


FIGURE 6-4

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDT IN SURFACE SOILS
Pesticide Storage Facility
Fort Riley, Kansas

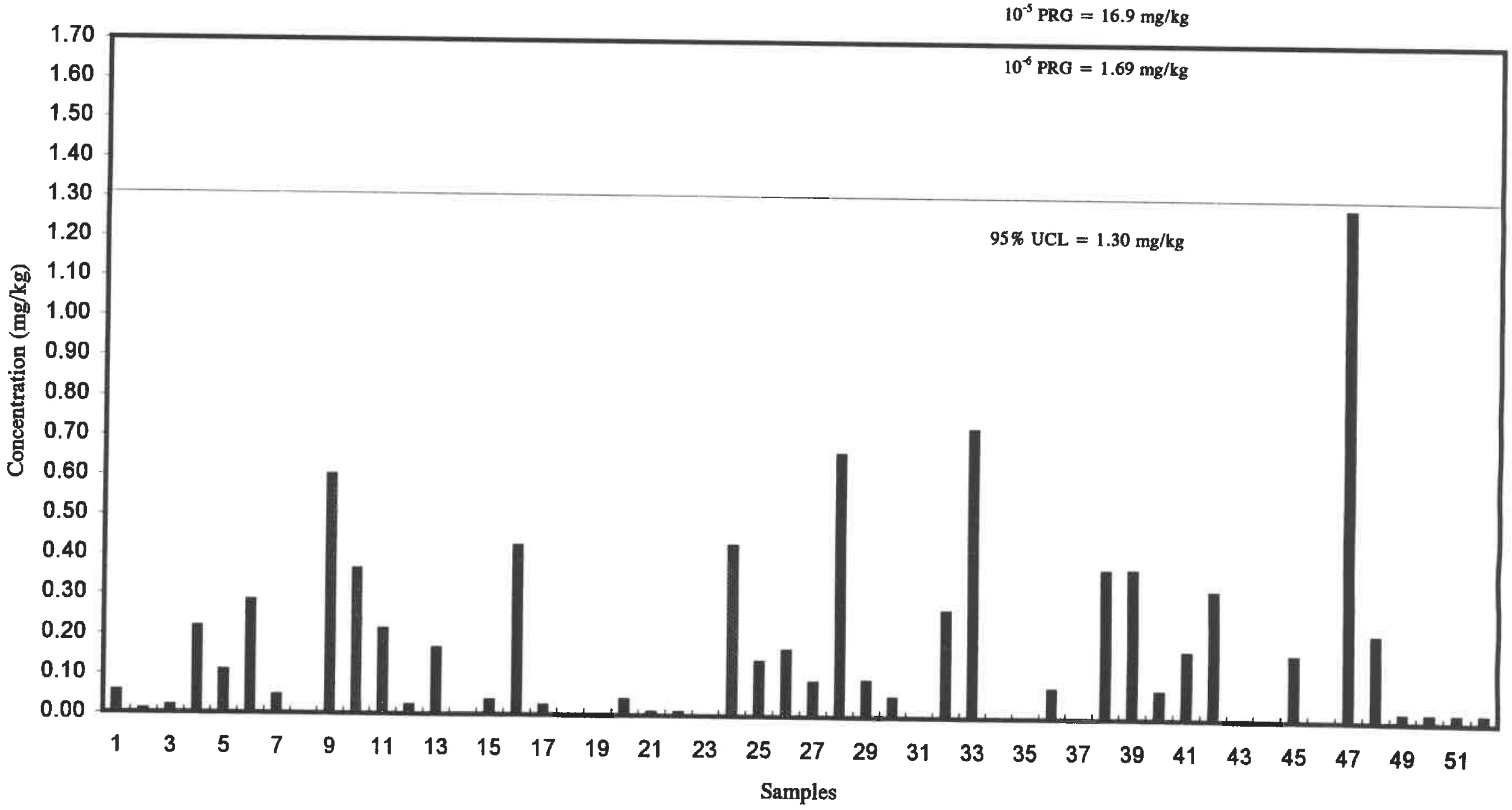


FIGURE 6-5

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DIELDRIN IN SURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

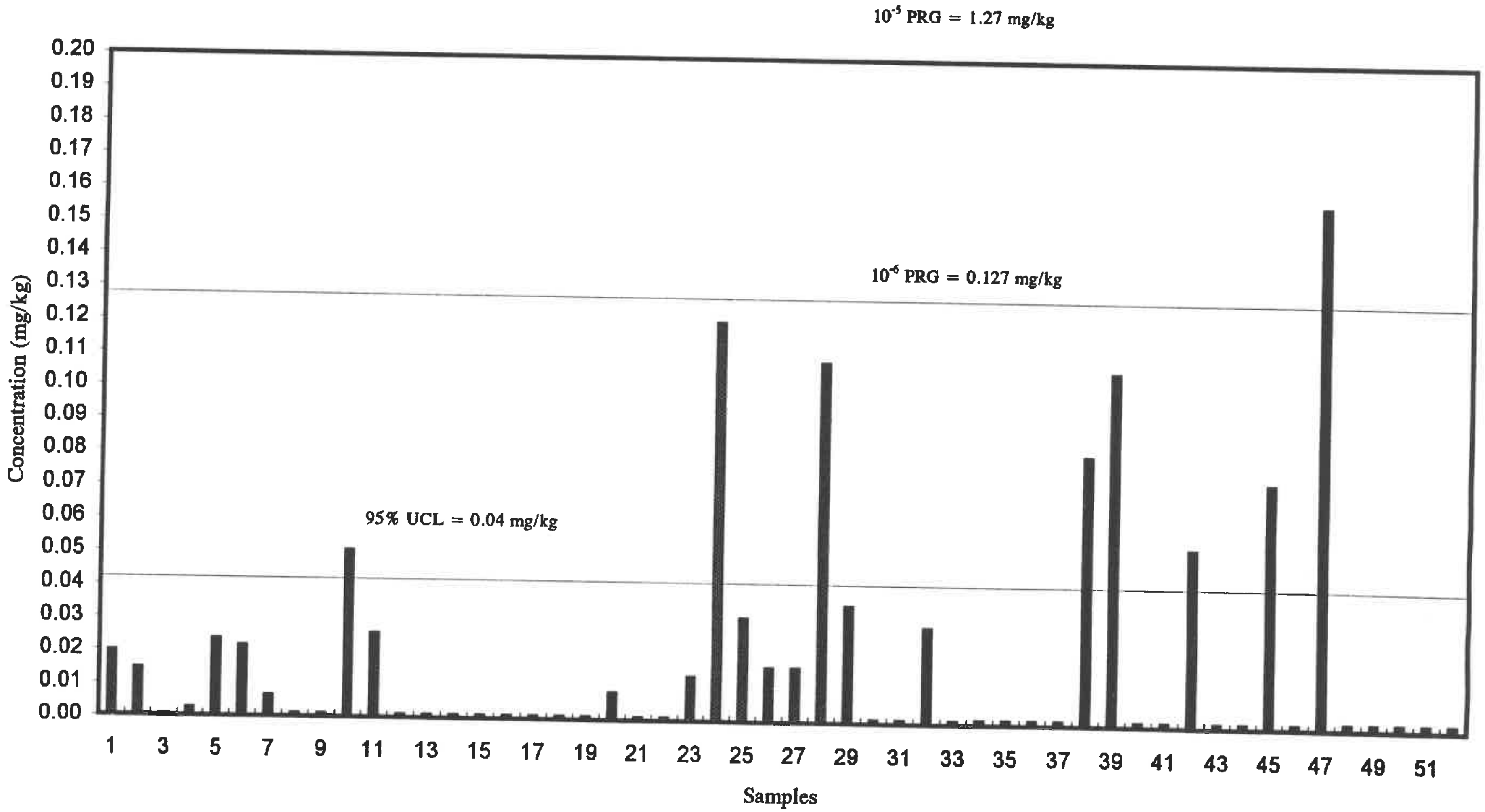


FIGURE 6-6

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED CHLORDANE IN SUBSURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

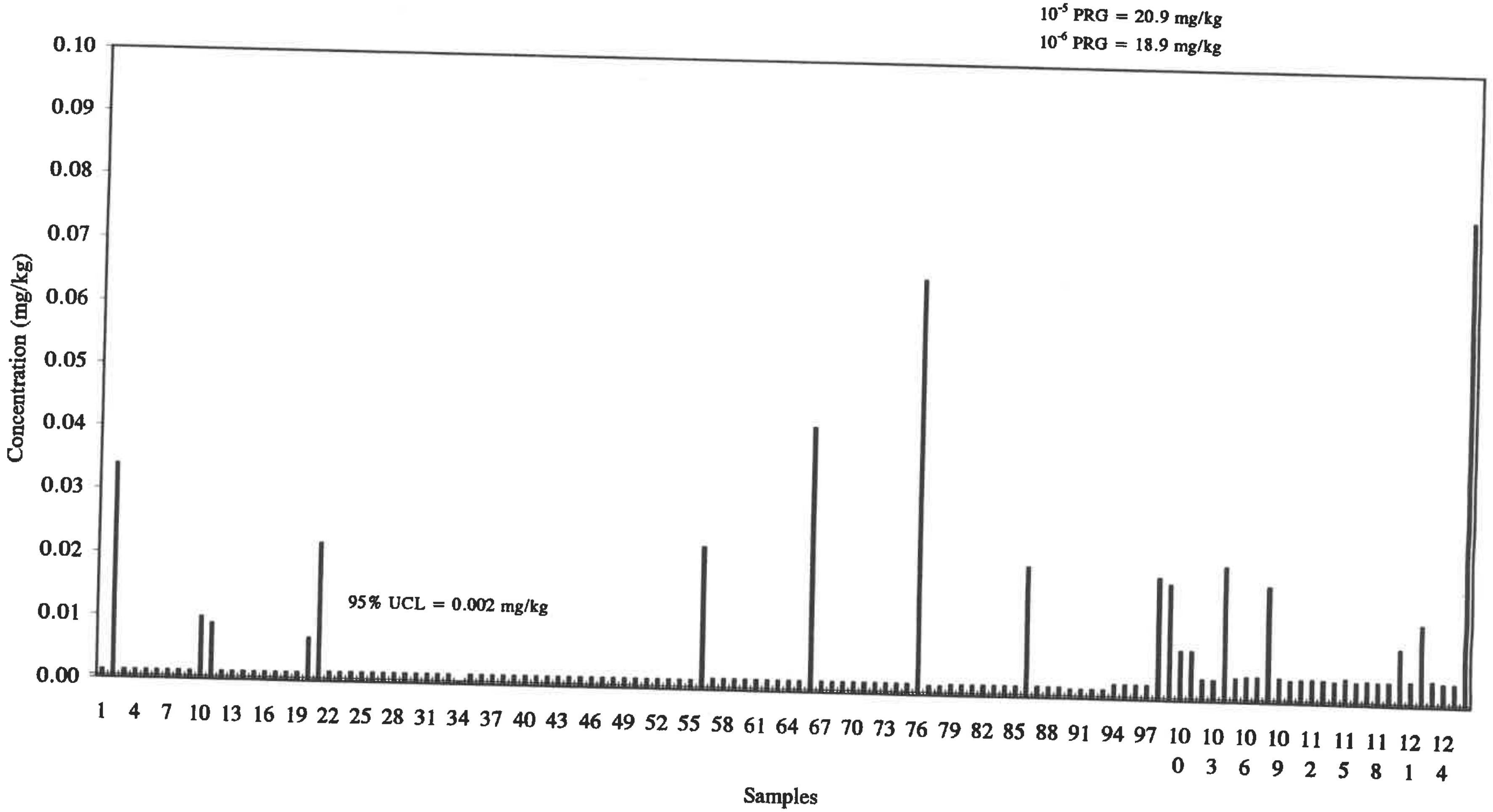


FIGURE 6-7

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDD IN SUBSURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

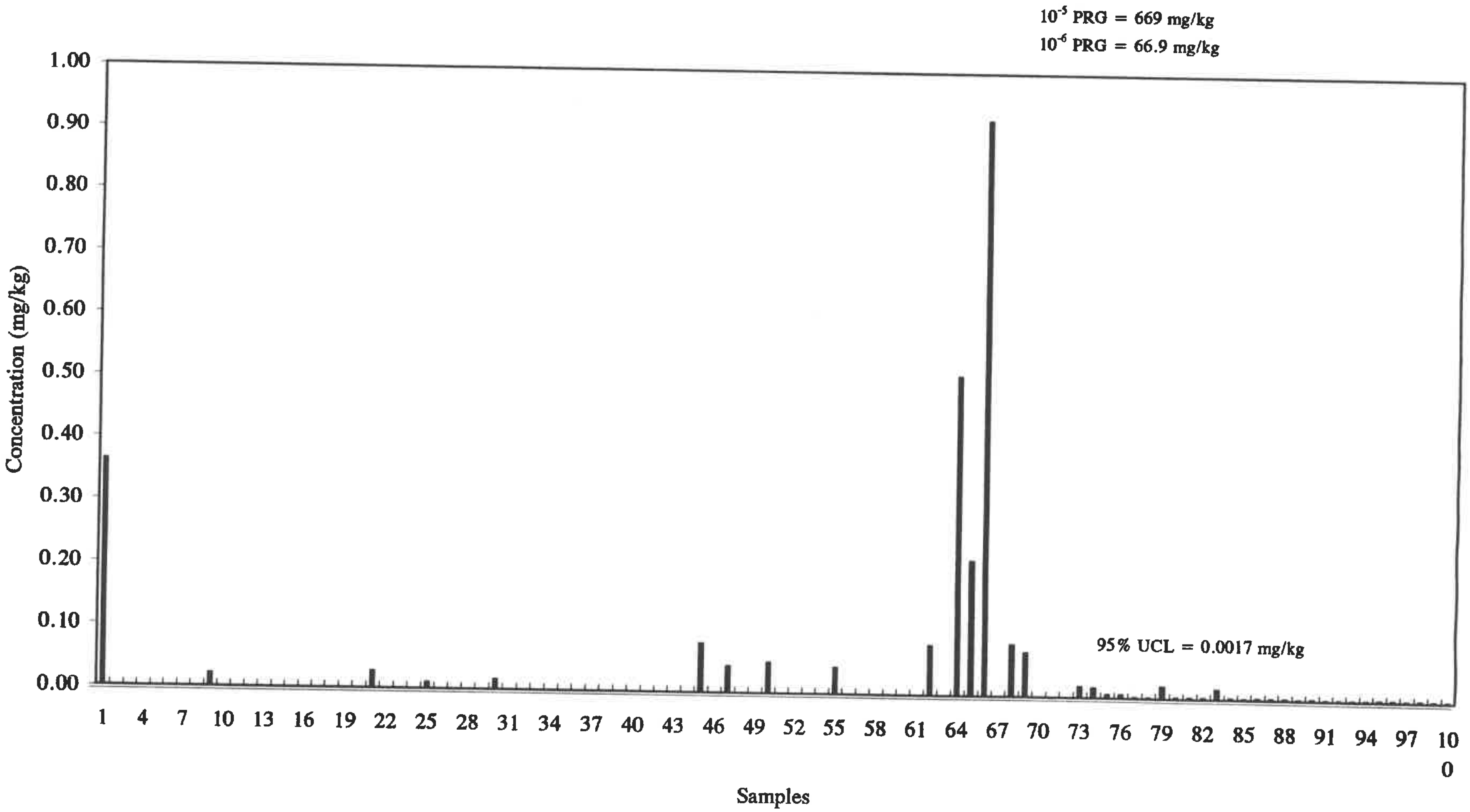


FIGURE 6-8

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDE IN SUBSURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

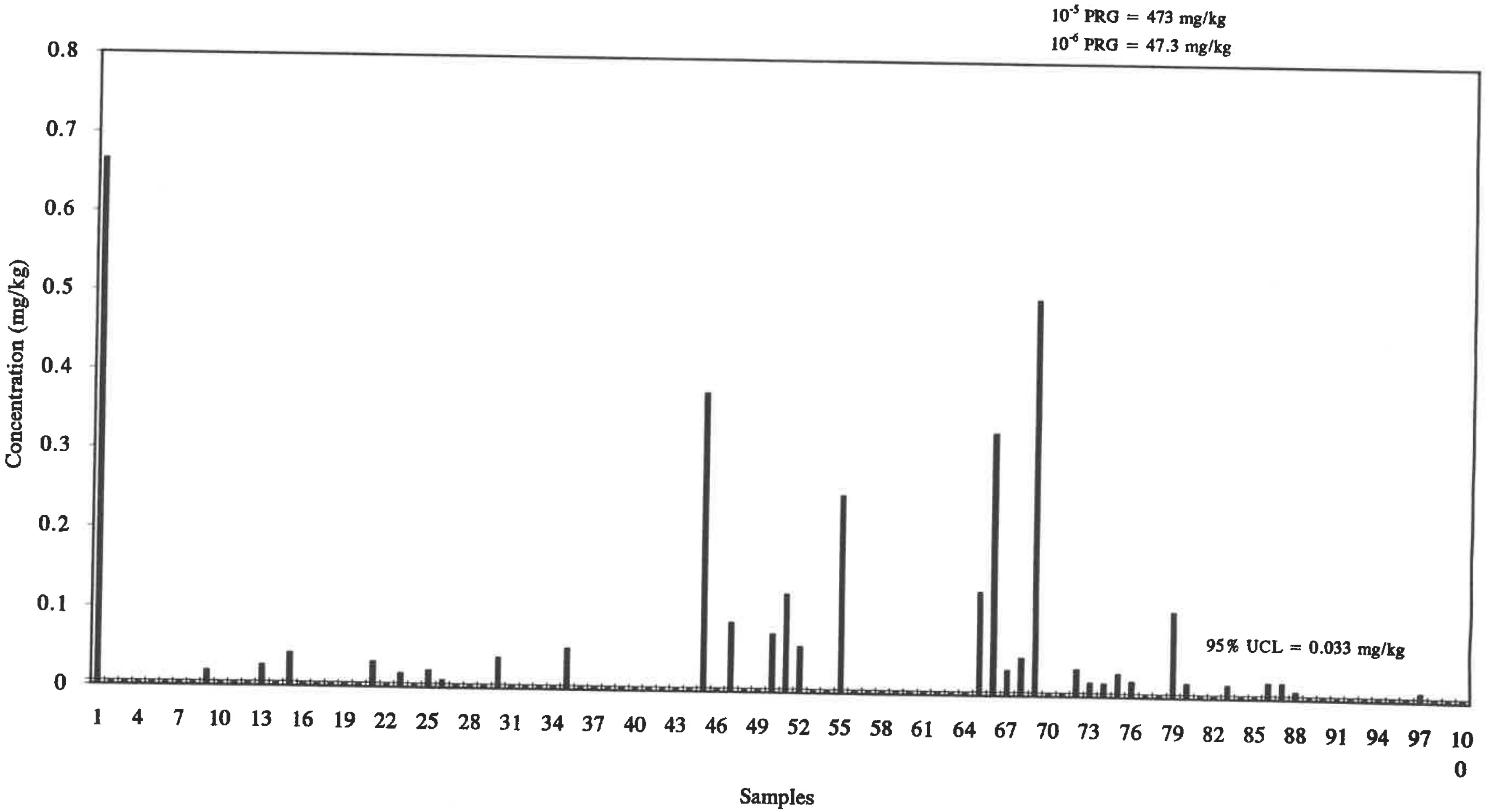


FIGURE 6-9

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DDT IN SUBSURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

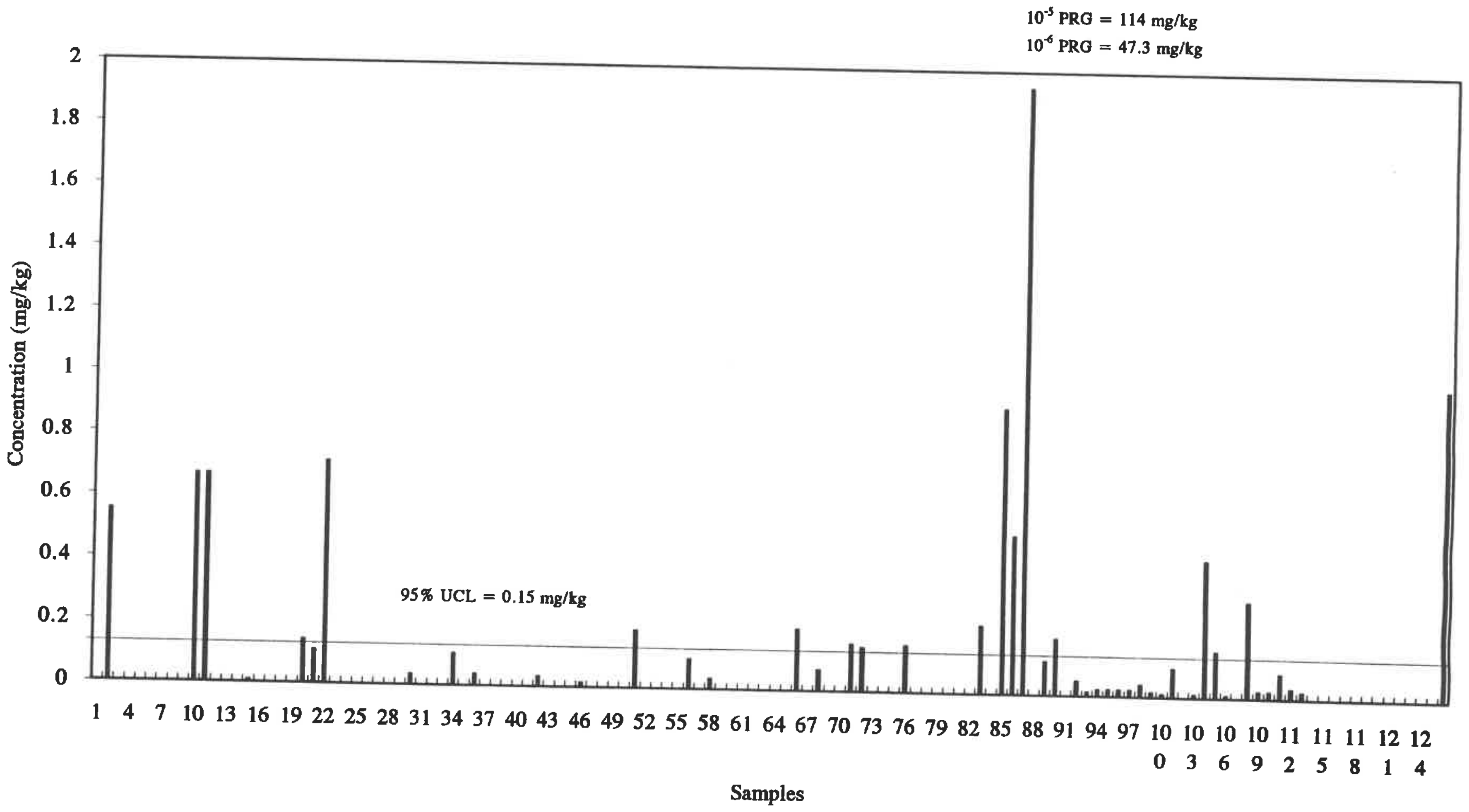


FIGURE 6-10

CONCENTRATIONS SUMMARY HISTOGRAM OF DETECTED DIELDRIN IN SUBSURFACE SOILS

Pesticide Storage Facility
Fort Riley, Kansas

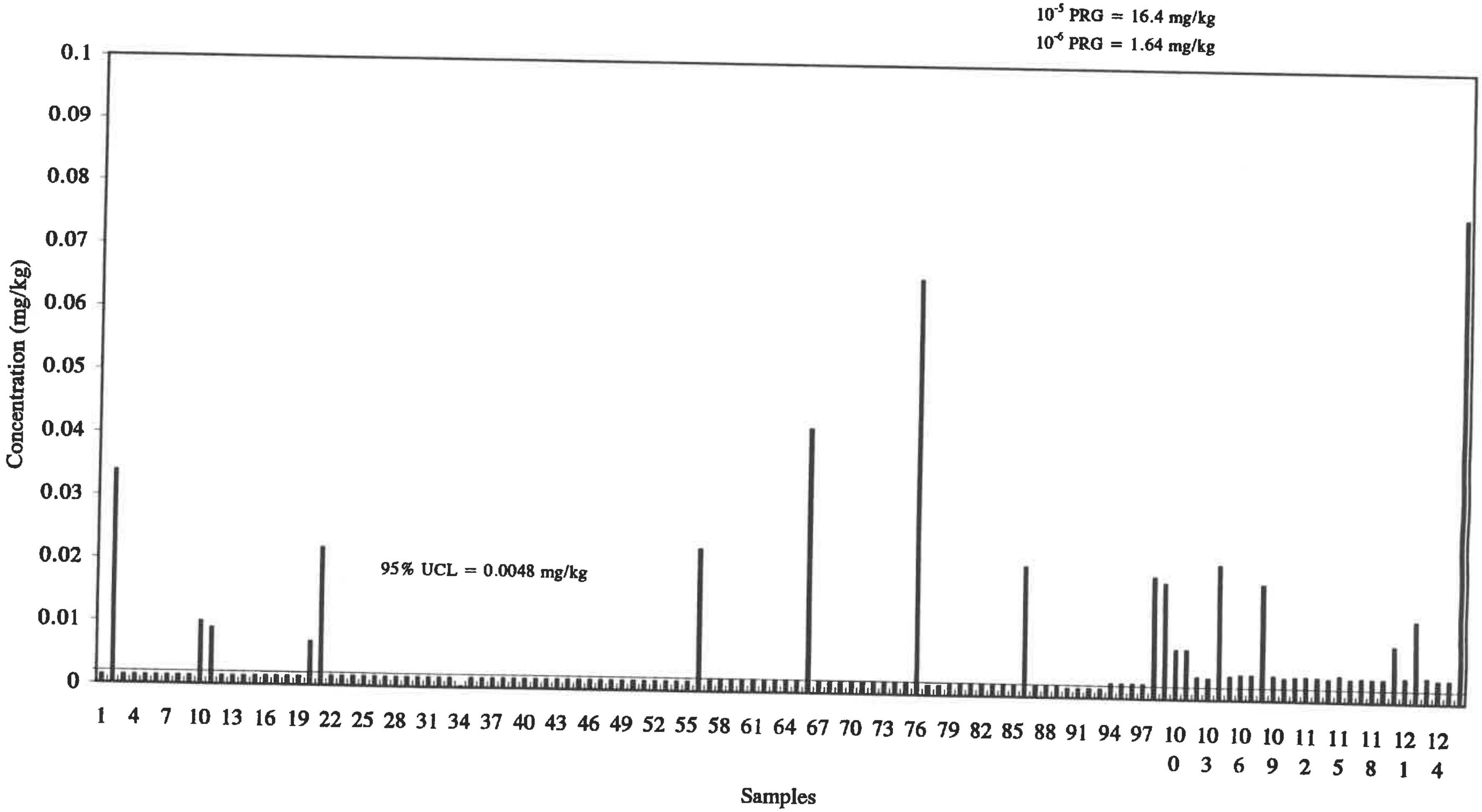
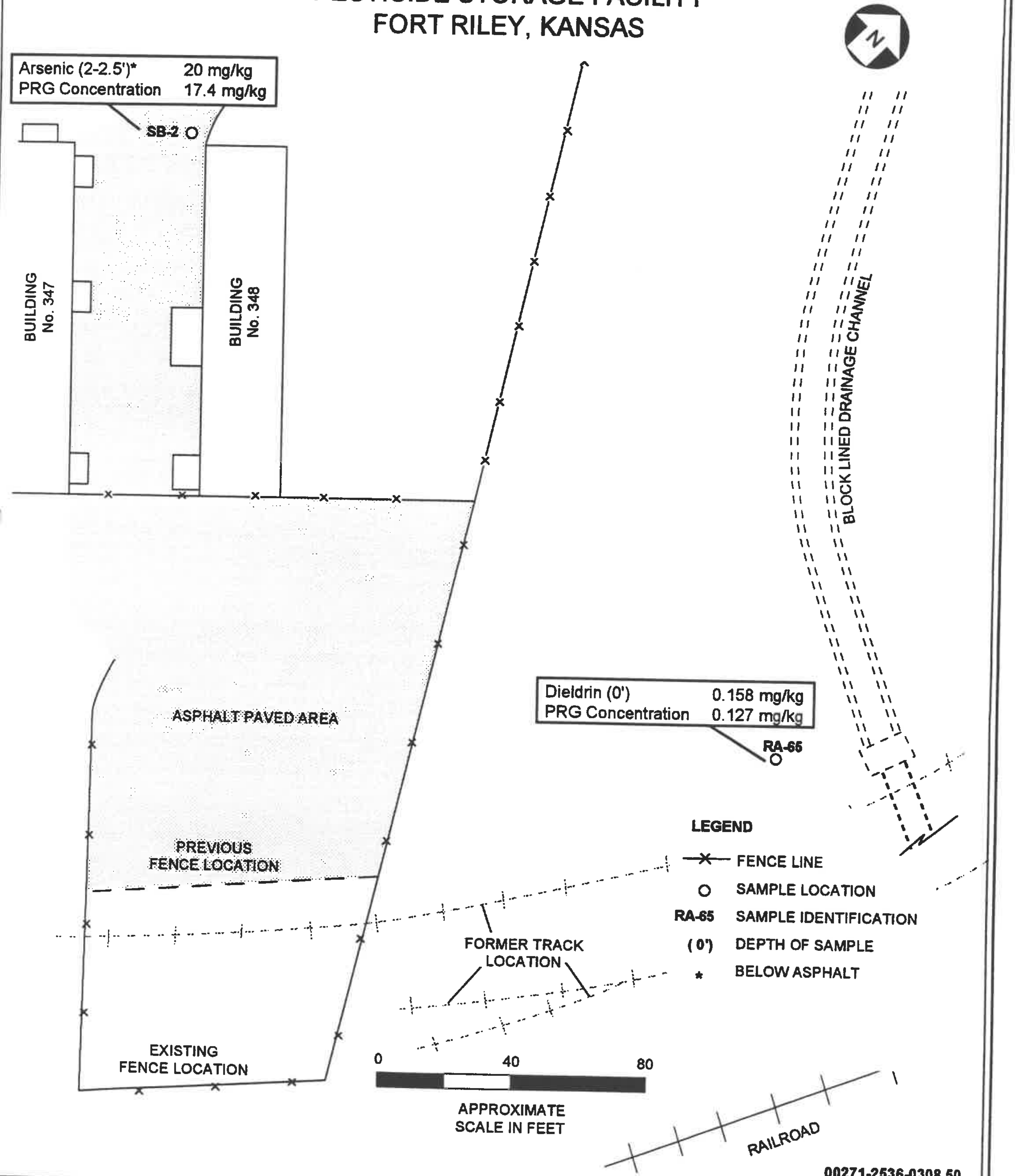


FIGURE 6-11

REMAINING SOIL SAMPLES EXCEEDING 10^{-6} PRELIMINARY REMEDIAL GOAL CONCENTRATIONS

PESTICIDE STORAGE FACILITY
FORT RILEY, KANSAS



00271-2536-0308.50

7.0 CONCLUSIONS

The Residual Risk Assessment, based on post-Removal Action site conditions, indicates that the conditions at the Pesticide Storage Facility site pose no current or potential threat to human health or the environment. Consequently, the statutory cleanup standards of CERCLA Section 121 do not apply. No additional remedial action is necessary to ensure protection of human health and the environment.

In the Removal Action completed in 1994, an area of less than 1/2 acre was excavated to a depth of between 1 and 8 feet below the land surface. A total of approximately 2,600 tons of soil was disposed of at an approved off-site landfill.

The Residual Risk Assessment has evaluated both the current and reasonable maximum exposure scenarios using appropriate health and environmental criteria and standards and indicates that unacceptable exposures will not occur. Human exposure risks following the Removal Action do not exceed National Contingency Plan protectiveness goals. Ecological risks are not a concern as the ecological impacts were judged to be minimal prior to the Removal Action.

The Residual Risk Assessment considered occupational and recreational exposures to surface and subsurface soils, sediment and surface water (in an adjacent intermittent drainage ditch) under current and anticipated land use and provides a conservative indication of the potential risks due to exposure to site-specific chemicals at the Pesticide Storage Facility. Exposure to groundwater was not included in the Residual Risk Assessment. The groundwater exposure pathway is currently incomplete and the future use of groundwater as a potable water supply is very unlikely. An existing potable water supply system with adequate future capacity serves the site. The on-site wells have a low yield, making their use for a water supply impractical.

7.0 CONCLUSIONS

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In the Removal Action completed in 1994, an area of less than 1/2 acre was excavated to a depth of between 1 and 8 feet below the land surface. A total of approximately 2,600 tons of soil was disposed of at an approved off-site landfill.

The Residual Risk Assessment has evaluated both the current and reasonable maximum exposure scenarios using appropriate health and environmental criteria and standards and indicates that unacceptable exposures will not occur. Human exposure risks following the Removal Action do not exceed National Contingency Plan protectiveness goals. Ecological risks are not a concern as the ecological impacts were judged to be minimal prior to the Removal Action.

The Residual Risk Assessment considered occupational and recreational exposures to surface and subsurface soils, sediment and surface water (in an adjacent intermittent drainage ditch) under current and anticipated land use and provides a conservative indication of the potential risks due to exposure to site-specific chemicals at the Pesticide Storage Facility. Exposure to groundwater was not included in the Residual Risk Assessment. The groundwater exposure pathway is currently incomplete and the future use of groundwater as a potable water supply is very unlikely. An existing potable water supply system with adequate future capacity serves the site. The on-site wells have a low yield, making their use for a water supply impractical.

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