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Date: MAY 24 1995
Refer to: EM/ER:95-224

RECEIVED
MAY 31 1995

Ms. Barbara Driscoll
RCRA Permits Branch
US Environmental Protection Agency
Region 6
1445 Ross Ave., Suite 1200
Dallas, TX 75202-2733

SUBJECT: RESPONSE TO NOTICE OF DEFICIENCY (NOD) CONCERNING RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION (RFI) REPORT FOR TECHNICAL AREA (TA) 33 WORK BREAKDOWN STRUCTURE NUMBER 1.4.2.6.1.3.1.4

Dear Ms. Driscoll:

Enclosed is the Los Alamos National Laboratory's (the Laboratory's) response to the Environmental Protection Agency's NOD concerning the RFI Report for TA-33 dated January 26, 1995, and a certification form signed by the appropriate Laboratory official. The NOD was received at the Los Alamos Area Office on April 28, 1995. A response within thirty days is required by the regulatory agency.

The enclosed response shows the comments from the NOD and proposed responses. The majority of the package consists of technical details of calculations and support documentation as attachments to this NOD response. A documented quality review of the enclosed response has been performed in accordance with administrative procedure LANL-ER-AP-01.3.

4719

Please let me know if there are any questions about this response to the NOD, or contact Brad Martin at (505) 667-6080 or Everett Trollinger at (505) 667-5801.

Sincerely,

Brad Martin

Jorg Jansen, Project Manager
Environmental Restoration

Sincerely,

Theodore J. Taylor, Program Manager
Los Alamos Area Office

JJ/TT/bp

Enclosures: (1) Response
(2) Signed Certification Form

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File: 1.4.2.6.1.3.1.4

Environmental
Restoration

CERTIFICATION

I certify under penalty of law that these documents and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violation.

Document Title:

Response To Notice Of Deficiency (NOD) Concerning Resource Conservation And Recovery Act Facility Investigation (RFI) Report For Technical Area (TA) 33 Work Breakdown Structure Number 1.4.2.6.1.3.1.4

Name: _____ Date: 5/19/95

Tom Baca, Program Director
Environmental Management
Los Alamos National Laboratory

or

Jorg Jansen, Project Manager
Environmental Restoration Project
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Name: _____ Date: 5/22/95

Joseph Vozella,
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Theodore J. Taylor
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Response to Notice of Deficiency
RFI Report LA-UR-95-882
Operable Unit 1122, TA-33

In the notice of deficiency for the January 31, 1995, RCRA facility investigation (RFI) report for Technical Area 33, (TA-33) the Environmental Protection Agency (EPA) requested figures and several sets of calculations. Los Alamos National Laboratory (LANL) is supplying the requested information as attachments to this response (Table 1).

TABLE 1
LIST OF ATTACHMENTS

DEFICIENCY NUMBER	ATTACHMENT NUMBER	SUBJECT
2	2-1	Calculations: mean and upper confidence limit for lead
2	2-2	Lead modeling results for PRS 33-004(i)
4	4-1	Figures of overlapping PRSs in LA-UR-95-882
5	5-1	Lead modeling results for PRS 33-015
6	6-1	Equations used in risk assessment at PRS 33-011(a)
6	6-2	Attachment 1, Appendix K (LANL 1993, 1017)
6	6-3	Risk assessment results at PRS 33-011(a)
6	6-4	Copy: Bradley et al. (1993, 1144)

List of Deficiencies

1. **Statistical Methodology, p. 21** - LANL should provide the methodology of how they will compare the upper tolerance limits from the background data with the upper confidence limits calculated from data for the risk assessment.

Response: LANL does not plan to compare the upper tolerance limits (UTLs) for the background population to upper confidence limits (UCLs) on the means over exposure units calculated for risk assessments. UTLs are used solely to compare potential release site (PRS) concentration data to local background levels in order to determine whether a particular constituent may have been released from that PRS. UCLs on means are compared with risk-based thresholds such as cleanup levels or preliminary remediation goals. The UCL is used as the concentration input term in the performance of a risk assessment.

2. **33-004(i)** - In order for EPA to evaluate the risk assessment which was conducted LANL must provide their calculations and a computer printout verifying their reported values.

Response: Two attachments are provided.

- Attachment 2-1 describes how the mean and 95% UCL concentrations for soil lead levels were developed. The calculations from SPLUS programming code are also included in Attachment 2-1.

- Attachment 2-2 is the computer printout generated by running EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model, Version 0.99d, for lead in children (EPA 1994, 1178). The printout presents the multimedia exposure parameters (i.e., input) used in running the model, as well as the modeling results.

  The value of the 95% UCL concentration is 211 mg/kg for lead in soil at PRS 33-004(i). This value was used as input to the IEUBK model (soil and dust), as stated in the first paragraph, last sentence, on page 70 of the RFI report. The value of 416.3 mg/kg was incorrectly reported in the second paragraph, last sentence, on page 70.

  The other input parameters were developed in accordance with EPA's *Guidance Manual for the Integrated Exposure Uptake Biokinetic Manual for Lead in Children* (EPA 1994, 1178). The model itself was developed by EPA and was not modified in any way for the modeling exercise conducted at PRS 33-004(i).

3. **33-005(a,b,c)** - Toluene was reported in a method blank, as well as several samples; however this information was not presented in the report. LANL needs to provide this information.

Response: On page 74, third paragraph of the RFI report, organic compounds found in samples at the former site of TA-33-21 were attributed to overlapping PRS 33-011(a) because organic contaminants are more characteristic of the PRS 33-011(a) drum storage area than of the plutonium cleanup investigation of PRSs 33-005(a,b,c) (LANL 1995, 1212). Because of this transfer of contaminants, no organics were reported for PRSs 33-005(a,b,c). Instead, all organics at the former site of TA-33-21 are reported on pages 109 and 110 of the RFI report in conjunction with PRS 33-011(a). The toluene-contaminated blank is mentioned in the first paragraph of the Data Qualifications box at

the end of Table 4-17 on page 110. Toluene is not reported in the tables because its presence in the samples is considered lab contamination.

4. Whenever contaminants found during the investigation of one PRS are attributed to an overlapping or adjacent PRS (for example: 33-011(a) and 33-005(a-c)), the report figure should indicate the location of the PRS to which the contamination is attributed.

Response: Three figures are provided as Attachment 4-1. Table 2 lists the overlapping PRSs proposed for no further action (NFA), the contaminants transferred, and the PRS under which the contamination will be addressed. Please note that in the TA-33 RFI report, the boundary of PRS 33-011(a) was expanded to include all of PRSs 33-005(a,b,c). PRS 33-009, a surface disposal area, and the vehicle maintenance area of PRS 33-017 will be discussed in the RFI report for TA-33 due in September 1995. In the future, we will provide overlapping information on the figures.

TABLE 2

OVERLAPPING PRSs IN RFI REPORT LA-UR-85-882

PRSs RECOMMENDED FOR NFA	CONTAMINANT	PRSs ASSIGNED CONTAMINATION	FIGURE NUMBER
33-004(g)	PCBs	33-009	4-1
33-004(i)	SVOCs (PAHs)	33-017[a]	4-2
33-005(a,b,c)	SVOCs (PAHs)	33-011(a)	4-3
33-012(a)	SVOCs (PAHs)	33-017[a]	4-2

[a] Includes only the vehicle maintenance area of PRS 33-017 east of shop TA-33-39.

5. **SWMU 33-015 p. 93** - See deficiency #2 above.

Response: No mean or UCL was calculated for lead at incinerator SWMU 33-015 because only two samples were taken. Lead values were 11 and 350 mg/kg, respectively. The 350 mg/kg value was input to the IEUBK model. The computer printout is supplied in Attachment 5-1.

6. **SWMU 33-011(a)** - EPA will need to evaluate whether it is reasonable for LANL to compare this area with a urban, nonindustrialized area as in the report by Bradley et. al. (1994). LANL needs to provide the calculations and a copy of the mentioned report. In addition, LANL needs to provide the calculations for the risk assessment which was conducted, and LANL should also provide risk calculations based on a residential scenario.

Response: The requested information is provided as follows:

- Attachment 6-1 is the set of the equations used in the risk assessment performed for PRS 33-011(a). Please note that the risk assessment methodology we used was taken from EPA's *Risk Assessment Guidance for Superfund* (EPA 1989, 0305). LANL describes the same methodology in Appendix K of the 1993 Installation Work Plan, and identifies exposure parameters for different exposure scenarios in Attachment 1 to Appendix K (LANL 1993, 1017). This table is provided for your convenience as Attachment 6-2.

- In the event that Attachments 6-1 and 6-2 are not sufficient for EPA's request for calculations, a set of computer printouts is supplied as Attachment 6-3. These printouts were generated in performing the risk assessment for PRS 33-011(a). A printout is included for each of the following scenarios:

  residential - adult;
  residential - child;
  camper - adult;
  camper - child;
  hiker - adult;
  construction worker - adult; and
  long-term worker - adult.

  Each of these printouts includes the following information:

  a statistical summary of the soil data;
  toxicity criteria for chemicals of potential concern;
  air concentrations of chemicals adhered onto dusts;
  carcinogenic and noncarcinogenic risks from soil ingestion;
  carcinogenic and noncarcinogenic risks from dermal contact;
  carcinogenic and noncarcinogenic risks from dust inhalation;
  a summary of carcinogenic risks; and

a summary of hazard indices.

Toxicity equivalency factors (TEFs) were applied to seven polycyclic aromatic hydrocarbons (PAHs) that are known or suspected carcinogens, in accordance with EPA's *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA 1993, 1168). Specifically, these factors were taken from Table 8 of that document.

A copy of the Bradley et al. paper is provided as Attachment 6-4 in accordance with your request (Bradley et al. 1994, 1144). The rationale for using the Bradley "urban background" data set as a surrogate background data set for LANL is as follows. Information regarding background levels of PAHs in soil in the vicinity of the Laboratory is not currently available, and the Bradley data set is more suitable for this comparison than any other published data on PAHs. Even the Agency for Toxic Substances and Disease Registry (ATSDR) background data set for PAHs is less conservative than the Bradley data set (i.e., the upper ends of the ranges of background concentrations for PAHs are higher in the ATSDR data set). Also, the ATSDR data set doesn't provide as much contextual information as the Bradley paper on the locations where samples were collected or the number of samples on which a given concentration range is based. The specific advantages of the Bradley data are the following.

- The analyses included all of the individual PAHs in which LANL is interested.
- The analytical methods and quality assurance/quality control measures were consistent with those used by LANL.
- The data were collected specifically to identify background concentrations of PAHs in soils.

References

Bradley, L. N. J., B. H. Magee, and S. L. Allen, 1994, "Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils," in *Journal of Soil Contamination,* Vol. 3(4), p.349. **(Bradley et al. 1994, 1144)**

EPA (US Environmental Protection Agency), December 1989. "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)," Interim Final, EPA 540/1-89/002, Office of Emergency and Remedial Response, Washington, DC. **(EPA 1989, 0305)**

EPA (US Environmental Protection Agency), July 1993. "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," EPA/600/R-93/089, Office of Research and Development, Washington, DC. **(EPA 1993, 1168)**

EPA (US Environmental Protection Agency), February 1994. *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, EPA 540-R-93-081, Office of Emergency and Remedial Response, Washington, DC. **(EPA 1994, 1178)**

Gilbert, R. O., 1987. *Statistical Methods for Environmental Pollution Monitoring*, Reinhold Van Nostrand, New York, New York. **(Gilbert 1987, 0312)**

LANL (Los Alamos National Laboratory), November 1993. "Installation Work Plan for Environmental Restoration," Los Alamos National Laboratory Report LA-UR-93-3987, Los Alamos, New Mexico. **(LANL 1993, 1017)**

LANL (Los Alamos National Laboratory), January 31, 1995. "Field Unit 3, Operable Unit 1122, Technical Area 33, RFI Report for PRSs 33-004(d), 33-004(g), 33-004(h), 33-004(i), 33-005(a), 33-005(b), 33-005(c), 33-010(e), 33-010(f), 33-011(e), 33-012(a), 33-015, 33-007(c), 33-011(a)," Los Alamos National Laboratory Report LA-UR-95-882, Los Alamos, New Mexico. **(LANL 1995, 1212)**

Attachment 2-1

Mean and 95% Upper Confidence Limit for Lead at PRS 33-004(i)

Mean and 95% Upper Confidence Limit for Lead at PRS 33-004(i)

A discussion of preliminary risk assessment results for the area east of TA-33-39 was given in Subsection 4.4.4 of the RFI report. The calculations leading to these results are given here. Table 2-1 lists lead values used in the calculations.

TABLE 2-1

LEAD VALUES IN EXPOSURE UNIT EAST OF TA-33-39

PRS	SITE ID	SAMPLE ID	LEAD (mg/kg)
33-004(i), north	33-1055	AAA1975	10
	33-1056	AAA1976	79
	33-1057	AAA1977	73
33-004(i), south	33-1058	AAA1978	800
	33-1059	AAA1979	71
	33-1060	AAA1980	210
33-012(a)	33-1086	AAA2031	104
	33-1087	AAA2032	118
	33-1088	AAA2033	53
	33-1089	AAA2034	9
33-017, vehicle maintenance area	33-1102	AAA2049	64
	33-1103	AAA2050	90
	33-1104	AAA2051	170
33-017, top of main drainage	33-1105	AAA2052	46
	33-1106	AAA2053	98
	33-1107	AAA2054	200

The calculation of the mean and upper confidence bound for lead contamination in the exposure unit east of TA-33-39 followed the method for minimum variance unbiased (MVU) estimation for lognormal populations described by Gilbert (1987, 0312), pp. 165-166. The data in Table 2-1 are seen to be approximately lognormally distributed in the probability plot of Fig. 2-1. This is a probability plot. That is, the observed values have been sorted and plotted, on a logarithmic scale, against order statistics from the standard normal distribution. Data from a lognormal distribution should fall approximately along a straight line in such a plot. The departures from a straight line that occur at the low end in Fig. 2-1 reflect the fact that in this area what we actually have is a mixture of background levels and contamination. Contaminated areas are over represented in these data because the sampling was biased toward potential release sites, providing additional conservatism in this risk calculation. The MVU estimate of the mean is

$$\hat{\mu} = [\exp(\bar{y})]\Psi_n\left(\frac{s_y^2}{2}\right) \qquad (1)$$

where: $\bar{y}$ is the sample mean of the logged data; s_y^2 is the sample variance; n is the sample size; and $\Psi_n(t)$ is a function from Gilbert's table (1987, 0312). For our calculations we programmed this function using the series expansion given on p. 165 of Gilbert and verified our program by comparing its results with Gilbert's Table A9.

An unbiased estimate of the variance of $\hat{\mu}$ is given by

$$s^2(\hat{\mu}) = \exp(2\bar{y})\left\{\left[\Psi_n\left(\frac{s_y^2}{2}\right)\right]^2 - \Psi_n\left(\frac{s_y^2(n-2)}{n-1}\right)\right\}, \tag{2}$$

and thus a 95% upper confidence interval for the mean is computed finally as

$$\hat{\mu} + t_{n-1,0.95}s(\hat{\mu}), \tag{3}$$

assuming approximate normality of the estimate $\hat{\mu}$ (an application of the Central Limit Theorem of probability theory) with the usual number of degrees of freedom.

The calculation of the 95% UCL was done in SPLUS. A complete record, with enough information to enable the reader to reproduce the calculations by hand, is attached.

```
#  SPLUS calculation of 95% UCL for lead at 33-004(i)

#  Lead data from vehicle maintenance and adjacent areas

ruse <- puse&!s4a
i <- match(Samples$id[ruse],substring(Data$id,1,7))
paste(format(Samples$prs[ruse]),Samples$site[ruse],Samples$id[ruse],
      format(Samples$dup[ruse]),format(Samples$east[ruse]),
      format(Samples$north[ruse]),format(Samples$depth1[ruse]),
      format(Samples$depth2[ruse]),format(Data$PB[i]),
      format(log(Data$PB[i])))

 [1] "33-004i  33-1055 AAA1975     1638.754 1740.357  0  6  10 2.302585"
 [2] "33-004i  33-1056 AAA1976     1638.760 1740.356 NA NA  79 4.369448"
 [3] "33-004i  33-1057 AAA1977     1638.798 1740.345  0  6  73 4.290459"
 [4] "33-004i  33-1058 AAA1978     1638.751 1740.298  0  6 800 6.684612"
 [5] "33-004i  33-1059 AAA1979     1638.759 1740.296  0  6  71 4.262680"
 [6] "33-004i  33-1060 AAA1980     1638.784 1740.295  0  6 210 5.347108"
 [7] "33-012a  33-1086 AAA2031     1638.724 1740.338  6 10 104 4.644391"
 [8] "33-012a  33-1087 AAA2032     1638.724 1740.359 10 14 118 4.770685"
 [9] "33-012a  33-1088 AAA2033     1638.744 1740.347  0  6  53 3.970292"
[10] "33-012a  33-1089 AAA2034     1638.745 1740.355  0  4   9 2.197225"
[11] "33-017VM 33-1102 AAA2049     1638.715 1740.320  0  8  64 4.158883"
[12] "33-017VM 33-1103 AAA2050 COL 1638.715 1740.321  0  8  90 4.499810"
[13] "33-017VM 33-1104 AAA2051     1638.711 1740.320  0  6 170 5.135798"
[14] "33-017DR 33-1105 AAA2052     1638.777 1740.400  0  6  46 3.828641"
[15] "33-017DR 33-1106 AAA2053     1638.804 1740.376  0  6  98 4.584967"
[16] "33-017DR 33-1107 AAA2054     1638.831 1740.361  0  6 200 5.298317"

#  Calculation of 95% UCL for mean, following Gilbert (1987),
#  Section 13.1.1

ly <- log(Data$PB[i])
lybar <- mean(ly)
[1] 4.396619
lyvar <- var(ly)
[1] 1.170557
p1 <- Fpsi(n,lyvar/2)
[1] 1.702724
p2 <- Fpsi(n,lyvar*(n-2)/(n-1))
[1] 2.63801
p3 <- Fpsi(n,2*lyvar)
[1] 7.202603

#  Equation for the mean (Gilbert, Eq. 13.3)
mn <- exp(lybar)*p1
[1] 138.2202

#  Equation for the variance of the mean (Gilbert, Eq. 13.5)
vmn <- exp(2*lybar)*(p1^2-p2)
[1] 1721.583

#  95% UCL, using the t distribution with 15 degrees of freedom
qt(.95,n-1)
[1] 1.75305
ucl <- mn+qt(.95,n-1)*sqrt(vmn)
[1] 210.9577
```

```
#  Lognormal probability plot of data

postscript(file="VMLead",width=6,height=5,horizontal=F,pointsize=9)
par(mar=c(5.1,4.1,1.1,2.1),err=-1)
yy <- Data$PB[i]
plot(qnorm(ppoints(yy)),sort(yy),log="y",bty="l",axes=F,
     xlab="",ylab="mg/kg")
axis(2)
box(bty="l")
mtext("Lead behind Building TA-33-39",3,1,cex=1.2)
abline(h=mn,lty=4)
text(-1.8,160,paste("Mean: ",round(mn)),adj=0)
abline(h=ucl)
text(-1.8,250,paste("95% UCL for mean: ",round(ucl)),adj=0)
abline(h=39,lty=2)
text(1.9,45,"(0.99,0.95) UTL for background:  39",adj=1)
dev.off()
```

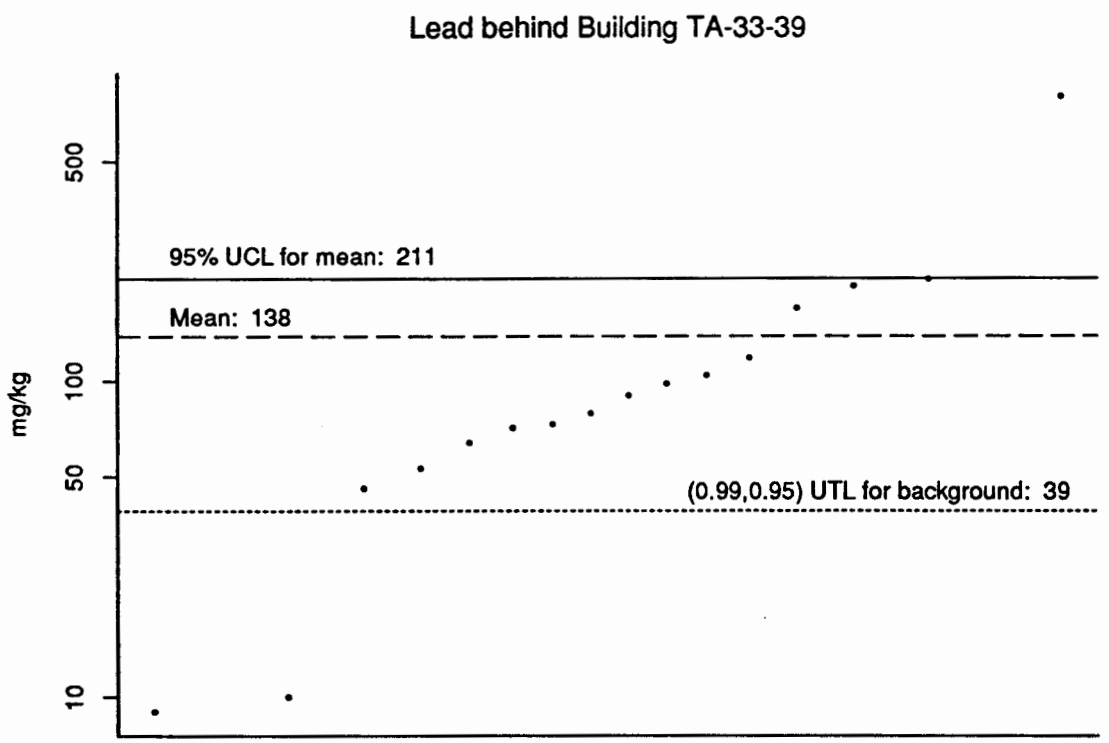


Fig. 2-1. Probability plot of lead values at sampling points east of TA-33-39.

```
#  Fpsi is the function for which a series expansion is provided
#  in Eq. (13.4), p. 165 of Gilbert (1987).

Fpsi <- function(n, t, tol=1e-6) {
        nxt <- (t*(n-1))/n
        psi <- 1+nxt
        k <- 1
        while(nxt > tol) {
                k <- k+1
                nxt <- (nxt*t*((n-1)/n)*((n-1)/(n-1+2*(k-1))))/k
                psi <- psi+nxt
        }
        return(psi)
}

#  Verify by reproducing part of Gilbert's Table A9, p. 263:

x <- seq(0.1,2.0,0.1)
y <- c(2,5,8,10,15,20,30,50,100)
z <- matrix(NA,length(x),length(y))
for (i in 1:length(x)) {
for (j in 1:length(y)) {
   z[i,j] <- Fpsi(y[j],x[i])
}
}
dimnames(z) <- list(x,y)
round(z,3)
        2     5     8    10    15    20    30    50   100
0.1 1.050 1.082 1.091 1.093 1.097 1.099 1.101 1.103 1.104
0.2 1.102 1.169 1.187 1.194 1.203 1.207 1.212 1.216 1.218
0.3 1.154 1.260 1.291 1.302 1.317 1.325 1.333 1.340 1.345
0.4 1.207 1.356 1.401 1.418 1.441 1.453 1.465 1.476 1.484
0.5 1.261 1.457 1.519 1.542 1.574 1.592 1.610 1.625 1.637
0.6 1.315 1.563 1.645 1.675 1.719 1.743 1.768 1.789 1.805
0.7 1.371 1.675 1.779 1.818 1.876 1.907 1.940 1.968 1.990
0.8 1.427 1.792 1.922 1.971 2.045 2.085 2.128 2.165 2.194
0.9 1.485 1.915 2.074 2.135 2.227 2.278 2.333 2.381 2.419
  1 1.543 2.044 2.235 2.310 2.424 2.487 2.557 2.617 2.666
1.1 1.602 2.180 2.407 2.498 2.636 2.714 2.800 2.876 2.938
1.2 1.662 2.321 2.589 2.698 2.864 2.960 3.066 3.159 3.236
1.3 1.724 2.470 2.783 2.911 3.111 3.226 3.354 3.470 3.565
1.4 1.786 2.626 2.988 3.139 3.376 3.513 3.669 3.809 3.926
1.5 1.849 2.788 3.206 3.382 3.661 3.825 4.011 4.181 4.323
1.6 1.913 2.959 3.437 3.642 3.967 4.161 4.383 4.587 4.759
1.7 1.977 3.137 3.682 3.918 4.297 4.525 4.788 5.031 5.239
1.8 2.043 3.323 3.942 4.212 4.651 4.917 5.227 5.517 5.766
1.9 2.110 3.518 4.216 4.525 5.031 5.341 5.705 6.048 6.344
  2 2.178 3.721 4.506 4.858 5.439 5.799 6.224 6.628 6.980
```

Attachment 2-2

Computer printout generated by running EPA's *Integrated Exposure Uptake Biokinetic* (IEUBK) Model (Version 0.99d) for lead in children

Table 1. Results of the EPA Lead Model (Version 0.99d) Based on 95% UCL Lead Concentration in Soil

AIR CONCENTRATION: 0.100 ug Pb/m3 DEFAULT
Indoor AIR Pb Conc: 40.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 4.00 ug Pb/L DEFAULT
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: Multiple Source Analysis

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-1	211.0	157.7
1-2	211.0	157.7
2-3	211.0	157.7
3-4	211.0	157.7
4-5	211.0	157.7
5-6	211.0	157.7
6-7	211.0	157.7

Additional Dust Sources: None DEFAULT
Soil contribution conversion factor: 0.70
Air contribution conversion factor: 100.0

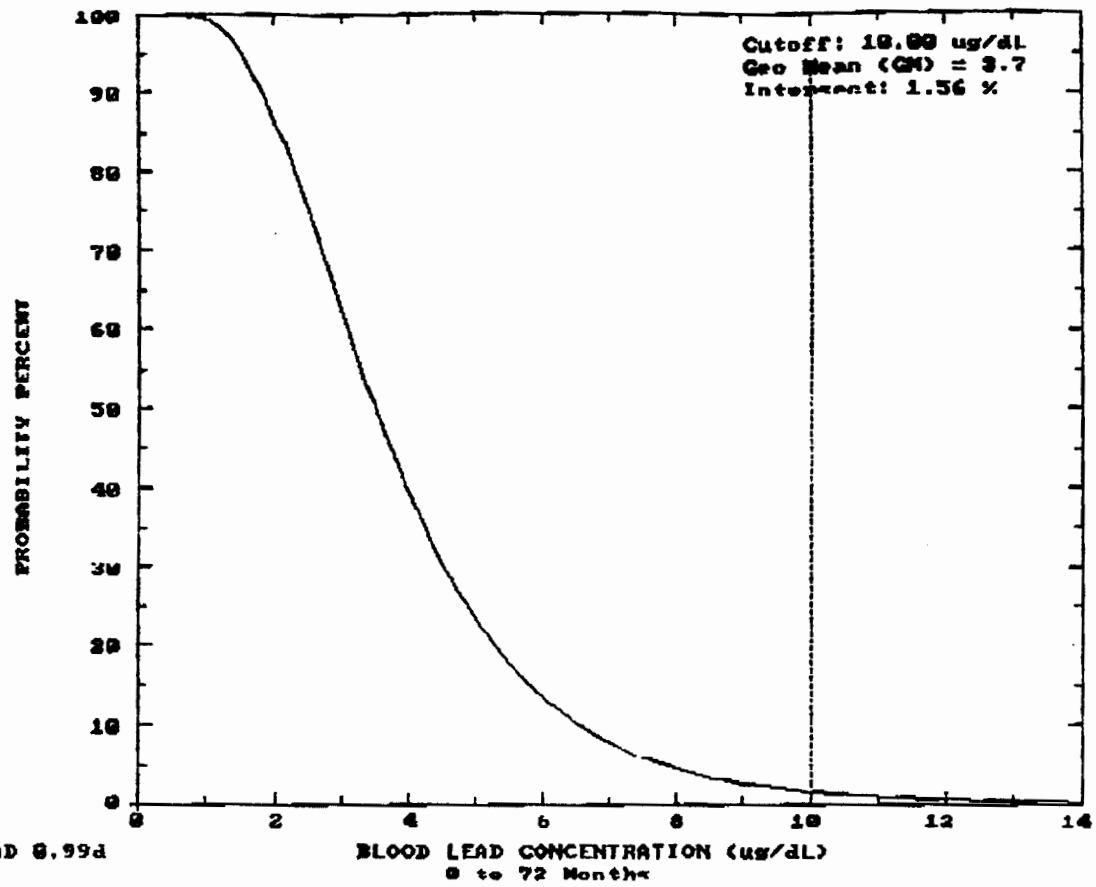
PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc. 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil+Dust Uptake (ug/day)
0.5-1:	3.9	7.21	4.27
1-2:	4.3	10.32	6.73
2-3:	4.0	10.82	6.79
3-4:	3.8	10.85	6.87
4-5:	3.2	9.17	5.19
5-6:	2.8	8.96	4.70
6-7:	2.6	9.06	4.45

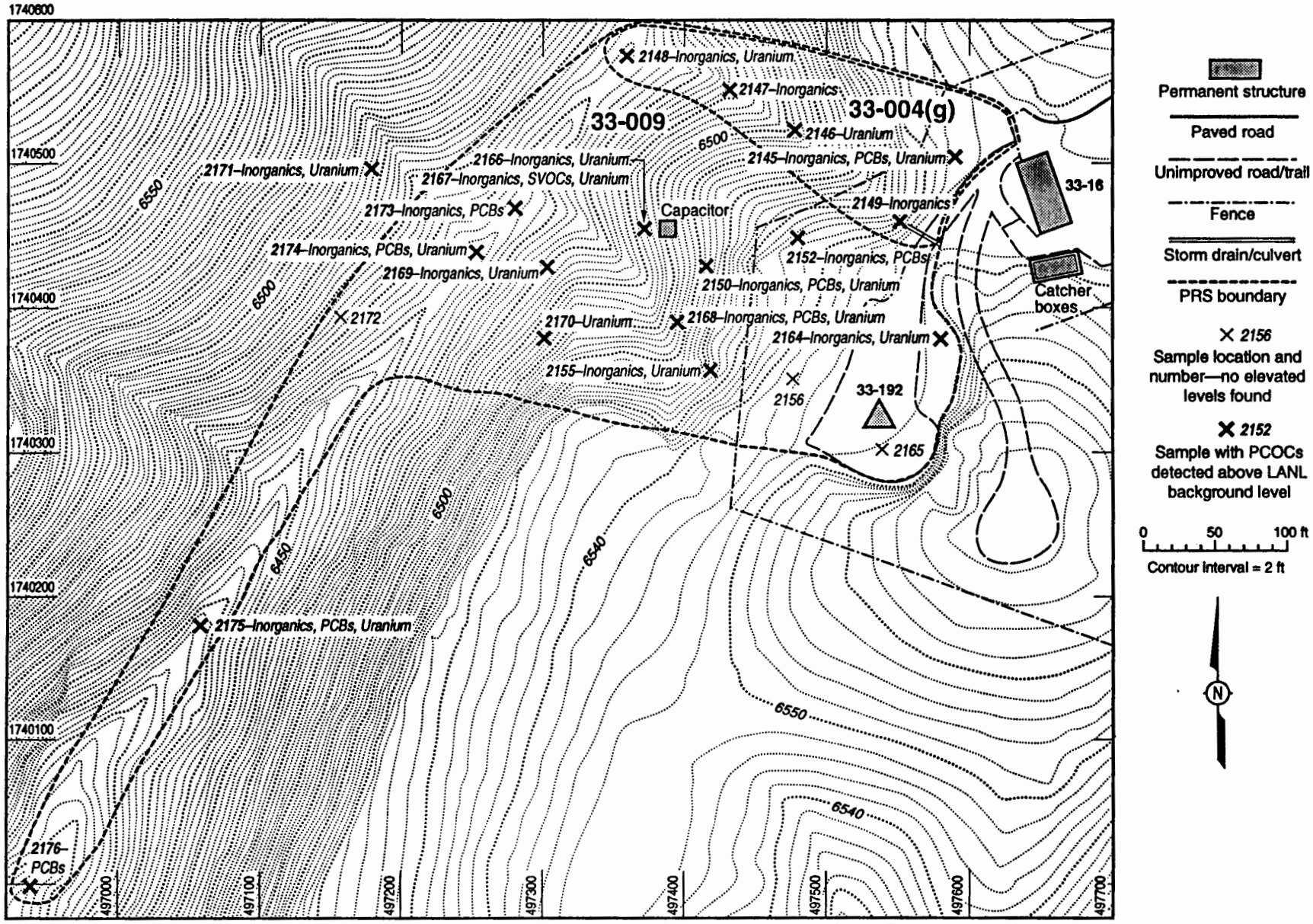
YEAR	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	2.55	0.37	0.00	0.03
1-2:	2.64	0.91	0.00	0.04
2-3:	2.89	0.96	0.00	0.08
3-4:	2.91	0.99	0.00	0.08
4-5:	2.86	1.05	0.00	0.06
5-6:	3.04	1.11	0.00	0.11
6-7:	3.36	1.13	0.00	0.11


Cutoff: 10.00 ug/dL
Geo Mean (GM) = 3.7
Intervent: 1.56 %
PROBABILITY PERCENT
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
BLOOD LEAD CONCENTRATION (ug/dL)
0 to 72 Months

LEAD 0.99d

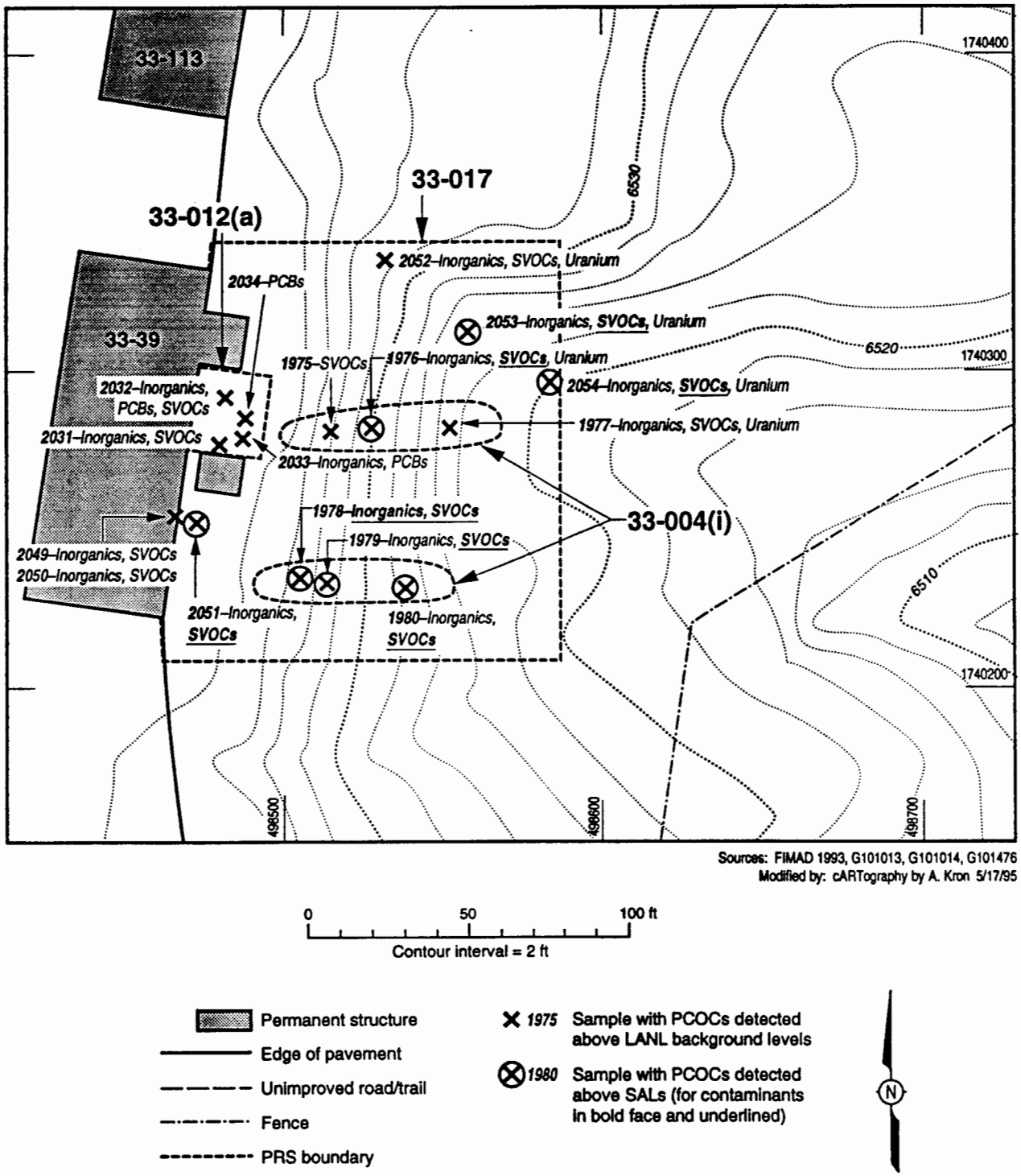
Attachment 4-1

Three Figures Showing Overlapping PRSs



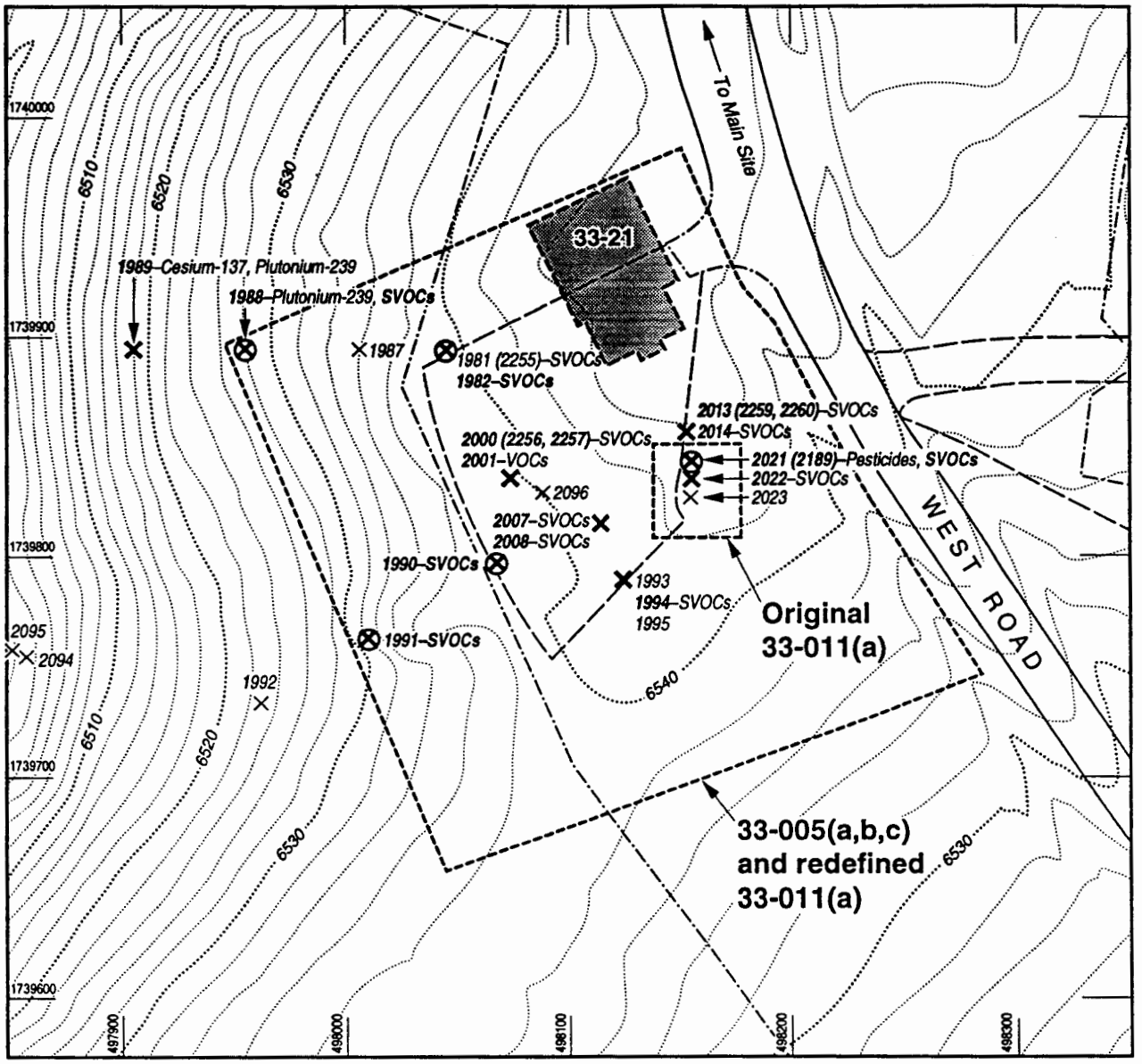
Sources: FIMAD 1993, G101009, G101010, G101476
Modified by: cARTography by A. Kron 5/17/95

Fig. 4-1. Area 6: PRS 33-009 showing overlapping PRS 33-004(g).



Sources: FIMAD 1993, G101013, G101014, G101476
Modified by: cARTography by A. Kron 5/17/95

Fig. 4-2. Main Site: Vehicle maintenance area of PRS 33-017 showing overlapping PRSs 33-004(i) and 33-012(a).



Sources: FIMAD 1993, G101015 & G101476
Modified by: cARTography by A. Kron 5/17/95

Former structure
Paved road
Unimproved road/trail
Fence
PRS boundary
× 1992 Sample location and number—no elevated levels found
✕ 1989 Sample with PCOCs detected above LANL background levels
⊗ 1990 Sample with PCOCs detected above SALs (for contaminant in bold face)
(2259, 2260) Duplicate samples are shown in parentheses

0 50 100 ft
Contour interval = 2 ft

N

Fig. 4-3. PRSs 33-011(a) and 33-005(a,b,c) showing the original configuration. PRS 33-011(a) expanded to include all of PRS 33-005(a,b,c).

Attachment 5-1

Risk Assessment Calculations for Lead at

PRS 33-015

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 ug Pb/m3 DEFAULT
Indoor AIR Pb Conc: 40.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 4.00 ug Pb/L DEFAULT
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: Multiple Source Analysis

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-1	350.0	255.0
1-2	350.0	255.0
2-3	350.0	255.0
3-4	350.0	255.0
4-5	350.0	255.0
5-6	350.0	255.0
6-7	350.0	255.0

Additional Dust Sources: None DEFAULT
Soil contribution conversion factor: 0.70
Air contribution conversion factor: 100.0

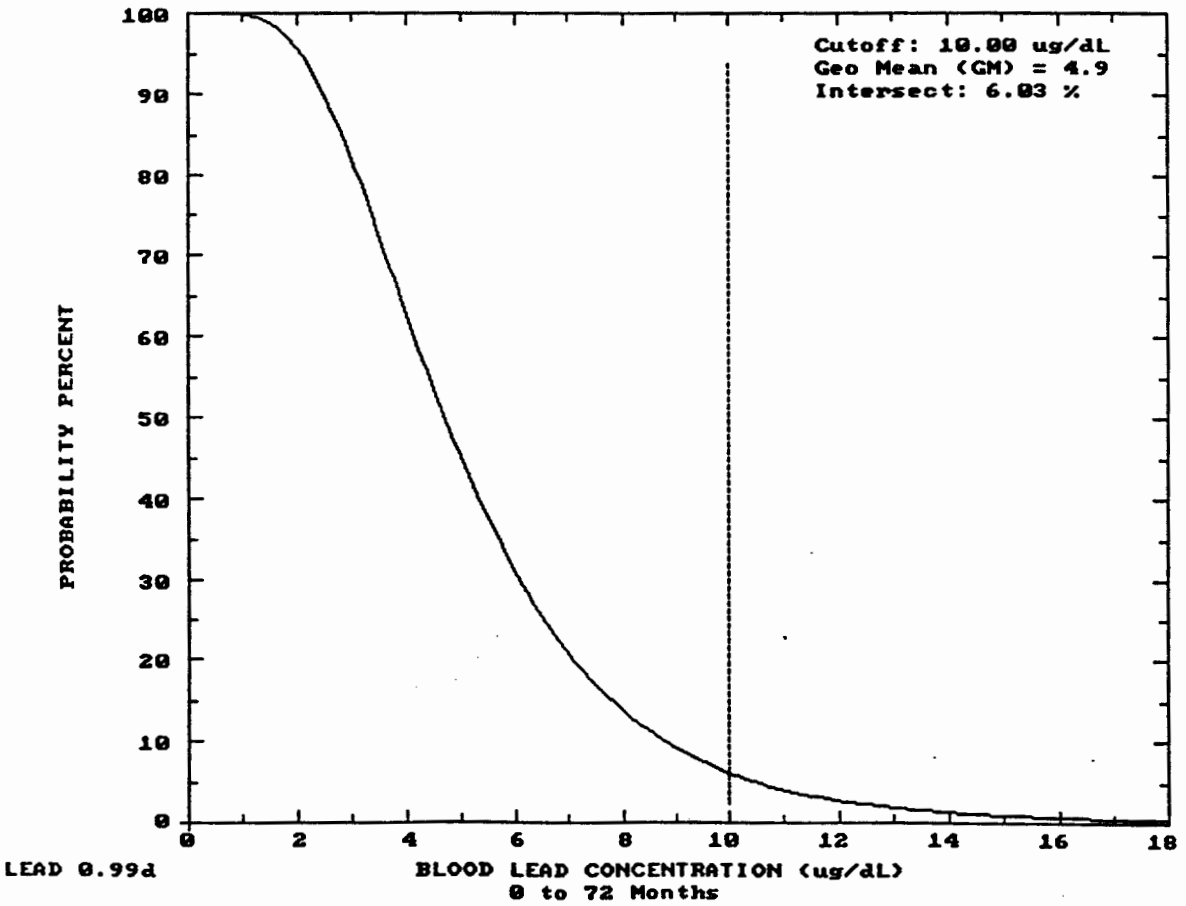
PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil+Dust Uptake (ug/day)
0.5-1:	5.2	9.66	6.80
1-2:	5.8	14.12	10.64
2-3:	5.5	14.71	10.80
3-4:	5.2	14.85	10.97
4-5:	4.3	12.27	8.35
5-6:	3.7	11.80	7.59
6-7:	3.4	11.76	7.21

YEAR	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	2.48	0.36	0.00	0.03
1-2:	2.55	0.88	0.00	0.04
2-3:	2.91	0.93	0.00	0.08
3-4:	2.84	0.96	0.00	0.08
4-5:	2.81	1.03	0.00	0.08
5-6:	2.99	1.10	0.00	0.11
6-7:	3.32	1.12	0.00	0.11



Attachment 6-1

Equations Used in the Risk Assessment Performed for

PRS 33-011(a)

RISK ASSESSMENT EXAMPLE CALCULATIONS, OU 1122

Inhalation LADD Intake Rate Factor:

LADD factor = [(IRa) x (ET) x (EF) x (ED) x (FI)] / [(BW) x (ATc)]

(See Attachment for Parameter Definitions)

LADD factor = [(m^3/hr) x (hr/day) x (day/yr) x (yr) x (1)] / [(kg) x (day)]

(Units check)

LADD factor = m^3/(kg-day)

LADD = LADD factor x C_i

(C_i = Concentration of chemical in air)

LADD = (m^3/kg-day) x (mg/m^3)

LADD = (mg/kg-day)

Inhalation Carcinogenic Risk:

Carcinogenic Risk = LADD x Inhalation Cancer Slope Factor

Carcinogenci Risk = (mg/kg-day) x $(mg/kg\text{-}day)^{-1}$

Ingestion LADD Intake Rate Factor:

LADD factor = [(IGs) x (EF) x (ED) x (FI) x (CF)] / [(BW) x (ATc)]

(See Attachment for Parameter Definitions)

LADD factor = [(mg/day) x (day/yr) x (yr) x (1) x (kg/mg)] / [(kg) x (day)]

(Units check)

LADD factor = 1 / day

LADD = LADD factor x C_i

(C_i = Concentration of chemical in soil)

LADD = (1/day) x (mg/kg)

LADD = (mg/kg-day)

Ingestion Carcinogenic Risk:

Carcinogenic Risk = LADD x Oral Cancer Slope Factor

Carcinogenci Risk = (mg/kg-day) x $(\text{mg/kg-day})^{-1}$

Ingestion ADD Intake Rate Factor:

ADD factor = [(IGs) x (EF) x (ED) x (FI) x (CF)] / [(BW) x (ATnc)]

(See Attachment for Parameter Definitions)

ADD factor = [(mg/day) x (day/yr) x (yr) x (1) x (kg/mg)] / [(kg) x (day)]

(Units check)

ADD factor = 1/day

ADD = ADD factor x C_i

(C_i = Concentration of chemical in soil)

ADD = (1/day) x (mg/kg)

ADD = (mg/kg-day)

Ingestion Noncarcinogenic Effect:

Noncarcinogenic Effect = ADD / Oral Reference Dose

Noncarcinogenic Effect = (mg/kg-day) / (mg/kg-day)

Dermal Contact LADD Intake Rate Factor:

LADD factor = [(SA) x (SAF) x (EF) x (ED) x (FC) x (CF)] / [(BW) x (ATc)]

(See Attachment for Parameter Definitions)

LADD factor = [(cm^2/day) x (mg/cm^2) x (day/yr) x (yr) x (1) x (kg/mg)] / [(kg) x (day)]

(Units check)

LADD factor = 1 / day

LADD = LADD factor x C_i

(C_i = Concentration of chemical in soil)

LADD = (1 / day) x (mg/kg)

LADD = (mg/kg-day)

Dermal Contact Carcinogenic Risk:

Carcinogenic Risk = LADD x Adjusted Dermal Cancer Slope Factor

Carcinogenci Risk = (mg/kg-day) x $(mg/kg\text{-}day)^{-1}$

Dermal Contact ADD Intake Rate Factor:

ADD factor = [(SA) x (SAF) x (EF) x (ED) x (FC) x (CF)] / [(BW) x (ATnc)]

(See Attachment for Parameter Definitions)

ADD factor = [(cm^2/day) x (mg/cm^2) x (day/yr) x (yr) x (1) x (kg/mg)] / [(kg) x (day)]

(Units check)

ADD factor = 1/day

ADD = ADD factor x C_i

(C_i = Concentration of chemical in soil)

ADD = (1/day) x (mg/kg)

ADD = (mg/kg-day)

Dermal Contact Noncarcinogenic Effect:

Noncarcinogenic Effect = ADD / Adjusted Dermal Reference Dose

Noncarcinogenic Effect = (mg/kg-day) / (mg/kg-day)

Attachment 6-2

Copy of Attachment 1 to Appendix K of the LANL 1993 Installation Work Plan

ATTACHMENT I

RISK ASSESSMENT FOR LOS ALAMOS NATIONAL LABORATORY: SUGGESTED VALUES FOR SCENARIO PARAMETERS

Parameter	Unit	Long-Term Worker[a]	Construction Worker[b]	Youth Recreational User[c]	Resident[d]	Future Camper[e]
General Exposure Parameters						
Total Exposure Time (ET)	h/d	8	8	2	20	24
Exposure Time Outdoors (ET_o)	h/d	0-8	8	2	2	24
Exposure Frequency (EF)	d/yr	250	90	170	350	28
Exposure Duration[f] (ED)	yr	25	1	9	30	20
Area of Exposure Unit[g] (A_{EU})	m^2	500	Area of Contamin-ation	2000	500	2000
Body Weight[h] (BW)	kg	70	70	50	70 Adult 15 Child	70 Adult 15 Child
Indoor Shielding Factor for External Gamma (SF)	%	70	NA[i]	NA	70	NA
Pathway-Specific Exposure Parameters						
Inhalation Pathway						
Inhalation Rate[j] (IR_a)	m^3/h	0.83 Indoors 1.7 Outdoors	1.7	3.2	0.83 Indoors 1.7 Outdoors	1.3
Particulate Concentration in Air[k] (PC)	mg/m^3	0.09	15	PRS-specific	0.09	0.09
Amount of Outdoor Dust Present Indoors[l]	%	40	NA	NA	40	NA
Ingestion Pathways						
Soil Ingestion Rate[m] (IR_s)	mg/d	50 or 100	480	100	100 Adult 200 Child	100 Adult 200 Child
Groundwater Ingestion Rate[n] (IR_{gw})	L/d	1	1	NA	2	2
Surface water Ingestion Rate[n] (IR_{sw})	L/d	1	1	0.05	0.05	0.05
Exposure Frequency for Surface Water Ingestion[o] (EF_{sw})	d/yr	NA	NA	40	40	28
Produce or Berry Ingestion Rate[p] (IR_p)	g/d	NA	NA	NA	340	140
Fraction Ingested Produce Grown on Contaminated Area[p] (F_{HG})	%	NA	NA	NA	30	100
Soil Dermal Contact Pathway						
Exposure Frequency for Soil Dermal Contact[q] (EF_d)	events/yr	NA	90	170	170	28
Skin Surface Area Available for Soil Contact[r] (SA_s)	cm^2/event	NA	3200 (arms & hands)	5000	5000	5000
Soil-to-Skin Adherence Factor[r] (ADF)	mg/cm^2	NA	1	1	1	1
Groundwater Dermal Contact Pathway						
Dermal Contact Exposure Time for Groundwater (ET_{gw})	h/event	NA	NA	NA	0.25	NA
Skin Surface Area Available for Groundwater Contact[r] (SA_{gw})	cm^2/event	NA	NA	NA	20,000	NA

Parameter	Unit	Long-Term Worker[a]	Construction Worker[b]	Youth Recreational User[c]	Resident[d]	Future Camper[e]
Surface Water Dermal Contact Pathway						
Dermal Contact Exposure Time for Surface Water (ET_{SW})	h/ event	NA	NA	1	1	1
Exposure Frequency for Surface Water Dermal Contact[o] (EF_{SW})	d/yr	NA	NA	40	40	28
Skin Surface Area Available for Surface Water Contact[r] (SA_{SW})	cm^2/ event	NA	NA	5000	5000	5000

a. Current and future long-term workers; usually will assume 4 h/d working outdoors (represents reasonable maximum exposure). Primarily for mesa top areas but may be used for canyon bottoms, as appropriate.

b. Construction worker; for evaluation of exposure to areas of surface and subsurface contamination as appropriate. Evaluation limited to contaminants in soils at depths of 12 ft or less.

c. Youth recreational user of canyon sides and bottoms. Receptor is a youth age 10 to 18 using canyon sides and bottoms for hiking or biking. This is the only land use scenario applicable for areas of contamination on canyon sides. Although unlikely as a current use scenario because of institutional controls on Laboratory property, it is possible that limited trespassing occurs.

d. Current or future resident is a resident of extra-Laboratory areas (may include some canyon bottom areas in the future). This scenario does not apply to Laboratory property, for which future land use will be controlled by DOE.

e. Future camper on Laboratory mesa top or canyon bottom areas, assuming the site is released for recreational use (e.g., released to National Park Service).

f. Exposure duration for occupational and residential scenarios (i.e., 25 and 30 yr) recommended by the EPA (1991, 0746). For youth recreational user, 9 yr is the age-range duration and is also the median time at one residence (EPA 1989, 0305). Construction worker exposure duration is chosen based on assumption that projects will be of limited scope. Future recreational users are assumed to use site as long-term vacation area.

g. Area of residential exposure unit based on EPA guidance (EPA 1989, 0305). Other areas based on assumptions on likely scenario-specific activity patterns.

h. Body weights: 70 kg for adult scenarios (EPA 1991, 0746); 50 kg for youth scenarios, 12 to <15 yr old (EPA 1989, 0304); 15 kg for child 1-6 yr old (EPA 1991, 0746).

i. Not applicable.

j. Inhalation Rates: standard default value of 0.83 m^3/h used for indoor residential and indoor long-term worker exposures (EPA 1991, 0746). Inhalation rates accounting for resting, light, moderate, and heavy activity (EPA 1989, 1011) are calculated for other scenarios as follows:

- Long-term or Construction Worker, Resident—outdoor inhalation rate of 1.7 m^3/h equal to 0.5 exposure time at light activity + 0.5 exposure time at moderate activity, adult male inhalation rate.
- Youth Recreational User—inhalation rate of 3.2 m^3/h equal to entire exposure time at moderate activity, inhalation rate for 10-yr olds.
- Future Camper—inhalation rate of 1.3 m^3/h equal to 8 h/d resting, 12 h/d light activity, 2 h/d moderate activity, and 2 h/d heavy activity, adult male inhalation rate.

- Definitions—resting: reading, sleeping, watching television; light activity: domestic work, personal care, minor indoor repairs and home improvements; moderate activity: heavy indoor cleanup, major indoor repairs, climbing stairs; heavy activity: vigorous physical exercise, climbing stairs carrying a load (EPA 1989, 1011).

k. Reference for 0.09 mg/m^3 particulate concentration in air is Environmental Protection Group (1990, 0497). Value of 15 mg/m^3 considered maximum for construction worker scenarios (OSHA 1991, 0610).

l. Based on value given in Alzona et al. (1979, 0994). Only applies for inhalation pathways and for soil ingestion pathway where entire exposure occurs indoors.

m. Standard default soil ingestion rates recommended by EPA (1991, 0746). For the resident and future camper scenarios, the soil ingestion pathway assumes an ingestion rate of 200 mg/d and a body weight of 15 kg for 6 yr exposure as a child and an ingestion rate of 100 mg/d and a body weight of 70 kg for 24 yr and 14 yr, respectively, for exposure as an adult. Long-term worker rates of 50 or 100 mg/d are rates recommended for commercial/industrial scenarios by EPA (1991, 0746). Rate of 480 mg/d for the future construction worker based on EPA guidance (1991, 0746) to account for substantial soil contact and potential ingestion of inhaled material that is not retained in the lungs.

n. For groundwater, standard default water ingestion rate recommended in EPA (1991, 0746). For surface water ingestion, 0.05 L/d based on EPA recommended ingestion level of 50 mL/h for the 1-h exposure time (EPA 1989, 0305).

o. Exposure frequency for surface water ingestion and dermal exposure equal to total exposure frequency (28 d/yr) for the future camper; equal to 40 d/yr for the youth recreational user and future residents (based on best professional judgment of likely wading frequency.

p. Produce ingestion rate and fraction produce grown on or collected from the contaminated area: 340 g/d, 30% for residential scenario includes ingestion of vegetables and fruits; 140 g/d, 100% for future recreational user for fruits only (EPA 1991, 0746).

q. Number of soil dermal contact events equal to exposure frequency, except for residential scenario. For residents, it is assumed that dermal contact occurs seasonally (e.g., during gardening), about 5 d/wk for 8 mo/yr.

r. Skin surface area available for contact and soil-to-skin adherence factor assumptions, as recommended in EPA (1992, 0833).

Attachment 6-3

Computer Printouts Generated in Performing the Risk Assessment for

PRS 33-011(a)

A printout is included for each of the following scenarios:

residential - adult;
residential - child;
camper - adult;
camper - child;
hiker - adult;
construction worker - adult; and
long-term worker - adult.

Residential - Adult

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	5.73E-07	7.30E-01	4.2E-07
Benzo(a)pyrene	1.12E+00	6.56E-07	7.30E+00	4.8E-06
Benzo(b)fluoranthene	1.03E+00	6.04E-07	7.30E-01	4.4E-07
Benzo(g,h,i)perylene	5.86E-01	3.44E-07	NC	NC
Benzo(k)fluoranthene	1.01E+00	5.92E-07	7.30E-02	4.3E-08
Chrysene	1.14E+00	6.70E-07	7.30E-03	4.9E-09
Dibenzo(a,h) anthracene	3.40E-01	2.00E-07	7.30E+00	1.5E-06
Indeno(1,2,3-cd)pyrene	6.37E-01	3.74E-07	7.30E-01	2.7E-07
TOTAL RISK				7.4E-06

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 5.87E-07
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	1.34E-06	NA	NA
Benzo(a)pyrene	1.12E+00	1.53E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.41E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	8.03E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	1.38E-06	NA	NA
Chrysene	1.14E+00	1.56E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	4.66E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	8.73E-07	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 1.37E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	4.30E-06	8.69E-01	3.7E-06
Benzo(a)pyrene	1.12E+00	0.15	4.92E-06	8.69E+00	4.3E-05
Benzo(b)fluoranthene	1.03E+00	0.15	4.53E-06	8.69E-01	3.9E-06
Benzo(g,h,i)perylene	5.86E-01	0.15	2.58E-06	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	4.44E-06	8.69E-02	3.9E-07
Chrysene	1.14E+00	0.15	5.02E-06	8.69E-03	4.4E-08
Dibenzo(a,h) anthracene	3.40E-01	0.15	1.50E-06	8.69E+00	1.3E-05
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	2.80E-06	8.69E-01	2.4E-06
TOTAL RISK					6.6E-05

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 2.94E-05
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Adult HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.00E-05	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	1.15E-05	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	1.06E-05	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	6.02E-06	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	1.04E-05	NA	NA
Chrysene	1.14E+00	0.15	1.17E-05	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	3.49E-06	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	6.54E-06	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 6.85E-05
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-1
CARCINOGENIC RISKS FROM DUST INHALATION
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m^3)	Adult LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	8.78E-08	1.75E-08	7.30E-01	1.3E-08
Benzo(a)pyrene	1.01E-07	2.01E-08	7.30E+00	1.5E-07
Benzo(b)fluoranthene	9.26E-08	1.85E-08	7.30E-01	1.3E-08
Benzo(g,h,i)perylene	5.27E-08	1.05E-08	NC	NC
Benzo(k)fluoranthene	9.08E-08	1.81E-08	7.30E-02	1.3E-09
Chrysene	1.03E-07	2.05E-08	7.30E-03	1.5E-10
Dibenzo(a,h) anthracene	3.06E-08	6.11E-09	7.30E+00	4.5E-08
Indeno(1,2,3-cd)pyrene	5.73E-08	1.14E-08	7.30E-01	8.4E-09
TOTAL RISK				2.3E-07

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 2.00E-01
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST–2
NONCARCINOGENIC HAZARD INDICES FROM DUST INHALATION
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Adult ADD (mg/kg/day)	Inhalation RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	8.78E–08	4.09E–08	NA	NA
Benzo(a)pyrene	1.01E–07	4.69E–08	NA	NA
Benzo(b)fluoranthene	9.26E–08	4.31E–08	NA	NA
Benzo(g,h,i)perylene	5.27E–08	2.46E–08	NA	NA
Benzo(k)fluoranthene	9.08E–08	4.23E–08	NA	NA
Chrysene	1.03E–07	4.78E–08	NA	NA
Dibenzo(a,h) anthracene	3.06E–08	1.43E–08	NA	NA
Indeno(1,2,3–cd)pyrene	5.73E–08	2.67E–08	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cp x ADD Factor
Inhalation Intake Rate ADD Factor = 4.66E–01
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE R–R
SUMMARY OF CARCINOGENIC RISKS
FUTURE RESIDENT SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	4.2E–07	3.7E–06	1.3E–08	4E–06	6%
Benzo(a)pyrene	4.8E–06	4.3E–05	1.5E–07	5E–05	64%
Benzo(b)fluoranthene	4.4E–07	3.9E–06	1.3E–08	4E–06	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	4.3E–08	3.9E–07	1.3E–09	4E–07	1%
Chrysene	4.9E–09	4.4E–08	1.5E–10	5E–08	0%
Dibenzo(a,h) anthracene	1.5E–06	1.3E–05	4.5E–08	1E–05	20%
Indeno(1,2,3–cd)pyrene	2.7E–07	2.4E–06	8.4E–09	3E–06	4%
TOTAL CANCER RISK	7E–06	7E–05	2E–07	7E–05	100%
Percent Contribution	10%	90%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

Residential - Child

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE E–E
EXPOSURE PARAMETERS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

Exposure Parameter	Symbol	Units	Residents		References
			Adults	Children	
Inhalation Rate – indoor air	IRa	m^3/hr	0.83	0.66	EPA, 1991
Inhalation Rate – outdoor air	IRa	m^3/hr	1.7	1.3	EPA, 1991
Soil Ingestion Rate	IGs	mg/day	100	200	EPA, 1991
Skin Surface Area Exposed	SA	cm^2/day	5000	2000	EPA, 1992
Soil–skin Adherence Factor	SAF	mg/cm^2	1	1	Assumed
Exposure Time	ET	hr/day	20	20	Assumed
Exposure Frequency	EF	days/yr	350	350	EPA, 1992
Exposure Duration	ED	year	30	6	EPA, 1989
Fraction Ingested, Inhaled or Contacted from Site	FI or FC	unitless	1	1	
Conversion Factor	CF	kg/mg	1E–06	1E–06	Conversion Factor
Body Weight	BW	kg	70	15	EPA, 1991
Averaging Time – Cancer	ATc	days	25550	25550	365 days/year x 70 years (lifetime)
Averaging Time – NonCancer	ATnc	days	10950	2190	365 days/year x ED

LADD/ADD = Lifetime Average Daily Dose/Average Daily Dose

Inhalation LADD Intake Rate Factors – outdoor air	2.00E–01	1.42E–01
Inhalation ADD Intake Rate Factors – outdoor air	4.66E–01	1.66E+00
Soil Ingestion LADD Intake Rate Factors	5.87E–07	1.10E–06
Soil Ingestion ADD Intake Rate Factors	1.37E–06	1.28E–05
Dermal Contact LADD Intake Rate Factors	2.94E–05	1.10E–05
Dermal Contact ADD Intake Rate Factors	6.85E–05	1.28E–04

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Child LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	1.07E-06	7.30E-01	7.8E-07
Benzo(a)pyrene	1.12E+00	1.23E-06	7.30E+00	8.9E-06
Benzo(b)fluoranthene	1.03E+00	1.13E-06	7.30E-01	8.2E-07
Benzo(g,h,i)perylene	5.86E-01	6.42E-07	NC	NC
Benzo(k)fluoranthene	1.01E+00	1.11E-06	7.30E-02	8.1E-08
Chrysene	1.14E+00	1.25E-06	7.30E-03	9.1E-09
Dibenzo(a,h) anthracene	3.40E-01	3.73E-07	7.30E+00	2.7E-06
Indeno(1,2,3-cd)pyrene	6.37E-01	6.98E-07	7.30E-01	5.1E-07
TOTAL RISK				1.4E-05

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 1.10E-06
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Child ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Child HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	1.25E-05	NA	NA
Benzo(a)pyrene	1.12E+00	1.43E-05	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.32E-05	NA	NA
Benzo(g,h,i)perylene	5.86E-01	7.49E-06	NA	NA
Benzo(k)fluoranthene	1.01E+00	1.29E-05	NA	NA
Chrysene	1.14E+00	1.46E-05	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	4.35E-06	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	8.14E-06	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 1.28E-05
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Child LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.60E-06	8.69E-01	1.4E-06
Benzo(a)pyrene	1.12E+00	0.15	1.84E-06	8.69E+00	1.6E-05
Benzo(b)fluoranthene	1.03E+00	0.15	1.69E-06	8.69E-01	1.5E-06
Benzo(g,h,i)perylene	5.86E-01	0.15	9.63E-07	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	1.66E-06	8.69E-02	1.4E-07
Chrysene	1.14E+00	0.15	1.88E-06	8.69E-03	1.6E-08
Dibenzo(a,h) anthracene	3.40E-01	0.15	5.59E-07	8.69E+00	4.9E-06
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	1.05E-06	8.69E-01	9.1E-07
TOTAL RISK					2.5E-05

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 1.10E-05
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Child ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Child HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.87E-05	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	2.14E-05	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	1.97E-05	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	1.12E-05	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	1.94E-05	NA	NA
Chrysene	1.14E+00	0.15	2.19E-05	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	6.52E-06	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	1.22E-05	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 1.28E-04
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-1
CARCINOGENIC RISKS FROM DUST INHALATION
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Child LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles				
Benzo(a)anthracene	8.78E-08	1.25E-08	7.30E-01	9.1E-09
Benzo(a)pyrene	1.01E-07	1.43E-08	7.30E+00	1.0E-07
Benzo(b)fluoranthene	9.26E-08	1.32E-08	7.30E-01	9.6E-09
Benzo(g,h,i)perylene	5.27E-08	7.51E-09	NC	NC
Benzo(k)fluoranthene	9.08E-08	1.29E-08	7.30E-02	9.4E-10
Chrysene	1.03E-07	1.46E-08	7.30E-03	1.1E-10
Dibenzo(a,h) anthracene	3.06E-08	4.36E-09	7.30E+00	3.2E-08
Indeno(1,2,3-cd)pyrene	5.73E-08	8.17E-09	7.30E-01	6.0E-09
TOTAL RISK				1.6E-07

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 1.42E-01
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE R–R
SUMMARY OF CARCINOGENIC RISKS
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	7.8E–07	1.4E–06	9.1E–09	2E–06	6%
Benzo(a)pyrene	8.9E–06	1.6E–05	1.0E–07	3E–05	64%
Benzo(b)fluoranthene	8.2E–07	1.5E–06	9.6E–09	2E–06	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	8.1E–08	1.4E–07	9.4E–10	2E–07	1%
Chrysene	9.1E–09	1.6E–08	1.1E–10	3E–08	0%
Dibenzo(a,h) anthracene	2.7E–06	4.9E–06	3.2E–08	8E–06	20%
Indeno(1,2,3–cd)pyrene	5.1E–07	9.1E–07	6.0E–09	1E–06	4%
TOTAL CANCER RISK	1E–05	2E–05	2E–07	4E–05	100%
Percent Contribution	36%	64%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE H–H
SUMMARY OF HAZARD INDICES
FUTURE RESIDENT SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

Camper - Adult

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	3.06E-08	7.30E-01	2.2E-08
Benzo(a)pyrene	1.12E+00	3.50E-08	7.30E+00	2.6E-07
Benzo(b)fluoranthene	1.03E+00	3.22E-08	7.30E-01	2.4E-08
Benzo(g,h,i)perylene	5.86E-01	1.83E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	3.16E-08	7.30E-02	2.3E-09
Chrysene	1.14E+00	3.57E-08	7.30E-03	2.6E-10
Dibenzo(a,h) anthracene	3.40E-01	1.06E-08	7.30E+00	7.8E-08
Indeno(1,2,3-cd)pyrene	6.37E-01	1.99E-08	7.30E-01	1.5E-08
TOTAL RISK				4.0E-07

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 3.13E-08
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	9.98E-07	NA	NA
Benzo(a)pyrene	1.12E+00	1.14E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.05E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	5.99E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	1.03E-06	NA	NA
Chrysene	1.14E+00	1.17E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	3.48E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	6.52E-07	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 1.02E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	2.29E-07	8.69E-01	2.0E-07
Benzo(a)pyrene	1.12E+00	0.15	2.63E-07	8.69E+00	2.3E-06
Benzo(b)fluoranthene	1.03E+00	0.15	2.42E-07	8.69E-01	2.1E-07
Benzo(g,h,i)perylene	5.86E-01	0.15	1.38E-07	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	2.37E-07	8.69E-02	2.1E-08
Chrysene	1.14E+00	0.15	2.68E-07	8.69E-03	2.3E-09
Dibenzo(a,h) anthracene	3.40E-01	0.15	7.98E-08	8.69E+00	6.9E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	1.50E-07	8.69E-01	1.3E-07
TOTAL RISK					3.5E-06

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 1.57E-06
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Adult HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	8.02E-07	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	9.19E-07	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	8.46E-07	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	4.82E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	8.29E-07	NA	NA
Chrysene	1.14E+00	0.15	9.38E-07	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	2.79E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	5.24E-07	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 5.48E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST–1
CARCINOGENIC RISKS FROM DUST INHALATION
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Adult LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	8.78E–08	8.58E–10	7.30E–01	6.3E–10
Benzo(a)pyrene	1.01E–07	9.83E–10	7.30E+00	7.2E–09
Benzo(b)fluoranthene	9.26E–08	9.05E–10	7.30E–01	6.6E–10
Benzo(g,h,i)perylene	5.27E–08	5.15E–10	NC	NC
Benzo(k)fluoranthene	9.08E–08	8.87E–10	7.30E–02	6.5E–11
Chrysene	1.03E–07	1.00E–09	7.30E–03	7.3E–12
Dibenzo(a,h) anthracene	3.06E–08	2.99E–10	7.30E+00	2.2E–09
Indeno(1,2,3–cd)pyrene	5.73E–08	5.60E–10	7.30E–01	4.1E–10
TOTAL RISK				1.1E–08

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 9.77E–03
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-2
NONCARCINOGENIC HAZARD INDICES FROM DUST INHALATION
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Adult ADD (mg/kg/day)	Inhalation RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	8.78E-08	3.00E-09	NA	NA
Benzo(a)pyrene	1.01E-07	3.44E-09	NA	NA
Benzo(b)fluoranthene	9.26E-08	3.17E-09	NA	NA
Benzo(g,h,i)perylene	5.27E-08	1.80E-09	NA	NA
Benzo(k)fluoranthene	9.08E-08	3.10E-09	NA	NA
Chrysene	1.03E-07	3.51E-09	NA	NA
Dibenzo(a,h) anthracene	3.06E-08	1.05E-09	NA	NA
Indeno(1,2,3-cd)pyrene	5.73E-08	1.96E-09	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cp x ADD Factor
Inhalation Intake Rate ADD Factor = 3.42E-02
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE R-R
SUMMARY OF CARCINOGENIC RISKS
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	2.2E-08	2.0E-07	6.3E-10	2E-07	6%
Benzo(a)pyrene	2.6E-07	2.3E-06	7.2E-09	3E-06	64%
Benzo(b)fluoranthene	2.4E-08	2.1E-07	6.6E-10	2E-07	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	2.3E-09	2.1E-08	6.5E-11	2E-08	1%
Chrysene	2.6E-10	2.3E-09	7.3E-12	3E-09	0%
Dibenzo(a,h) anthracene	7.8E-08	6.9E-07	2.2E-09	8E-07	20%
Indeno(1,2,3-cd)pyrene	1.5E-08	1.3E-07	4.1E-10	1E-07	4%
TOTAL CANCER RISK	4E-07	4E-06	1E-08	4E-06	100%
Percent Contribution	10%	90%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE H–H
SUMMARY OF HAZARD INDICES
FUTURE CAMPER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

Camper - Child

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE E–E
EXPOSURE PARAMETERS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

Exposure Parameter	Symbol	Units	Residents		References
			Adults	Children	
Inhalation Rate – indoor air	IRa	m^3/hr	1.3	0.66	EPA, 1991
Inhalation Rate – outdoor air	IRa	m^3/hr	1.3	0.66	EPA, 1991
Soil Ingestion Rate	IGs	mg/day	100	200	EPA, 1991
Skin Surface Area Exposed	SA	cm^2/day	5000	2000	EPA, 1992
Soil–skin Adherence Factor	SAF	mg/cm^2	1	1	Assumed
Exposure Time	ET	hr/day	24	24	IWP, 1993
Exposure Frequency	EF	days/yr	28	28	IWP, 1993
Exposure Duration	ED	year	20	6	IWP, 1993
Fraction Ingested, Inhaled or Contacted from Site	FI or FC	unitless	1	1	Assumed
Conversion Factor	CF	kg/mg	1E–06	1E–06	Conversion Factor
Body Weight	BW	kg	70	15	EPA, 1991
Averaging Time – Cancer	ATc	days	25550	25550	365 days/year x 70 years (lifetime)
Averaging Time – NonCancer	ATnc	days	7300	2190	365 days/year x ED

LADD/ADD = Lifetime Average Daily Dose/Average Daily Dose

Inhalation LADD Intake Rate Factors – outdoor air	9.77E–03	6.94E–03
Inhalation ADD Intake Rate Factors – outdoor air	3.42E–02	8.10E–02
Soil Ingestion LADD Intake Rate Factors	3.13E–08	8.77E–08
Soil Ingestion ADD Intake Rate Factors	1.10E–07	1.02E–06
Dermal Contact LADD Intake Rate Factors	1.57E–06	8.77E–07
Dermal Contact ADD Intake Rate Factors	5.48E–06	1.02E–05

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Child LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	8.56E-08	7.30E-01	6.2E-08
Benzo(a)pyrene	1.12E+00	9.80E-08	7.30E+00	7.2E-07
Benzo(b)fluoranthene	1.03E+00	9.02E-08	7.30E-01	6.6E-08
Benzo(g,h,i)perylene	5.86E-01	5.14E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	8.85E-08	7.30E-02	6.5E-09
Chrysene	1.14E+00	1.00E-07	7.30E-03	7.3E-10
Dibenzo(a,h) anthracene	3.40E-01	2.98E-08	7.30E+00	2.2E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	5.58E-08	7.30E-01	4.1E-08
TOTAL RISK				1.1E-06

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 8.77E-08
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Child ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Child HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	9.98E-07	NA	NA
Benzo(a)pyrene	1.12E+00	1.14E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.05E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	5.99E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	1.03E-06	NA	NA
Chrysene	1.14E+00	1.17E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	3.48E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	6.52E-07	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 1.02E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Child LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.28E-07	8.69E-01	1.1E-07
Benzo(a)pyrene	1.12E+00	0.15	1.47E-07	8.69E+00	1.3E-06
Benzo(b)fluoranthene	1.03E+00	0.15	1.35E-07	8.69E-01	1.2E-07
Benzo(g,h,i)perylene	5.86E-01	0.15	7.71E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	1.33E-07	8.69E-02	1.2E-08
Chrysene	1.14E+00	0.15	1.50E-07	8.69E-03	1.3E-09
Dibenzo(a,h) anthracene	3.40E-01	0.15	4.47E-08	8.69E+00	3.9E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	8.38E-08	8.69E-01	7.3E-08
TOTAL RISK					2.0E-06

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 8.77E-07
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Child ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Child HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.50E-06	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	1.72E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	1.58E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	8.99E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	1.55E-06	NA	NA
Chrysene	1.14E+00	0.15	1.75E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	5.22E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	9.77E-07	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 1.02E-05
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-1
CARCINOGENIC RISKS FROM DUST INHALATION
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m^3)	Child LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Child Cancer Risk
Semivolatiles				
Benzo(a)anthracene	8.78E-08	6.10E-10	7.30E-01	4.5E-10
Benzo(a)pyrene	1.01E-07	6.99E-10	7.30E+00	5.1E-09
Benzo(b)fluoranthene	9.26E-08	6.43E-10	7.30E-01	4.7E-10
Benzo(g,h,i)perylene	5.27E-08	3.66E-10	NC	NC
Benzo(k)fluoranthene	9.08E-08	6.31E-10	7.30E-02	4.6E-11
Chrysene	1.03E-07	7.13E-10	7.30E-03	5.2E-12
Dibenzo(a,h) anthracene	3.06E-08	2.12E-10	7.30E+00	1.6E-09
Indeno(1,2,3-cd)pyrene	5.73E-08	3.98E-10	7.30E-01	2.9E-10
TOTAL RISK				7.9E-09

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 6.94E-03
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE R-R
SUMMARY OF CARCINOGENIC RISKS
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	6.2E-08	1.1E-07	4.5E-10	2E-07	6%
Benzo(a)pyrene	7.2E-07	1.3E-06	5.1E-09	2E-06	64%
Benzo(b)fluoranthene	6.6E-08	1.2E-07	4.7E-10	2E-07	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	6.5E-09	1.2E-08	4.6E-11	2E-08	1%
Chrysene	7.3E-10	1.3E-09	5.2E-12	2E-09	0%
Dibenzo(a,h) anthracene	2.2E-07	3.9E-07	1.6E-09	6E-07	20%
Indeno(1,2,3-cd)pyrene	4.1E-08	7.3E-08	2.9E-10	1E-07	4%
TOTAL CANCER RISK	1E-06	2E-06	8E-09	3E-06	100%
Percent Contribution	36%	64%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE H–H
SUMMARY OF HAZARD INDICES
FUTURE CAMPER SCENARIO (CHILDREN)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

Hiker - Adult

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE D–1
AIR CONCENTRATIONS OF CHEMICALS ADHERED ONTO DUSTS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	RME EPC (Cs) (mg/kg)	RME EPC (Cp) (mg/m³)
Semivolatiles		
Benzo(a)anthracene	9.76E–01	8.78E–08
Benzo(a)pyrene	1.12E+00	1.01E–07
Benzo(b)fluoranthene	1.03E+00	9.26E–08
Benzo(g,h,i)perylene	5.86E–01	5.27E–08
Benzo(k)fluoranthene	1.01E+00	9.08E–08
Chrysene	1.14E+00	1.03E–07
Dibenzo(a,h) anthracene	3.40E–01	3.06E–08
Indeno(1,2,3–cd)pyrene	6.37E–01	5.73E–08

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
Cs = Concentration in soil
Cp = Concentration in dust particles = Cs x PC
PC = Particulate Concentration in Air = 9×10^{-8} kg/m^3

TABLE T-T
TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	Inhalation CSF $(mg/kg/day)^{-1}$	Chronic Oral CSF $(mg/kg/day)^{-1}$	Chronic Inhalation RfD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Oral Absorption Fraction	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adjusted Dermal RfD (mg/kg/day)
Semivolatiles							
Benzo(a)anthracene	7.30E-01	7.30E-01	NA	NA	0.84	8.69E-01	NA
Benzo(a)pyrene	7.30E+00	7.30E+00	NA	NA	0.84	8.69E+00	NA
Benzo(b)fluoranthene	7.30E-01	7.30E-01	NA	NA	0.84	8.69E-01	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	0.84	NA	NA
Benzo(k)fluoranthene	7.30E-02	7.30E-02	NA	NA	0.84	8.69E-02	NA
Chrysene	7.30E-03	7.30E-03	NA	NA	0.84	8.69E-03	NA
Dibenzo(a,h) anthracene	7.30E+00	7.30E+00	NA	NA	0.84	8.69E+00	NA
Indeno(1,2,3-cd)pyrene	7.30E-01	7.30E-01	NA	NA	0.84	8.69E-01	NA

COPCs = Chemicals of potential concern
CSF – Cancer Slope Factor
RfD – Reference Dose
Adjusted Dermal CSF = Chronic Oral CSF / Oral Absorption Fraction
Adjusted Dermal RfD = Chronic Oral RfD x Oral Absorption Fraction
NA – No available data

TABLE E–E
EXPOSURE PARAMETERS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

Exposure Parameter	Symbol	Units	Hiker		References
			Adults	Children	
Inhalation Rate – Indoor air	IRa	m^3/hr	3.2	NC	IWP, 1993
Inhalation Rate – outdoor air	IRa	m^3/hr	3.2	NC	IWP, 1993
Soil Ingestion Rate	IGs	mg/day	100	NC	EPA, 1991
Skin Surface Area Exposed	SA	cm^2/day	5000	NC	EPA, 1992
Soil–skin Adherence Factor	SAF	mg/cm^2	1	NC	Assumed
Exposure Time	ET	hr/day	2	NC	IWP, 1993
Exposure Frequency	EF	days/yr	170	NC	IWP, 1993
Exposure Duration	ED	year	9	NC	IWP, 1993
Fraction Ingested, Inhaled or Contacted from Site	FI or FC	unitless	1	NC	Assumed
Conversion Factor	CF	kg/mg	1E–06	NC	Conversion Factor
Body Weight	BW	kg	70	NC	EPA, 1991
Averaging Time – Cancer	ATc	days	25550	NC	365 days/year x 70 years (lifetime)
Averaging Time – NonCancer	ATnc	days	3285	NC	365 days/year x ED

Not calculated
LADD/ADD = Lifetime Average Daily Dose/Average Daily Dose

Inhalation LADD Intake Rate Factors – outdoor air	5.47E–03	NC
Inhalation ADD Intake Rate Factors – outdoor air	4.26E–02	NC
Soil Ingestion LADD Intake Rate Factors	8.55E–08	NC
Soil Ingestion ADD Intake Rate Factors	6.65E–07	NC
Dermal Contact LADD Intake Rate Factors	3.56E–07	NC
Dermal Contact ADD Intake Rate Factors	2.77E–06	NC

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	8.35E-08	7.30E-01	6.1E-08
Benzo(a)pyrene	1.12E+00	9.56E-08	7.30E+00	7.0E-07
Benzo(b)fluoranthene	1.03E+00	8.80E-08	7.30E-01	6.4E-08
Benzo(g,h,i)perylene	5.86E-01	5.01E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	8.63E-08	7.30E-02	6.3E-09
Chrysene	1.14E+00	9.76E-08	7.30E-03	7.1E-10
Dibenzo(a,h) anthracene	3.40E-01	2.91E-08	7.30E+00	2.1E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	5.45E-08	7.30E-01	4.0E-08
TOTAL RISK				1.1E-06

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 8.55E-08
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	6.49E-07	NA	NA
Benzo(a)pyrene	1.12E+00	7.44E-07	NA	NA
Benzo(b)fluoranthene	1.03E+00	6.85E-07	NA	NA
Benzo(g,h,i)perylene	5.86E-01	3.90E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	6.71E-07	NA	NA
Chrysene	1.14E+00	7.59E-07	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	2.26E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	4.24E-07	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 6.65E-07
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	5.22E-08	8.69E-01	4.5E-08
Benzo(a)pyrene	1.12E+00	0.15	5.98E-08	8.69E+00	5.2E-07
Benzo(b)fluoranthene	1.03E+00	0.15	5.50E-08	8.69E-01	4.8E-08
Benzo(g,h,i)perylene	5.86E-01	0.15	3.13E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	5.39E-08	8.69E-02	4.7E-09
Chrysene	1.14E+00	0.15	6.10E-08	8.69E-03	5.3E-10
Dibenzo(a,h) anthracene	3.40E-01	0.15	1.82E-08	8.69E+00	1.6E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	3.41E-08	8.69E-01	3.0E-08
TOTAL RISK					8.1E-07

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 3.56E-07
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Adult HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	4.06E-07	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	4.65E-07	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	4.28E-07	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	2.44E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	4.20E-07	NA	NA
Chrysene	1.14E+00	0.15	4.74E-07	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	1.41E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	2.65E-07	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 2.77E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE R-R
SUMMARY OF CARCINOGENIC RISKS
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	6.1E-08	4.5E-08	3.5E-10	1E-07	6%
Benzo(a)pyrene	7.0E-07	5.2E-07	4.0E-09	1E-06	64%
Benzo(b)fluoranthene	6.4E-08	4.8E-08	3.7E-10	1E-07	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	6.3E-09	4.7E-09	3.6E-11	1E-08	1%
Chrysene	7.1E-10	5.3E-10	4.1E-12	1E-09	0%
Dibenzo(a,h) anthracene	2.1E-07	1.6E-07	1.2E-09	4E-07	20%
Indeno(1,2,3-cd)pyrene	4.0E-08	3.0E-08	2.3E-10	7E-08	4%
TOTAL CANCER RISK	1E-06	8E-07	6E-09	2E-06	100%
Percent Contribution	57%	43%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE H–H
SUMMARY OF HAZARD INDICES
FUTURE HIKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

Construction Worker - Adult

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	2.36E-08	7.30E-01	1.7E-08
Benzo(a)pyrene	1.12E+00	2.70E-08	7.30E+00	2.0E-07
Benzo(b)fluoranthene	1.03E+00	2.49E-08	7.30E-01	1.8E-08
Benzo(g,h,i)perylene	5.86E-01	1.42E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	2.44E-08	7.30E-02	1.8E-09
Chrysene	1.14E+00	2.76E-08	7.30E-03	2.0E-10
Dibenzo(a,h) anthracene	3.40E-01	8.21E-09	7.30E+00	6.0E-08
Indeno(1,2,3-cd)pyrene	6.37E-01	1.54E-08	7.30E-01	1.1E-08
TOTAL RISK				3.1E-07

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 2.42E-08
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	1.65E-06	NA	NA
Benzo(a)pyrene	1.12E+00	1.89E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.74E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	9.91E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	1.71E-06	NA	NA
Chrysene	1.14E+00	1.93E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	5.75E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	1.08E-06	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 1.69E-06
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	2.36E-08	8.69E-01	2.0E-08
Benzo(a)pyrene	1.12E+00	0.15	2.70E-08	8.69E+00	2.3E-07
Benzo(b)fluoranthene	1.03E+00	0.15	2.49E-08	8.69E-01	2.2E-08
Benzo(g,h,i)perylene	5.86E-01	0.15	1.42E-08	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	2.44E-08	8.69E-02	2.1E-09
Chrysene	1.14E+00	0.15	2.76E-08	8.69E-03	2.4E-10
Dibenzo(a,h) anthracene	3.40E-01	0.15	8.21E-09	8.69E+00	7.1E-08
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	1.54E-08	8.69E-01	1.3E-08
TOTAL RISK					3.6E-07

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 1.61E-07
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Adult HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	1.65E-06	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	1.89E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	1.74E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	9.91E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	1.71E-06	NA	NA
Chrysene	1.14E+00	0.15	1.93E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	5.75E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	1.08E-06	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 1.13E-05
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-1
CARCINOGENIC RISKS FROM DUST INHALATION
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m^3)	Adult LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	1.46E-07	2.15E-10	7.30E-01	1.6E-10
Benzo(a)pyrene	1.68E-07	2.46E-10	7.30E+00	1.8E-09
Benzo(b)fluoranthene	1.54E-07	2.27E-10	7.30E-01	1.7E-10
Benzo(g,h,i)perylene	8.79E-08	1.29E-10	NC	NC
Benzo(k)fluoranthene	1.51E-07	2.22E-10	7.30E-02	1.6E-11
Chrysene	1.71E-07	2.51E-10	7.30E-03	1.8E-12
Dibenzo(a,h) anthracene	5.10E-08	7.49E-11	7.30E+00	5.5E-10
Indeno(1,2,3-cd)pyrene	9.56E-08	1.40E-10	7.30E-01	1.0E-10
TOTAL RISK				2.8E-09

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 1.47E-03
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-2
NONCARCINOGENIC HAZARD INDICES FROM DUST INHALATION
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Adult ADD (mg/kg/day)	Inhalation RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	1.46E-07	1.51E-08	NA	NA
Benzo(a)pyrene	1.68E-07	1.72E-08	NA	NA
Benzo(b)fluoranthene	1.54E-07	1.59E-08	NA	NA
Benzo(g,h,i)perylene	8.79E-08	9.04E-09	NA	NA
Benzo(k)fluoranthene	1.51E-07	1.56E-08	NA	NA
Chrysene	1.71E-07	1.76E-08	NA	NA
Dibenzo(a,h) anthracene	5.10E-08	5.25E-09	NA	NA
Indeno(1,2,3-cd)pyrene	9.56E-08	9.83E-09	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cp x ADD Factor
Inhalation Intake Rate ADD Factor = 1.03E-01
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE R–R
SUMMARY OF CARCINOGENIC RISKS
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	1.7E–08	2.0E–08	1.6E–10	4E–08	6%
Benzo(a)pyrene	2.0E–07	2.3E–07	1.8E–09	4E–07	64%
Benzo(b)fluoranthene	1.8E–08	2.2E–08	1.7E–10	4E–08	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	1.8E–09	2.1E–09	1.6E–11	4E–09	1%
Chrysene	2.0E–10	2.4E–10	1.8E–12	4E–10	0%
Dibenzo(a,h) anthracene	6.0E–08	7.1E–08	5.5E–10	1E–07	20%
Indeno(1,2,3–cd)pyrene	1.1E–08	1.3E–08	1.0E–10	2E–08	4%
TOTAL CANCER RISK	3E–07	4E–07	3E–09	7E–07	100%
Percent Contribution	45%	54%	0%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE E–E
EXPOSURE PARAMETERS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

Exposure Parameter	Symbol	Units	Construction Worker		References
			Adults	Children	
Inhalation Rate – indoor air	IRa	m^3/hr	3.65	NC	IWP, 1993
Inhalation Rate – outdoor air	IRa	m^3/hr	3.65	NC	IWP, 1993
Soil Ingestion Rate	IGs	mg/day	480	NC	EPA, 1991
Skin Surface Area Exposed	SA	cm^2/day	3200	NC	EPA, 1992
Soil–skin Adherence Factor	SAF	mg/cm^2	1	NC	Assumed
Exposure Time	ET	hr/day	8	NC	IWP, 1993
Exposure Frequency	EF	days/yr	90	NC	IWP, 1993
Exposure Duration	ED	year	1	NC	IWP, 1993
Fraction Ingested, Inhaled or Contacted from Site	FI or FC	unitless	1	NC	Assumed
Conversion Factor	CF	kg/mg	1E–06	NC	Conversion Factor
Body Weight	BW	kg	70	NC	EPA, 1991
Averaging Time – Cancer	ATc	days	25550	NC	365 days/year x 70 years (lifetime)
Averaging Time – NonCancer	ATnc	days	365	NC	365 days/year x ED

Not calculated
LADD/ADD = Lifetime Average Daily Dose/Average Daily Dose

Inhalation LADD Intake Rate Factors – outdoor air	1.47E–03	NC
Inhalation ADD Intake Rate Factors – outdoor air	1.03E–01	NC
Soil Ingestion LADD Intake Rate Factors	2.42E–08	NC
Soil Ingestion ADD Intake Rate Factors	1.69E–06	NC
Dermal Contact LADD Intake Rate Factors	1.61E–07	NC
Dermal Contact ADD Intake Rate Factors	1.13E–05	NC

TABLE H–H
SUMMARY OF HAZARD INDICES
CONSTRUCTION WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

ong Term Worker - Adult

TABLE C–C
STATISTICAL SUMMARY OF SOIL DATA
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

COPCs	FOD	Minimum Detected Conc.	Maximum Detected Conc.	Arithmetic Mean	95% UCL	Lesser of Max. or 95% UCL
Semivolatiles						
Benzo(a)anthracene	5/26	< 0.33	26.9	0.625	0.976	0.976
Benzo(a)pyrene	6/26	< 0.33	28.8	0.708	1.118	1.118
Benzo(b)fluoranthene	6/26	< 0.33	28.4	0.659	1.029	1.029
Benzo(g,h,i)perylene	4/26	< 0.33	12.6	0.407	0.586	0.586
Benzo(k)fluoranthene	6/26	< 0.33	21.4	0.651	1.009	1.009
Chrysene	6/26	< 0.33	29.2	0.721	1.141	1.141
Dibenzo(a,h) anthracene	1/26	< 0.33	4.7	0.260	0.340	0.340
Indeno(1,2,3–cd)pyrene	5/26	< 0.33	14.3	0.438	0.637	0.637

COPCs = Chemicals of potential concern
FOD = Frequency of detection
Conc. = Concentration
UCL = Upper confidence limit
Max. = Maximum detected concentration
All concentrations are in units of mg/kg.

TABLE E–E
EXPOSURE PARAMETERS
PIPE STORAGE YARD, BUILDING 21
LANL, LOS ALAMOS, NEW MEXICO

Exposure Parameter	Symbol	Units	Long–Term Worker		References
			Adults	Children	
Inhalation Rate – indoor air	IRa	m^3/hr	0.83	NC	EPA, 1991
Inhalation Rate – outdoor air	IRa	m^3/hr	1.70	NC	IWP, 1993
Soil Ingestion Rate	IGs	mg/day	100	NC	EPA, 1991
Skin Surface Area Exposed	SA	cm^2/day	NA	NC	EPA, 1992
Soil–skin Adherence Factor	SAF	mg/cm^2	1	NC	Assumed
Exposure Time	ET	hr/day	8	NC	EPA, 1992
Exposure Frequency	EF	days/yr	250	NC	EPA, 1992
Exposure Duration	ED	year	25	NC	EPA, 1992
Fraction Ingested, Inhaled or Contacted from Site	FI or FC	unitless	1	NC	Assumed
Conversion Factor	CF	kg/mg	1E–06	NC	Conversion Factor
Body Weight	BW	kg	70	NC	EPA, 1991
Averaging Time – Cancer	ATc	days	25550	NC	365 days/year x 70 years (lifetime)
Averaging Time – NonCancer	ATnc	days	9125	NC	365 days/year x ED

Not calculated
LADD/ADD = Lifetime Average Daily Dose/Average Daily Dose

Inhalation LADD Intake Rate Factors – outdoor air	4.75E–02	NC
Inhalation ADD Intake Rate Factors – outdoor air	1.33E–01	NC
Soil Ingestion LADD Intake Rate Factors	3.49E–07	NC
Soil Ingestion ADD Intake Rate Factors	9.78E–07	NC
Dermal Contact LADD Intake Rate Factors	0.00E+00	NC
Dermal Contact ADD Intake Rate Factors	0.00E+00	NC

TABLE I-1
CARCINOGENIC RISKS FROM SOIL INGESTION
LONG-TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult LADD (mg/kg/day)	Oral CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	9.76E-01	3.41E-07	7.30E-01	2.5E-07
Benzo(a)pyrene	1.12E+00	3.91E-07	7.30E+00	2.9E-06
Benzo(b)fluoranthene	1.03E+00	3.60E-07	7.30E-01	2.6E-07
Benzo(g,h,i)perylene	5.86E-01	2.05E-07	NC	NC
Benzo(k)fluoranthene	1.01E+00	3.53E-07	7.30E-02	2.6E-08
Chrysene	1.14E+00	3.99E-07	7.30E-03	2.9E-09
Dibenzo(a,h) anthracene	3.40E-01	1.19E-07	7.30E+00	8.7E-07
Indeno(1,2,3-cd)pyrene	6.37E-01	2.23E-07	7.30E-01	1.6E-07
TOTAL RISK				4.4E-06

COPCs = Chemicals of potential concern
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration in soil
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Soil Ingestion Intake Rate LADD Factor = 3.49E-07
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE I-2
NONCARCINOGENIC RISKS FROM SOIL INGESTION
LONG-TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Adult ADD (mg/kg/day)	Chronic Oral RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	9.76E-01	9.55E-07	NA	NA
Benzo(a)pyrene	1.12E+00	1.09E-06	NA	NA
Benzo(b)fluoranthene	1.03E+00	1.01E-06	NA	NA
Benzo(g,h,i)perylene	5.86E-01	5.73E-07	NA	NA
Benzo(k)fluoranthene	1.01E+00	9.87E-07	NA	NA
Chrysene	1.14E+00	1.12E-06	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	3.33E-07	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	6.23E-07	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Soil Ingestion Intake Rate ADD Factor = 9.78E-07
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE D-1
CARCINOGENIC RISKS FROM DERMAL CONTACT
LONG-TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult LADD (mg/kg/day)	Adjusted Dermal CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	0.00E+00	8.69E-01	0.0E+00
Benzo(a)pyrene	1.12E+00	0.15	0.00E+00	8.69E+00	0.0E+00
Benzo(b)fluoranthene	1.03E+00	0.15	0.00E+00	8.69E-01	0.0E+00
Benzo(g,h,i)perylene	5.86E-01	0.15	0.00E+00	NC	NC
Benzo(k)fluoranthene	1.01E+00	0.15	0.00E+00	8.69E-02	0.0E+00
Chrysene	1.14E+00	0.15	0.00E+00	8.69E-03	0.0E+00
Dibenzo(a,h) anthracene	3.40E-01	0.15	0.00E+00	8.69E+00	0.0E+00
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	0.00E+00	8.69E-01	0.0E+00
TOTAL RISK					0.0E+00

AF = Aderence Factor
RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cs x LADD Factor
Dermal Contact Intake Rate LADD Factor = 0.00E+00
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE D-2
NONCARCINOGENIC RISKS FROM DERMAL CONTACT
LONG-TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cs) (mg/kg)	Dermal AF (unitless)	Adult ADD (mg/kg/day)	Adjusted Dermal RfD (mg/kg/day)	Adult HQ
Semivolatiles					
Benzo(a)anthracene	9.76E-01	0.15	0.00E+00	NA	NA
Benzo(a)pyrene	1.12E+00	0.15	0.00E+00	NA	NA
Benzo(b)fluoranthene	1.03E+00	0.15	0.00E+00	NA	NA
Benzo(g,h,i)perylene	5.86E-01	0.15	0.00E+00	NA	NA
Benzo(k)fluoranthene	1.01E+00	0.15	0.00E+00	NA	NA
Chrysene	1.14E+00	0.15	0.00E+00	NA	NA
Dibenzo(a,h) anthracene	3.40E-01	0.15	0.00E+00	NA	NA
Indeno(1,2,3-cd)pyrene	6.37E-01	0.15	0.00E+00	NA	NA
TOTAL HAZARD INDEX					0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cs x ADD Factor
Dermal Contact Intake Rate ADD Factor = 0.00E+00
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST-1
CARCINOGENIC RISKS FROM DUST INHALATION
LONG-TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m^3)	Adult LADD (mg/kg/day)	Inhalation CSF $(mg/kg/day)^{-1}$	Adult Cancer Risk
Semivolatiles				
Benzo(a)anthracene	8.78E-08	4.17E-09	7.30E-01	3.0E-09
Benzo(a)pyrene	1.01E-07	4.78E-09	7.30E+00	3.5E-08
Benzo(b)fluoranthene	9.26E-08	4.40E-09	7.30E-01	3.2E-09
Benzo(g,h,i)perylene	5.27E-08	2.51E-09	NC	NC
Benzo(k)fluoranthene	9.08E-08	4.32E-09	7.30E-02	3.2E-10
Chrysene	1.03E-07	4.88E-09	7.30E-03	3.6E-11
Dibenzo(a,h) anthracene	3.06E-08	1.45E-09	7.30E+00	1.1E-08
Indeno(1,2,3-cd)pyrene	5.73E-08	2.72E-09	7.30E-01	2.0E-09
TOTAL RISK				5.4E-08

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
LADD = Lifetime Average Daily Dose = Cp x LADD Factor
Inhalation Intake Rate LADD Factor = 4.75E-02
CSF = Carcinogenic Slope Factor
NC = Noncarcinogen
NA = Not Applicable

TABLE DUST–2
NONCARCINOGENIC HAZARD INDICES FROM DUST INHALATION
LONG–TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	RME EPC (Cp) (mg/m³)	Adult ADD (mg/kg/day)	Inhalation RfD (mg/kg/day)	Adult HQ
Semivolatiles				
Benzo(a)anthracene	8.78E–08	1.17E–08	NA	NA
Benzo(a)pyrene	1.01E–07	1.34E–08	NA	NA
Benzo(b)fluoranthene	9.26E–08	1.23E–08	NA	NA
Benzo(g,h,i)perylene	5.27E–08	7.02E–09	NA	NA
Benzo(k)fluoranthene	9.08E–08	1.21E–08	NA	NA
Chrysene	1.03E–07	1.37E–08	NA	NA
Dibenzo(a,h) anthracene	3.06E–08	4.07E–09	NA	NA
Indeno(1,2,3–cd)pyrene	5.73E–08	7.63E–09	NA	NA
TOTAL HAZARD INDEX				0.0E+00

RME EPC = Reasonable Maximum Exposure Exposure Point Concentration
ADD = Average Daily Dose = Cp x ADD Factor
Inhalation Intake Rate ADD Factor = 1.33E–01
RfD = Reference Dose
HQ = Hazard Quotient
NC = Noncarcinogen
NA = Not Applicable

TABLE R–R
SUMMARY OF CARCINOGENIC RISKS
LONG–TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL CANCER RISK	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	2.5E–07	0.0E+00	3.0E–09	3E–07	6%
Benzo(a)pyrene	2.9E–06	0.0E+00	3.5E–08	3E–06	64%
Benzo(b)fluoranthene	2.6E–07	0.0E+00	3.2E–09	3E–07	6%
Benzo(g,h,i)perylene	NC	NC	NC	NA	0%
Benzo(k)fluoranthene	2.6E–08	0.0E+00	3.2E–10	3E–08	1%
Chrysene	2.9E–09	0.0E+00	3.6E–11	3E–09	0%
Dibenzo(a,h) anthracene	8.7E–07	0.0E+00	1.1E–08	9E–07	20%
Indeno(1,2,3–cd)pyrene	1.6E–07	0.0E+00	2.0E–09	2E–07	4%
TOTAL CANCER RISK	4E–06	0E+00	5E–08	4E–06	100%
Percent Contribution	99%	0%	1%	100%	

COPCS = Chemicals of potential concern
NC = Noncarcinogen
NA = Not Available

TABLE H–H
SUMMARY OF HAZARD INDICES
LONG–TERM WORKER SCENARIO (ADULTS)
PIPE STORAGE YARD, BUILDING 21

COPCs	Soil Ingestion	Dermal Contact	Inhalation of Dusts	TOTAL HAZARD INDEX	Percent Contribution
Semivolatiles					
Benzo(a)anthracene	NA	NA	NA	NA	ERR
Benzo(a)pyrene	NA	NA	NA	NA	ERR
Benzo(b)fluoranthene	NA	NA	NA	NA	ERR
Benzo(g,h,i)perylene	NA	NA	NA	NA	ERR
Benzo(k)fluoranthene	NA	NA	NA	NA	ERR
Chrysene	NA	NA	NA	NA	ERR
Dibenzo(a,h) anthracene	NA	NA	NA	NA	ERR
Indeno(1,2,3–cd)pyrene	NA	NA	NA	NA	ERR
HAZARD INDEX	0E+00	0E+00	0E+00	0E+00	ERR
Percent Contribution	ERR	ERR	ERR	ERR	

COPCs = Chemicals of potential concern
NA = Not Available

Attachment 6-4

Bradley et al., 1994. Background level of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils

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Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils

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ABSTRACT: Polycyclic aromatic hydrocarbons (PAH) are byproducts of combustion and are ubiquitous in the urban environment. They are also present in industrial chemical wastes, such as coal tar, petroleum refinery sludges, waste oils and fuels, and wood-treating residues. Thus, PAHs are chemicals of concern at many waste sites. Risk assessment methods will yield risk-based cleanup levels for PAHs that range from 0.1 to 0.7 mg/kg. Given their universal presence in the urban environment, it is important to compare risk-based cleanup levels with typical urban background levels before utilizing unrealistically low cleanup targets. However, little data exist on PAH levels in urban, nonindustrial soils. In this study, 60 samples of surficial soils from urban locations in three New England cities were analyzed for PAH compounds. In addition, all samples were analyzed for total petroleum hydrocarbons (TPH) and seven metals. The upper 95% confidence interval on the mean was 3 mg/kg for benzo(*a*)pyrene toxic equivalents, 12 mg/kg for total potentially carcinogenic PAH, and 25 mg/kg for total PAH. The upper 95% confidence interval was 373 mg/kg for TPH, which exceeds the target level of 100 mg/kg used by many state regulatory agencies. Metal concentrations were similar to published background levels for all metals except lead. The upper 95% confidence interval for lead was 737 mg/kg in Boston, 463 mg/kg in Providence, and 378 mg/kg in Springfield.

KEY WORDS: background, PAH, metals, urban, anthropogenic, soil.

I. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are byproducts of combustion and are naturally occurring chemicals in the environment. Forest fires and volcanoes are major natural sources of PAHs, but there are anthropogenic sources as well due to burning of fossil fuels, including automobile and industrial emissions. PAHs are chemicals of concern in many waste site investigations that are undertaken pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), and state

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hazardous waste programs. Risk assessments performed according to federal guidance for former manufactured gas plant sites, wood treating facilities, petroleum refineries, and other sites generally conclude that PAHs pose unreasonable risks to human health and that remedial actions must be taken to reduce risks to acceptable levels. The majority of the risk posed by PAHs is generally due to benzo(*a*)pyrene and the other PAHs that have been shown to cause cancer in laboratory animals after repeated dosings. The U.S. EPA (1993a) currently identifies seven PAHs as "probable human (B2) carcinogens": benzo(*a*)pyrene, benzo(*a*)anthracene, benzo(*b*)fluoranthene, benzo(*k*)fluoranthene, chrysene, dibenz(*a,h*)anthracene, and indeno(1,2,3-c,d)pyrene.

Because of the very health-protective assumptions used in regulatory risk assessments, very low risk-based clean-up levels for PAHs are derived for such sites. In Michigan, residential soil cleanup levels of 0.33 mg/kg for each carcinogenic PAH have been set (MDNR, 1993). In New Jersey, proposed residential soil cleanup levels are 0.66 mg/kg for benzo(*a*)pyrene (New Jersey *Register*, 1992). The use of standard CERCLA risk assessment guidance (U.S. EPA, 1993b) results in the derivation of a risk-based cleanup level for benzo(*a*)pyrene of 0.1 mg/kg.

All of these risk-based soil cleanup levels are below the urban, nonindustrial background soil concentrations presently reported in the literature. However, the availability of such data is very limited. Blumer (1961) reports that benzo(*a*)pyrene concentrations in Cape Cod, MA, soils range from 0.04 to 1.3 mg/kg. Menzie et al. (1992) report that urban background soil levels of total carcinogenic PAH range from 0.06 to 5.8 mg/kg. Butler et al. (1984) report that total PAH levels in soils alongside roadways in England range from 4 to 20 mg/kg, and potentially carcinogenic PAH range from 0.8 to 11.5 mg/kg. Blumer et al. (1977) report that total PAH levels in soils in a Swiss town range from 6 to 300 mg/kg.

It is very difficult to compare the data from these studies to the results of site risk assessments due to the limited dataset and the nonuniformity of the PAH compounds evaluated. Clearly, more data are required from nonindustrial urban locations to define the urban background level for PAH and to critically evaluate the role of risk assessment in setting remedial goals for PAH in soils. Accordingly, we have collected 60 samples of surficial soils from urban locations in three New England cities and analyzed them for all 17 PAH compounds present on the EPA's Target Compound List, which is used in the Superfund program. In addition, all samples were analyzed for total petroleum hydrocarbons (TPH) and for seven metals: arsenic, barium, cadmium, chromium, lead, mercury, and selenium.

II. METHODS

A. Sample Collection

Samples of surficial soils from urban locations in three New England cities were collected: Boston, MA; Providence, RI; and Springfield, MA. Twenty independent

samples and duplicates of two samples were collected in each city. The samples were collected on July 21, 22, and 23, 1992, respectively. The samples were taken at a depth of 0 to 6 in. in areas considered to be not directly affected by industrial sites. Generally, the locations were along roads and sidewalks, and in parks and open lots. Each location was characterized in writing, including a soil description, and photographically documented. The samples were collected following standard environmental sampling protocols (U.S. EPA, 1986).

B. Sample Analysis

Chemical analysis of the samples was performed by AnalytiKEM, Inc. (Cherry Hill, NJ). The samples were analyzed by GC-MS for the 17 PAH compounds present on the EPA's Target Compound List using the methods required by EPA Method 8270 for the analysis of semivolatile compounds. In addition, the samples were analyzed for the eight RCRA metals, total petroleum hydrocarbons (TPH; EPA Method 418.1), and total solids. The complete analyte list is given in Table 1.

C. Data Validation

Validation of the data received from AnalytiKEM was performed according to U.S. EPA (1991) guidelines. The data were reviewed for completeness, holding times, GC-MS tuning and system performance, initial and continuing calibrations, laboratory method blank analysis, surrogate recoveries, matrix spike and matrix spike duplicate analysis, field duplication precision, and compound quantitation and detection limits.

D. Data Analysis

The analytical data were summarized in accordance with U.S. EPA (1989) risk assessment guidance. If a compound was detected at least once in surface soil, one half the sample quantitation limit (SQL) was used as a proxy concentration for all samples reported as "below detection limit" in the estimation of exposure point concentrations. However, if a compound was not detected in any sample, that compound was omitted from further consideration. In addition, when a proxy concentration (i.e., one half the detection limit) was greater than the highest actual detected value for a compound in any sample, that concentration was considered to be an aberration and was omitted from the database. This is consistent with U.S. EPA (1989) guidance, which recognizes that high sample quantitation limits can lead to unrealistic concentration estimates.

TABLE 1
Chemical Analyses of Urban Soils

Semivolatile Organics, EPA Target Compound List
Naphthalene
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo(*a*)anthracene
Chrysene
Benzo(*b*)fluoranthene
Benzo(*k*)fluoranthene
Benzo(*a*)pyrene
Indeno(1,2,3-*cd*)pyrene
Dibenzo(*a,h*)anthracene
Benzo(*g,h,i*)perylene
2-Methylnaphthalene
Metals
Arsenic, total
Barium, total
Cadmium, total
Chromium, total
Lead, total
Mercury, total
Selenium, total
Silver, total
Other
Total petroleum hydrocarbons
Solids

A slightly different method of analysis was used to evaluate PAH. Because PAH are generally found in groups, it was conservatively assumed that if one PAH was detected in a sample, other compounds in that class might also be present in that sample. Therefore, if one PAH was detected in a sample, all undetected PAH were assigned a proxy concentration equal to one half the SQL. If a sample had no detected PAH, no PAH were assumed to be present in the sample, and a concentration of zero was used for all nondetects.

Summary statistics (minimum, maximum, arithmetic mean, upper 95% confidence limit on the arithmetic mean, and frequency of detection) were generated for each compound for each city and for all three cities combined.

The data for PAH were summarized in several different ways. Of the 17 PAH analyzed in each sample, seven are considered to be probable human carcinogens (Group B2) by the U.S. EPA (1993a). The U.S. EPA has derived a cancer slope factor, which is a measure of the carcinogenic potency of a compound, only for benzo(*a*)pyrene (B(*a*)P) (U.S. EPA, 1993a). Review of the literature indicates that not all PAH are equally potent with respect to tumor induction. Several researchers have proposed toxic equivalency schemes that relate the tumorigenic potency of each PAH to that of B(*a*)P (ICF-Clement Associates, 1988; Woo, 1989). B(*a*)P toxic equivalency factors (B(*a*)P-TEFs) can be used to adjust either the B(*a*)P dose-response value to provide a compound-specific dose-response value, or the concentration of each PAH in a sample to be expressed in terms of B(*a*)P toxic equivalents (B(*a*)P-TE). The latter method was used here. B(*a*)P-TE were calculated using the B(*a*)P toxic equivalency factors recommended for use by the U.S. EPA (1993c), as shown in Table 2. For each sample, PAH concentrations were reported for each of the 17 PAH on the analyte list, for total PAH (tPAH), for total carcinogenic PAH (cPAH), and for B(*a*)P-TE, and these values were used to generate the summary statistics for each group of samples.

III. RESULTS

Analysis of the laboratory results for the PAH indicates that quality control criteria were acceptable. The data were analyzed to determine if any statistically significant differences existed between the datasets for the three cities. A Hartley test for homogeneity of variances (Mendenhall, 1979) and a one-factor analysis of variance to test for equality of the means (Mendenhall, 1979) indicated no statistically significant differences. The results indicate that the PAH data can be pooled and treated as one dataset for further statistical analyses.

TABLE 2
Benzo(*a*)Pyrene Toxic Equivalent Factors (BAP-TEF)

Compound	EPA TEF
Benzo(*a*)pyrene	1.0
Benz(*a*)anthracene	0.1
Benzo(*b*)fluoranthene	0.1
Benzo(*k*)fluoranthene	0.1
Chrysene	0.001
Dibenzo(*a,h*)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

The results of the PAH analyses are presented in Table 3 for all cities combined. A summary of the PAH results by city and for all cities combined is presented in Table 4, which reports for each: tPAH, total cPAH, and total B(*a*)P-TE. The arithmetic mean and the upper 95% confidence limit concentration are reported for each. Table 4 provides a summary of the data by city, and the results are graphically presented in Figure 1.

Table 5 presents a summary of the metals, TPH, and solids data by city. A Hartley test for homogeneity of variances and a one-factor analysis of variance to test for equality of the means indicated that the metals and TPH data from the three cities cannot be combined. This is due to the fact that the concentrations in each city are not normally distributed and did not have equal variances. The concentrations of the metals are compared to the arithmetic mean concentrations in the eastern U.S. (ATSDR, 1992) in Table 5. Most notably, lead concentrations are much higher than background concentrations. This is most likely due to the effects of automobile exhaust.

In order to determine if sample location significantly affected PAH concentration results, individual samples were classified based on the sample location's

TABLE 3
Summary Statistics for PAH — All Areas Combined

Compound	Minimum detect (mg/kg)	Maximum detect (mg/kg)	Arithmetic mean	Upper 95% interval (mg/kg)	Frequency of detection[a]	
2-Methylnaphthalene	0.017	0.64	0.151	0.173	19	62
Acenaphthene	0.024	0.34	0.201	0.306	30	62
Acenaphthylene	0.018	1.10	0.173	0.208	24	62
Anthracene	0.029	5.70	0.351	0.535	54	62
Benzo(*a*)anthracene	0.048	15.00	1.319	1.858	58	62
Benzo(*a*)pyrene	0.040	13.00	1.323	1.816	57	62
Benzo(*b*)fluoranthene	0.049	12.00	1.435	1.973	55	62
Benzo(*g,h,i*)perylene	0.200	5.90	0.891	1.195	36	62
Benzo(*k*)fluoranthene	0.043	25.00	1.681	2.522	59	62
Chrysene	0.038	21.00	1.841	2.693	60	62
Dibenzo(*a,h*)anthracene	0.020	2.90	0.388	0.521	32	62
Fluoranthene	0.110	39.00	3.047	4.444	60	62
Fluorene	0.022	3.30	0.214	0.317	35	62
Indeno(1,2,3-c,d)pyrene	0.093	6.00	0.987	1.293	43	62
Naphthalene	0.018	0.66	0.125	0.149	35	62
Phenanthrene	0.071	36.00	1.838	2.982	61	62
Pyrene	0.082	11.00	2.398	2.945	61	62
Total BAP-TE	0.257	21.31	2.437	3.324	62	62
Total carcinogenic PAH	0.680	77.70	8.973	12.423	62	62
Total PAH	2.292	166.65	18.361	24.819	62	62

[a] Frequency of detection = number detected: number samples.

TABLE 4
Background PAH Concentrations in Urban Surface Soils[a]

Compound	Boston (n = 20)		Providence (n = 20)		Springfield (n = 20)		All cities (n = 60)	
	Arithmetic mean (ppm)	Upper 95% CI (ppm)	Arithmetic mean (ppm)	Upper 95% CI (ppm)	Arithmetic mean (ppm)	Upper 95% CI (ppm)	Arithmetic mean (ppm)	Upper 95% CI (ppm)
Total B(*a*)P-TE	2.4	4.6	2.1	2.9	2.8	4.5	2.4	3.3
Total cPAH	8.4	16.0	7.8	11.0	10.6	18.3	9.0	12.4
Total PAH	18.7	35.9	16.8	23.5	19.1	29.9	18.4	24.8
TPH	474.9	652.6	267.4	338.2	184.4	233.3	306.2	372.8

[a] 0 to 6 in.

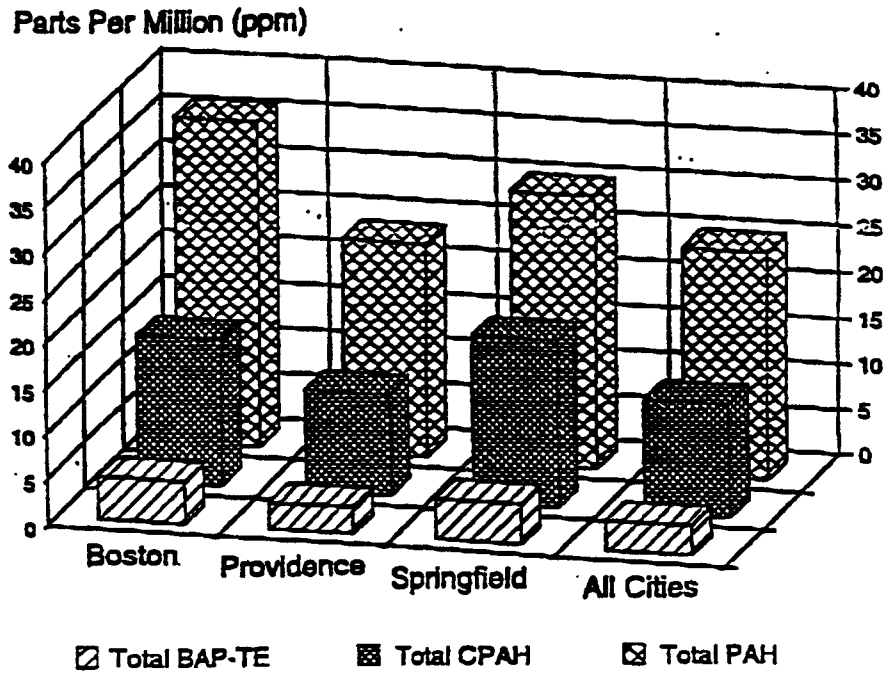

FIGURE 1. Background concentrations of PAH in urban soils. Data presented are the upper 95% confidence interval on the arithmetic mean. Data are presented numerically in Table 4.

proximity to asphalt pavement, based on both written and photographic documentation of sample location. Generally, samples collected within 4 to 6 ft of a road were considered to be near pavement. Of the 60 separate locations, 42 were considered to be near pavement and 18 were not. When tested for equality of variance and means as above, the two populations were determined to be significantly different. The mean total PAH concentration near pavement was 22 ppm compared to 8 ppm not near pavement. These results are shown in Table 6.

Similar analyses were performed to see if TPH or total organic carbon concentrations could be used as surrogates for PAH concentrations. The results showed that there is no correlation between PAH and TPH concentrations, nor between PAH and total organic carbon concentrations (data not shown).

The highest total PAH concentration detected was 166 mg/kg, taken from a street corner in Boston. The next highest PAH concentration was 109 mg/kg, taken at the base of a telephone pole. Four of the 60 samples were taken at the bases of telephone poles, with widely varying results. The total PAH concentrations in the other three locations were 62, 4, and 45 mg/kg.

TABLE 5
Summary Statistics for Metals, TPH, and Soils by City

Compound	Boston (n = 20) Arithmetic mean (mg/kg)	Boston (n = 20) Upper 95% interval (mg/kg)	Providence (n = 20) Arithmetic mean (mg/kg)	Providence (n = 20) Upper 95% interval (mg/kg)	Springfield (n = 20) Arithmetic mean (mg/kg)	Springfield (n = 20) Upper 95% interval (mg/kg)	Arithmetic mean in U.S. soils[a] (mg/kg)
Arsenic, total	4.20	5.59	3.53	4.27	5.63	9.23	7.4
Barium, total	53.95	66.25	45.29	59.43	45.17	51.03	420
Cadmium, total	1.55	2.79	ND	ND	ND	ND	0.25[b]
Chromium, total	23.00	27.69	12.08	14.35	12.62	14.45	52
Lead, total	398.70	737.44	305.76	462.98	261.69	377.76	17
Mercury, total	0.29	0.39	0.19	0.24	0.20	0.25	0.12
Selenium, total	0.51	0.57	0.39	0.48	0.53	0.55	0.45
Total petroleum hydrocarbons	474.90	652.62	267.43	338.19	184.38	233.27	—
Total solids	90%	93%	93%	95%	90%	92%	—

[a] ATSDR. 1992. *Public Health Assessment Guidance Manual.* PB92-147164. U.S. Department of Health and Human Services.
[b] ATSDR. 1991. *Toxicological Profile for Cadmium.* PB92-147164. Draft. U.S. Department of Health and Human Services.

TABLE 6
Comparison of Background PAH Concentrations in Urban Soils: The Effects of Proximity to Pavement

					Results of statistical analysis					
					Test for homogeneity of variances			Test of equality of means		
	Near pavement		Not near pavement							
Compound	Arithmetic mean (ppm)	Standard deviation	Arithmetic mean (ppm)	Standard deviation	Sample F-statistics	Associated degrees of freedom	Statistically significant at 0.05 level of significance	Sample Student's t	Associated degrees of freedom	Statistically significant at 0.05 level of significance
Total B(a)P-TB	2.9	4.2	1.1	0.92	21.3	41, 17	Yes	2.69	50	Yes
Total PAH	21.9	30.7	8.3	7.2	18.4	41, 17	Yes	2.69	50	Yes

IV. CONCLUSION

In this study, 20 surface soil samples were collected from each of three New England cities and analyzed for PAH, TPH, and metals. The results of the statistical analyses described in the previous section show that, with respect to PAH, the three datasets are not significantly different and can be considered as one dataset representative of urban environments. The samples were taken in typical urban areas but not near known industrial sites. Therefore, these data are considered to be representative of the generalized effects of urban activities.

It is clear from the results presented here that common regulatory target cleanup levels for cPAH and B(*a*)P-TE (0.1 to 0.66 mg/kg) are much below the background concentrations of these compounds in urban surface soils (upper 95% confidence interval of 3.3 and 12.4 mg/kg for total B(*a*)P-TE and total cPAH, respectively). Figure 2 graphically compares the "bright line" target cleanup level for B(*a*)P of 0.1 mg/kg with the total B(*a*)P-TE (upper 95% confidence interval on the arithmetic mean) measured in urban environments.

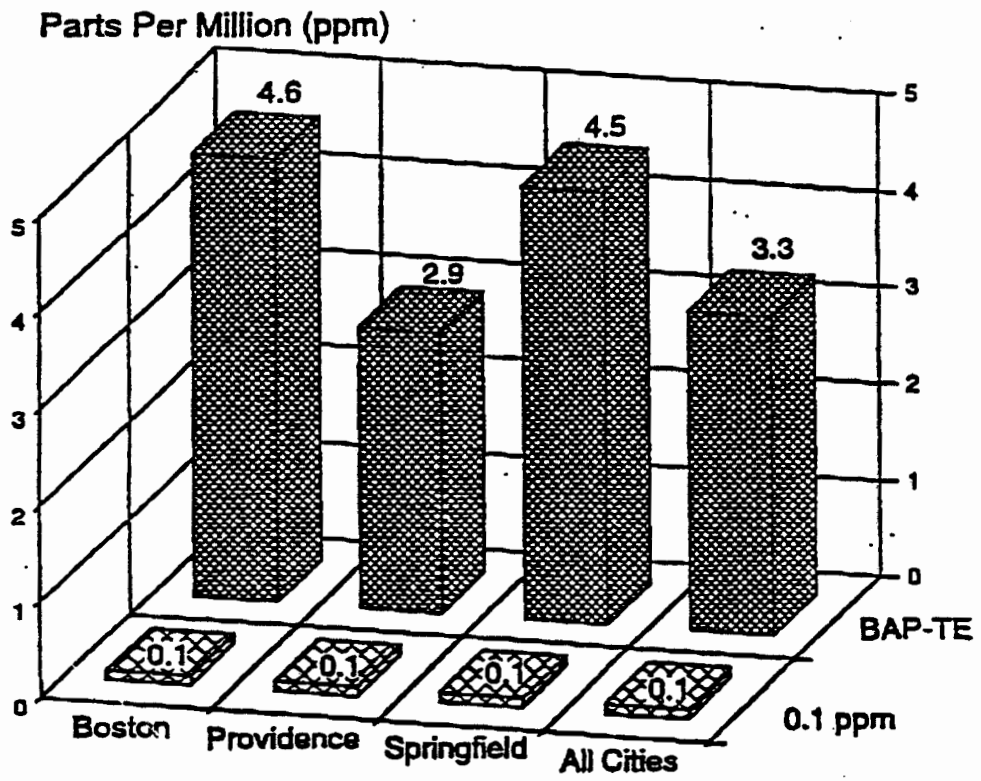

FIGURE 2. Comparison of B(*a*)P-TE with U.S. EPA Region III[4] risk-based concentration for B(*a*)P. B(*a*)P data presented are the upper 95% confidence interval on the arithmetic mean.

Upper 95% confidence intervals are compared because this is the statistic preferred by EPA and many states for risk assessment. Moreover, the State of Massachusetts defines its background concentrations of metals based on the upper 95% confidence limit on the arithmetic mean concentration (Massachusetts Department of Environmental Protection, 1992). For all cities combined, the background level of B(*a*)P-TE of 3.3 mg/kg is approximately ten times greater than the target cleanup level of 0.33 mg/kg and approximately 30 times higher than the target cleanup level of 0.1 mg/kg. For those regulatory situations in which the use of B(*a*)P-TEFs in determining site risk is not allowed, the background level of cPAH is approximately 40 to 100 times greater than these target cleanup levels.

An analysis of the data comparing samples taken near pavement with those determined to be not near pavement indicated that those samples designated near pavement had significantly higher, approximately threefold higher, PAH concentrations for both total PAH and total B(*a*)P-TE. This is most likely due to the presence of diesel and automobile exhaust particles, perhaps influenced by the presence of asphalt and runoff of vehicular oil from the roads.

Total petroleum hydrocarbons (TPH) were also found at consistently high levels in each city. The commonly applied regulatory cleanup level for TPH is 100 mg/kg. This cleanup level is not risk based and is three times lower than the background concentration of TPH found in this study (arithmetic mean of 306 mg/kg and upper 95% confidence interval on the mean of 373 mg/kg).

It is incumbent upon the regulatory agencies to recognize that substantial background levels of PAH and TPH exist in our urban environments and to acknowledge this information in the development of realistic target cleanup levels. The use of these background data in setting more realistic target cleanup levels may result in better allocation of remedial and regulatory dollars in site investigations.

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