143572
M-594

Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for Maywood, New Jersey

U.S. Department of Energy

0489-0613.1

143572 96-322

Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—8723

June 25, 1996

Ms. Angela Carpenter
Federal Facilities Section
U.S. Environmental Protection Agency, Region II
290 Broadway
New York, New York 10007-1866

Dear Ms. Carpenter:

MAYWOOD SITE - PROPOSED USE OF SUPPLEMENTAL STANDARDS AT LODI PARK

As you know, cleanup of the Maywood Phase I vicinity properties is underway and because of smaller volumes than anticipated, on the first five properties that have been remediated, we have been able to accelerate the cleanup of some of the properties. One of these is Lodi Municipal Park which is located at Redstone Lane and Long Valley Road in Lodi. Lodi Park contains several mature trees that act as an important natural element for both the park and the residential properties surrounding the park. Therefore, DOE is proposing the use of supplemental standards for radiological material that is beneath the mature trees. Project representatives have met with the Borough of Lodi Manager, Mr. Joe Dominic, to explain that DOE is presenting a hazard assessment to EPA, and he expressed a desire to keep the trees, if at all possible.

To support the use of supplemental criteria I am enclosing the required hazard assessment (Attachment A). The scenarios are modeled using RESRAD Version 5.61 to obtain dose and risk information. Attachment B contains a summary of additional sampling data for this area that was collected in May 1996. Attachment C presents supporting documentation for the statistical analysis of data outlined in Attachment A.

The enclosed hazard assessment incorporates the changes that you suggested in you letters dated January 24, 1996 and May 29, 1996. Specifically, our analysis includes a drinking water pathway, uses the $UCL_{0.95}$ instead of the arithmetic mean activity concentration values, includes a future use scenario which evaluates soil disturbance, and removes surface contamination wherever possible. The 95% upper confidence level of the mean activity concentration values are used throughout the final dose analysis. A future worker scenario has been included, evaluating the dose to a worker who cuts down and removes the trees. The future resident scenario includes a drinking water and a produce ingestion (garden) pathway. A cover layer of 0.3 m of clean soil is included throughout the analysis.

The maximum dose to current park users from the area of interest is 0.2 mrem/yr. The excess cancer risk is estimated to be 1.7×10^{-6}. The future one-time dose to a worker cutting down the trees is estimated to be 0.03 mrem with an incremental cancer risk of 1.6×10^{-7}. The maximum dose to a future resident (including drinking water and produce ingestion pathways) is estimated to be 5 mrem/yr with an excess cancer risk of 2.6×10^{-5}. The maximum dose results for all three scenarios are below the EPA proposed guideline of 15 mrem/yr and the DOE guideline of 100 mrem/yr. Also, the maximum excess cancer risks are all within the EPA target risk range of 10^{-6} to 10^{-4}.

At this time, I am requesting your approval to establish supplemental criteria for this area at the existing radionuclide activity concentration values. As we have discussed, the application of supplemental criteria is considered an acceptable approach and has been implemented at a number of sites by both DOE and EPA. Their use is explicitly provided for under DOE directives (DOE Order 5400.5 and proposed 10 CFR 834 regulations) and EPA regulations pertaining to residual radioactive materials similar to those at the Maywood site (40 CFR 192).

If you have any questions or would like to discuss the enclosed information in greater detail please call me at (423) 576-5724.

Sincerely,

A M. Cange

Susan M. Cange, Site Manager
Former Sites Restoration Division

Enclosure

cc: Joe Dominic, Borough of Lodi
Nick Marton, NJDEP
Alexander Williams, DOE-HQ

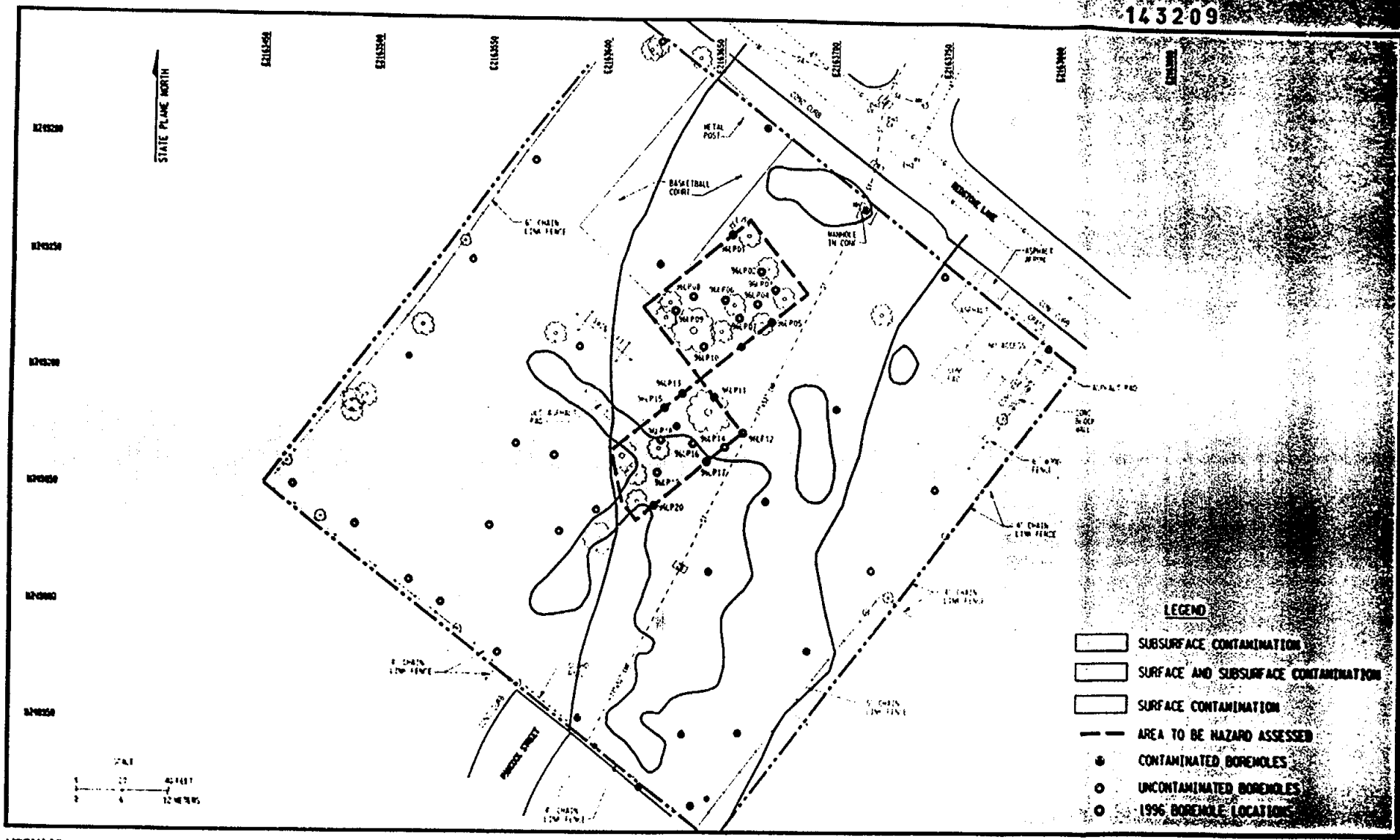

Figure 1
Lodi Park
Hazard Assessment

ATTACHMENT A

LODI PARK
HAZARD ASSESSMENT

LODI PARK
HAZARD ASSESSMENT

A.1. Introduction

This analysis presents estimates of incremental doses and cancer risks to current and potential receptors at Lodi Park (Figure 1). An area of mature trees is present along the center of the property (Figure 2). This area of trees acts as an important natural element for both the park and the residences surrounding the park. Residual radioactive material above criteria is present in this area ranging from approximately 0.3 m to approximately 1 m in depth. The surface contamination shown on Figures 1 and 2 will be removed when the remainder of the property is remediated. Recent data indicates an average depth of 0.7 m and an areal extent of 378 m^2. The area for which supplemental criteria will be developed is shown with a blue line on both Figure 1 and Figure 2. The additional areas and the surface contamination will be remediated in 1996.

The risk estimates for these properties have been computed using RESRAD Version 5.61 computer code (Yu et. al. 1993a) which has been developed to implement the DOE guidelines for residual radioactive material as specified in DOE Order 5400.5 (DOE 1990).

Exposure assumptions for the residual risk analysis were selected to maintain consistency with those previously used in the *Baseline Risk Assessment for the Maywood Site* (DOE 1993) and the DOE statement of position regarding the dispute on cleanup criteria (Price 1993). Key exposure parameter assumptions are presented within each scenario discussion (current park user, future worker, future resident). Parameter values assumed for site-specific geotechnical characteristics are summarized in Table A-1. The unsaturated zone thickness is assumed to be 0 m based on recent data that indicates that the groundwater table is high in this area and is in contact with the contaminated zone.

Estimates of residual dose and risk are presented out to a period of 1000 years (except for the future worker scenario which is a one-time exposure). The 1000-year period was selected as a reasonable maximum time horizon, as predictions at longer times become increasingly uncertain.

A.2. Determination of the 95% Upper Confidence Level of the Mean Activity Concentration Values

In "Supplemental Guidance to RAGS (Risk Assessment Guidance for Superfund): Calculating the Concentration Term", the EPA describes its rationale behind the use of and provides examples of how to calculate the 95% UCL of the mean (EPA 1992b). The 95% UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95% of the time. The 95% UCL therefore accounts for uncertainties due to limited sampling data. As the quantity of sampling data increases, uncertainties decrease, and the UCL moves closer to the true mean. Historical sampling data from Superfund sites have shown that

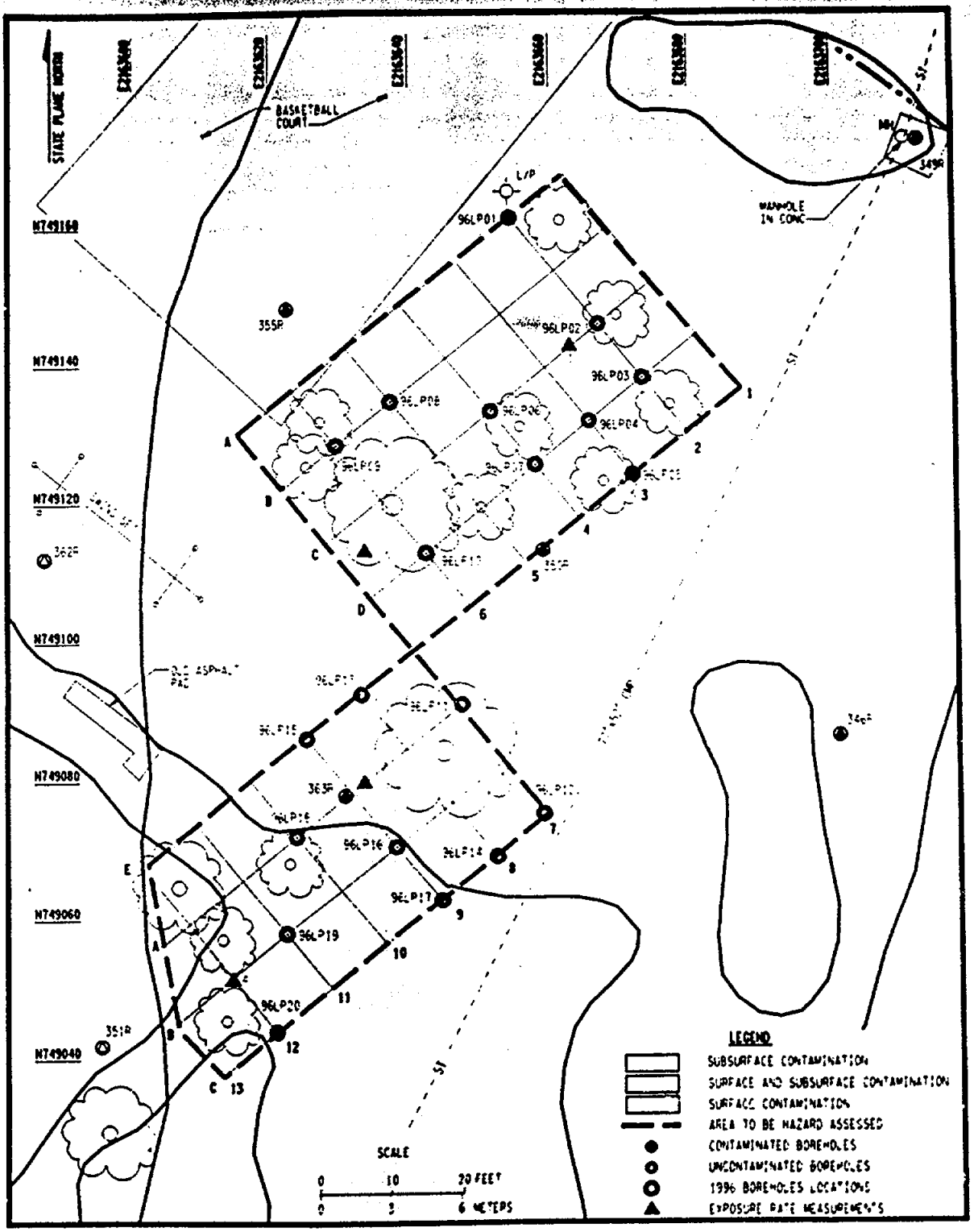

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Figure 2
Lodi Park
Hazard Assessment Detail

Table A-1. Geotechnical Parameter Assumptions.

Parameter	Assumed Value
Contaminated zone total porosity	0.45
Contaminated zone effective porosity	0.26
Contaminated zone hydraulic conductivity	1.23 m/yr
Saturated zone total porosity	0.45
Saturated zone effective porosity	0.26
Saturated zone hydraulic conductivity	123 m/yr
Saturated zone hydraulic gradient	0.01
Unsaturated zone thickness	0 m
Precipitation rate	1.07 m/yr
Runoff coefficient	0.25
Average annual wind speed	4.6 m/s
Soil specific b	5.3
Soil density	1.6 g/cm^3
Well pump intake depth below water table	1 m
Soil erosion rate[a]	6 x 10^{-5} m/yr
Distribution coefficient, K_d[b]	
Thorium	60,000
Radium	450
Uranium	450
Lead	900
Actinium	1,500
Protactinium	2,500

[a] Reference: Yu et.al. 1993b.

[b] Reference: Baes et.al. 1984; Sheppard and Thibault 1990.

data sets with 20 to 30 samples per exposure area provide fairly consistent estimates of the mean (i.e., the 95% UCL is close to the sample mean).

A.2.1. Additional Sampling

Historically, only gamma radiation readings had been collected in this area. No soil samples had been analyzed for activity concentrations. A statistically-based sampling plan was developed to augment the existing data and allow for the use of the 95% upper confidence limit (UCL) of the mean activity concentrations in the dose calculations for this hazard assessment.

A classical random sampling design was used to locate 20 additional boreholes in the area of concern. The EPA "Guidance for Data Useability in Risk Assessment (Part A)" asserts that a classical random sampling design is appropriate for use in sampling any medium to define the representative concentration value over the exposure area (EPA 1992a). It is not subject to judgmental biases, and produces known estimates as well as recognized statistical measures and guidelines.

In order to develop a random sampling design, a 10 ft x 10 ft grid was superimposed on the area. A random number generator was used to generate 20 sets of random grid coordinates. Soil samples and downhole gamma radiation readings were collected from the boreholes located as these grid coordinates. Samples were analyzed from the depth with the highest gamma reading from each borehole. This strategy skews the mean concentration for the area high and provides conservative dose and risk estimates. Nine additional samples were analyzed from the area of concern in order to present a more representative data set. This data is presented in Table B-1. Borehole locations are shown on Figure 2.

A.2.2. Data Analysis

The appropriate statistical method needed to calculate the mean and 95% UCL activity concentration is dependent on the data distribution. The Ra-226 data is normally distributed, the Th-232 data is lognormally distributed, and the U-238 data does not fit either distribution. Further analysis was not performed on U-238 because of the proliferation of results that are below the detection limit. The highest value shown in Table B-1 of 9.80 pCi/g was used as the U-238 activity concentration in the dose assessment.

The mean and standard deviation for the normally distributed Ra-226 data were determined to be 1.02 pCi/g and 0.17 pCi/g by standard methods. The following equation is used to determine the 95% UCL of the mean activity concentration for the Ra-226 normally distributed data (Gilbert 1987).

$$UCL_{0.95} = X + t_{0.95,n-1}\frac{s}{\sqrt{n}}$$

where: $\bar{X}$ = mean activity concentration, 1.02 pCi/g
s = standard deviation, 0.17 pCi/g
n = number of samples, 29
$t_{0.95,n-1}$ = student t statistic given in Gilbert 1987, 1.701

Ra-226 $UCL_{0.95}$ = 1.07 pCi/g

For the Th-232 data, the mean and variance must be calculated using lognormal statistics. In lognormal statistics, the data is transformed using the natural logarithm of the concentration values. The mean and variance of the transformed data is used to find the 95% UCL of the mean of the untransformed (original) data. The data in Table B-1 were entered into a spreadsheet shown in Table C-1. Each concentration value, x, was transformed by taking the natural log, ln(x). The mean of the transformed data, y, was found to be 1.56. The variance, s_y^2, is calculated by the spreadsheet using the following equation (Gilbert 1987):

$$s_y^2 = \frac{\sum (\ln(x) - y)^2}{n-1}$$

where: y = mean of the transformed data, 1.56
$\ln(x)$ = natural logarithm of each concentration value
n = number of samples, 29

The mean of the untransformed (original) data is calculated using the following equation (Gilbert 1987):

$$X = \exp\left(y + \frac{s_y^2}{2}\right)$$

Th-232 Mean = 8.4 pCi/g

The 95% UCL of the mean is derived by using the following equation (Gilbert 1987):

$$UCL_{0.95} = \exp\left(y + 0.5 s_y^2 + \frac{s_y H_{0.95}}{\sqrt{n-1}}\right)$$

where: $\bar{y}$ = mean of transformed data, 1.56
s_y^2 = variance of transformed data, 1.14
$H_{0.95}$ = H statistic (Gilbert 1987), 2.44
n = number of samples, 29

$$\text{Th-232 } UCL_{0.95} = 13.8 \text{ pCi/g}$$

Since the 95% UCL is close to the mean for both Ra-226 and Th-232, the data set is sufficient to support the statistical analysis performed. The 95% UCL concentrations are very conservative because the majority of the analyzed samples were taken from the highest gamma radiation reading throughout the depth of each borehole. For U-238, the maximum measured concentration is used for this analysis. The activity concentration values used in the RESRAD analyses are:

Th-232:	13.8 pCi/g
Ra-226:	1.07 pCi/g
U-238:	9.80 pCi/g

A.3. Current Park User Scenario

The current park user scenario mimics the current site usage. The current park user scenario includes outdoor external exposure, particulate inhalation, and incidental soil ingestion pathways. On-site production of produce, meat, milk, or fish is not considered, and all water is obtained from a municipal water supply. Site-specific source term assumptions are summarized in Table A-2 and are used in the future worker and the future resident scenario as well. Exposure parameter assumptions for the current park user scenario are shown in Table A-3.

Indoor exposure is not considered in this analysis because no resident is present. However, to be conservative, exposure rate measurements were collected in the area and the locations are shown on Figure 2. The results are summarized in Table A-4 and compared to the background exposure rate for the area as determined in the *Remedial Investigation Report for the Maywood Site* (DOE 1992). The exposure rates measured are equivalent to background even before any remediation of the property is performed. This indicates that there is no additional dose to residents in the homes surrounding the park from the residual radioactive material above criteria.

Table A-2. Source Term Assumptions for Lodi Park.

Parameter	Units	Lodi Park Trees
Area of contaminated zone	m^2	378
Thickness of contaminated zone	m	0.7
Cover depth	m	0.3
Radionuclide concentrations	pCi/g	
Th-232 + Progeny		13.8
Ra-226 + Progeny		1.07
U-238 + Progeny		9.80
U-234		0.45
U-235 + Progeny[a]		

[a] Assumed 4.6% of U-238 concentration, based on relative isotopic abundance.

Table A-3. Exposure Parameter Assumptions for Current Park User Scenario.

Parameter	Units	Input value
Outdoor occupancy factor	%	2
Exposure duration	yrs	30
Inhalation rate	m^3/yr	7300
Dust loading	$\mu g/m^3$	200
Dust from soil origin	%	50
Dust respirable fraction	%	30
Soil ingestion rate	g/yr	35
Fraction of drinking water from onsite well	-	0

Table A-4. Exposure Rate Measurements.

Location	Exposure Rate[a] (μR/h)	Background Exposure Rate[b] (μR/h)
#1	9.9	9
#2	9.2	9
#3	9.8	9
#4	9.9	9

[a] Measurements include background.
[b] Data source: DOE 1992.

The park user is assumed to spend 2% of his time outside in the area of interest. The risk analysis assumes clean cover material of 0.3 m; in addition, the trees themselves provide shielding from the trunk and roots (however, this is not accounted for in the analysis).

The total effective dose equivalent (TEDE) and incremental risk estimates for the current park user from the residual radioactive material are summarized in Table A-5. The maximum dose from this scenario is well below the EPA proposed guideline of 15 mrem and the maximum cancer risk is within the EPA target risk range of 10^{-4} to 10^{-6}.

Table A-5. Estimated Dose and Risk from Current Park User Scenario.

Time Increment	TEDE (mrem/yr)	Lifetime Excess Cancer Risk
0 yrs	0.098	6.6×10^{-7}
Maximum at 1000 yrs	0.22	1.7×10^{-6}

A.4. Future Worker Scenario

The future worker scenario assumes that a worker cuts down and removes the mature trees in the area. External exposure, particulate inhalation, and incidental soil ingestion are the exposure pathways assumed for the future worker scenario. This activity is conservatively estimated to take one week (40 hrs/week which is 0.5% of one year). Source term assumptions are shown in Table A-2. Exposure parameter assumptions are summarized in Table A-6.

Table A-6. Exposure Parameter Assumptions for Future Worker Scenario.

Parameter	Units	Input value
Outdoor occupancy factor	%	0.5
Exposure duration	yrs	1
Inhalation rate	m^3/yr	7300
Dust loading	$\mu g/m^3$	200
Dust from soil origin	%	50
Dust respirable fraction	%	30
Soil ingestion rate	g/yr	35
Fraction of drinking water from onsite well	-	0

The estimated dose from this activity is 0.025 mrem; the estimated cancer risk is 1.6×10^{-7}. Both values are within current and proposed EPA guidelines.

A.5. Future Resident Scenario

A future resident scenario is modelled by assuming that the area of trees has been cleared and a house with a garden and a well have been installed in the area. Thus, the future resident scenario included the outdoor external exposure, particulate inhalation, incidental soil ingestion, produce ingestion, and drinking water ingestion pathways. This future resident scenario represents the worst-case, but highly unlikely, future use for the property.

Source term assumptions are shown in Table A-2. Exposure parameter assumptions are given in Table A-7. Again, indoor exposure is not evaluated due to existing exposure rate data. This would not change in the future resident scenario.

Site-specific values were developed for several of the garden pathway parameters to better approximate actual site conditions. As shown in Table A-7, the amount of fruit and non-leafy vegetables consumed yearly is estimated to be 105 kg/yr and the amount of leafy vegetables consumed yearly is given as 14 kg/yr. These values were computed with information from the EPA *Exposure Factors Handbook* (EPA 1989) and NUREG/CR-5512 (NRC 1992). The NRC estimates that Americans eat 11 kg/yr of leafy vegetables, 51 kg/yr of other vegetables, and 46 kg/yr of fruit. EPA estimates slightly higher consumption rates of 70 kg/yr of vegetables and 49 kg/yr of fruits. Using the NRC data to determine that approximately 20% of consumed vegetables are leafy and 80% are non-leafy, the EPA data yields consumption rates of 105 kg/yr of non-leafy vegetables and fruit and 14 kg/yr of leafy vegetables.

Since the size of a home garden in the future in this area is unknown, the amount of fruit and vegetables consumed from a home garden must be estimated. The draft *Exposure Factors Handbook* (EPA 1996) estimates that 8% of the fruit and 4.4% of the vegetables consumed yearly come from home gardens in suburban areas in the Northeast. A combined percentage of 5.2% was used in the analysis.

Plant/soil transfer factors were computed from data in NUREG/CR-5512. The NRC presents plant/soil transfer factors by leafy vegetables, other vegetables, and fruits. The data discussed above for consumption rates were used to obtain weighted average plant/soil transfer factors for each element of interest. These weighted average plant/soil transfer factors are given in Table A-7.

The dose and incremental cancer risk from the future resident scenario are summarized in Table A-8. The resulting values are within current and proposed EPA guidelines.

A.6. Conclusions

Results of these analyses (summarized in Table A-9) indicate that the current and future usage scenarios for Lodi Park will not exceed the proposed EPA TEDE guideline of 15 mrem/yr or the DOE guideline of 100 mrem/yr. Estimates of excess cancer risk are within EPA's target risk range of 10^{-6} to 10^{-4}. Due to the conservative nature of the analysis, actual doses and risks from the residual radioactive material above criteria around the tree area are expected to be lower. Therefore, supplemental standards of current radionuclide concentrations should be established for this area.

Table A-7. Exposure Parameter Assumptions for Future Resident Scenario.

Parameter	Units	Input value
Outdoor occupancy factor	%	2
Exposure duration	yrs	30
Inhalation rate	m^3/yr	7300
Dust loading	$\mu g/m^3$	200
Dust from soil origin	%	50
Dust respirable fraction	%	30
Soil ingestion rate	g/yr	35
Fraction of drinking water from onsite well	-	1
Fraction of irrigation water from onsite well	-	1
Fruit and non-leafy vegetables consumed yearly	kg/yr	105
Leafy vegetables consumed yearly	kg/yr	14
Fraction of produce from home garden	-	0.052
Plant/soil transfer factors	-	
Lead		5.9E-3
Radium		1.2E-2
Actinium		6.7E-4
Thorium		7.7E-4
Protactinium		4.8E-4
Uranium		1.0E-2

Table A-8. Estimated Dose and Risk from Future Resident Scenario.

Time Increment	TEDE (mrem/yr)	Lifetime Excess Cancer Risk
0 yrs	1.8	8.8×10^{-6}
Maximum at 0.58 yrs	5.2	2.6×10^{-5}

Table A-9. Estimated Dose and Risk from Supplemental Criteria.

Scenario	TEDE[a] (mrem/yr)	Lifetime Excess Cancer Risk[a]
Current Park User	0.10 0.22	6.6×10^{-7} 1.7×10^{-6}
Future Worker	0.025 (one-time only)	1.6×10^{-7}
Future Resident	1.8 5.2	8.8×10^{-6} 2.6×10^{-5}

[a] Top value represents time=0; bottom value is maximum dose/risk over the period of analysis (t=1000 yrs), if different from t=0.

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ATTACHMENT B

Sampling Data

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park	96LP01	N 749161 E 2163654	0 - 0.5	9853						
			0.5 - 1.0	11112						
			1.0 - 1.5	12372						
			1.5 - 2.0	16667						
			2.0 - 2.5	26906	2.10	0.30	1.10	0.18	4.20	
			2.5 - 3.0	17093						
			3.0 - 3.5	11059						
			3.5 - 4.0	10527						
	96LP02	N 749146 E 2163667	0 - 0.5	8558						
			0.5 - 1.0	13364						
			1.0 - 1.5	14286						
			1.5 - 2.0	27292	4.90	0.31	0.98	0.15	2.60	0.98
			2.0 - 2.5	25532						
			2.5 - 3.0	21439						
			3.0 - 3.5	14609						
			3.5 - 4.0	11300						
	96LP03	N 749138 E 2163673	0 - 0.5	12346						
			0.5 - 1.0	17193						
			1.0 - 1.5	46215						
			1.5 - 2.0	87805	14.10	0.55	1.30	0.16	4.40	
			2.0 - 2.5	40868	8.80	0.46	1.50	0.20	5.60	
			2.5 - 3.0	20762						
			3.0 - 3.5	16449						
			3.5 - 4.0	14926						
	96LP04	N 749132 E 2163665	0 - 0.5	10668						
			0.5 - 1.0	14899						
			1.0 - 1.5	24692	7.90	0.38	1.00	0.14	3.60	
			1.5 - 2.0	54055	10.10	0.49	1.20	0.21	5.20	2.10
			2.0 - 2.5	52632						

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park			2.5 - 3.0	20488						
			3.0 - 3.5	12507						
			3.5 - 4.0	12589						
	96LP05	N 749124	0 - 0.5	12059						
		E 2163672	0.5 - 1.0	21990						
			1.0 - 1.5	67420						
			1.5 - 2.0	94490	7.40	0.35	0.38		3.20	
			2.0 - 2.5	63900	17.10	0.65	2.00	0.20	5.50	1.80
			2.5 - 3.0	28850						
			3.0 - 3.5	15249						
			3.5 - 4.0	10939						
	96LP06	N 749133	0 - 0.5	10601						
		E 2163651	0.5 - 1.0	12553						
			1.0 - 1.5	14230						
			1.5 - 2.0	24692	2.40	0.21	0.74	0.12	2.50	0.87
			2.0 - 2.5	17440						
			2.5 - 3.0	13101						
			3.0 - 3.5	11470						
			3.5 - 4.0	10292						
	96LP07	N 749125	0 - 0.5	11769						
		E 2163658	0.5 - 1.0	12998						
			1.0 - 1.5	16574						
			1.5 - 2.0	53572	9.40	0.48	1.10	0.21	6.70	
			2.0 - 2.5	35677	2.70	0.24	1.20	0.13	4.40	1.30
			2.5 - 3.0	19673						
			3.0 - 3.5	14815						
			3.5 - 4.0	11473						

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park	96LP08	N 749135	0 - 0.5	10811						
		E 2163637	0.5 - 1.0	17009						
			1.0 - 1.5	27523						
			1.5 - 2.0	76340	14.40	0.56	1.20	0.17	3.00	1.20
			2.0 - 2.5	48245	6.00	0.31	0.80	0.12	3.00	
			2.5 - 3.0	23167						
			3.0 - 3.5	12606						
			3.5 - 4.0	10600						
	96LP09	N 749128	0 - 0.5	9885						
		E 2163629	0.5 - 1.0	11812						
			1.0 - 1.5	12712						
			1.5 - 2.0	13589	0.88	0.13	0.50	0.09	1.90	
			2.0 - 2.5	12998						
			2.5 - 3.0	12507						
			3.0 - 3.5	11495						
			3.5 - 4.0	9434						
	96LP10	N 749113	0 - 0.5	9376						
		E 2163642	0.5 - 1.0	12794						
			1.0 - 1.5	14399						
			1.5 - 2.0	21583						
			2.0 - 2.5	62180	5.90	0.31	0.88	0.13	3.30	
			2.5 - 3.0	51725						
			3.0 - 3.5	13168						
			3.5 - 4.0	12171						
	96LP11	N 749091	0 - 0.5	10640						
		E 2163647	0.5 - 1.0	16000						
			1.0 - 1.5	24800						
			1.5 - 2.0	33750						
			2.0 - 2.5	34130	0.78	0.12	0.72	0.10	1.90	
			2.5 - 3.0	14300						

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park			3.0 - 3.5	10520						
			3.5 - 4.0	10680						
	96LP12	N 749075	0 - 0.5	30300	1.80	0.16	0.38	0.08	2.00	
		E 2163660	0.5 - 1.0	52920						
			1.0 - 1.5	144200	38.30	1.10	2.30	0.39	8.20	
			1.5 - 2.0	29130						
			2.0 - 2.5	15790						
			2.5 - 3.0	13450						
			3.0 - 3.5	12400						
			3.5 - 4.0	11090						
	96LP13	N 749092	0 - 0.5	8670						
		E 2163633	0.5 - 1.0	11030						
			1.0 - 1.5	14850						
			1.5 - 2.0	25110						
			2.0 - 2.5	29560	1.20	0.26	0.91	0.16	2.70	
			2.5 - 3.0	14470						
			3.0 - 3.5	10650						
			3.5 - 4.0	8580						
	96LP14	N 749069	0 - 0.5	17390						
		E 2163652	0.5 - 1.0	28990						
			1.0 - 1.5	81090	10.70	0.66	1.20	0.29	4.90	
			1.5 - 2.0	64870						
			2.0 - 2.5	14540						
			2.5 - 3.0	10860						
			3.0 - 3.5	11670						
			3.5 - 4.0	8900						

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park	96LP15	N 749086	0 - 0.5	12620						
		E 2163625	0.5 - 1.0	30210						
			1.0 - 1.5	43306	1.10	0.25	0.46		2.10	
			1.5 - 2.0	23290						
			2.0 - 2.5	27520						
			2.5 - 3.0	14060						
			3.0 - 3.5	11090						
			3.5 - 4.0	10150						
	96LP16	N 749071	0 - 0.5	9980						
		E 2163638	0.5 - 1.0	15310						
			1.0 - 1.5	27150						
			1.5 - 2.0	51280	8.80	0.42	1.40	0.16	5.70	1.70
			2.0 - 2.5	45110						
			2.5 - 3.0	25110						
			3.0 - 3.5	13900						
			3.5 - 4.0	11030						
	96LP17	N 749063	0 - 0.5	14090						
		E 2163644	0.5 - 1.0	26560						
			1.0 - 1.5	60860	16.00	0.58	1.30	0.21	7.90	
			1.5 - 2.0	139870	20.50	0.75	1.10	0.28	9.80	
			2.0 - 2.5	130630						
			2.5 - 3.0	28170						
			3.0 - 3.5	16390						
			3.5 - 4.0	9490						
	96LP18	N 749072	0 - 0.5	10130						
		E 2163624	0.5 - 1.0	12810						
			1.0 - 1.5	17750						
			1.5 - 2.0	26670	1.30	0.16	0.68	0.11	3.00	0.91
			2.0 - 2.5	15920						
			2.5 - 3.0	11940						

Table B-1
Hazard Assessment Area
Borehole Data

Property	Borehole	Coordinates	Depth (ft)	Gamma (cpm)	Th-232 (pCi/g)	ERR	Ra-226 (pCi/g)	ERR	U-238 (pCi/g)	ERR
Lodi Park			3.0 - 3.5	11050						
			3.5 - 4.0	10410						
	96LP19	N 749058	0 - 0.5	28572	2.30	0.26	0.71	0.15	4.20	
		E 2163622	0.5 - 1.0	46510						
			1.0 - 1.5	53110	4.50	0.28	0.79	0.15	4.80	1.40
			1.5 - 2.0	28170						
			2.0 - 2.5	17700						
			2.5 - 3.0	12220						
			3.0 - 3.5	10520						
			3.5 - 4.0	9902						
	96LP20	N 749044	0 - 0.5	20203	1.10	0.19	0.71	0.12	3.30	
		E 2163621	0.5 - 1.0	35520	3.50	0.25	0.92	0.12	2.30	0.86
			1.0 - 1.5	21829						
			1.5 - 2.0	14564						
			2.0 - 2.5	11268						
			2.5 - 3.0	11364						
			3.0 - 3.5	10773						
			3.5 - 4.0	10051						

Shaded areas represent a result that was less than the detection limit (MDA).
All results include background.

ATTACHMENT C

Statistical Analysis of Th-232 Sampling Data

Table C-1
Mean and Variance of
Transformed Th-232 Data

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Sample Number	Th-232 (pCi/g)	ERR	ln (x)	Mean (y)	(ln(x)-y)²	Sum	Variance
1	2.10	0.30	0.74	1.58	0.66	32.01	1.14
2	4.90	0.31	1.59		0.00		
3	14.10	0.55	2.65		1.19		
4	8.80	0.46	2.17		0.38		
5	7.90	0.38	2.07		0.26		
6	10.10	0.49	2.31		0.57		
7	7.40	0.35	2.00		0.20		
8	17.10	0.65	2.84		1.65		
9	2.40	0.21	0.88		0.46		
10	9.40	0.48	2.24		0.47		
11	2.70	0.24	0.99		0.32		
12	14.40	0.56	2.67		1.23		
13	6.00	0.31	1.79		0.06		
14	0.88	0.13	-0.13		2.84		
15	5.90	0.31	1.77		0.05		
16	0.78	0.12	-0.25		3.26		
17	1.80	0.16	0.59		0.94		
18	38.30	1.10	3.65		4.36		
19	1.20	0.26	0.18		1.89		
20	10.70	0.66	2.37		0.66		
21	1.10	0.25	0.10		2.13		
22	8.80	0.42	2.17		0.38		
23	16.00	0.58	2.77		1.48		
24	20.50	0.75	3.02		2.14		
25	1.30	0.16	0.26		1.67		
26	2.30	0.26	0.83		0.52		
27	4.50	0.28	1.50		0.00		
28	1.10	0.19	0.10		2.13		
29	3.50	0.25	1.25		0.09		