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Los Alamos Area Office, MS A316
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Los Alamos, New Mexico 87544
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Date: February 11, 1997
Refer to: EM/ER:97-012

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87502

SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION FOR RFI REPORT ON TA-50

Dear Mr. Garcia:

Enclosed please find a copy of the Los Alamos National Laboratory Environmental Restoration (ER) Project's response to the New Mexico Environment Department (NMED) request for additional Information on the Resource Conservation and Recovery Act Facility Investigation Report on Technical Area 50 (LA-UR 95-2738), Potential Release Sites 50-006(a, c), 50-007, and 50-008. The request was included as Attachment A on your letter dated August 19, 1996. In the response, the four issues raised by NMED and the Environmental Protection Agency are repeated, and the ER Project responses follow.

If you have any questions, please contact Don Krier at (505) 665-7834 or Mike Gilgosch at (505) 667-5794.

Sincerely,

Jorg Jansen, Program Manager
LANL/ER Project

Sincerely,

Theodore J. Taylor, Program Manager
DOE/LAAO

JJ/TT/rfr

Enclosures: (1) Additional Request for information on TA-50 RFI Report
(2) Certification

8836

Cy (w/ enc.):
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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 gathered and evaluated 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: Request for Additional Information of TA-50 RFI Report, PRSs 50-006(a, c), 50-007, and 50-008

Name: _____ Date: 2-12-97

Jorg Jansen, Program Manager
Environmental Restoration Project
Los Alamos National Laboratory

or

Tom Baca, Program Director
Environmental Management
Los Alamos National Laboratory

Name: _____ Date: 2/12/97

Joseph Vozella,
Acting Assistant Area Manager of
Environment Projects
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DOE-Los Alamos Area Office

or

Theodore J. Taylor, Program Manager
Environment Restoration Program
DOE-Los Alamos Area Office

REQUEST FOR ADDITIONAL INFORMATION ON TECHNICAL AREA 50 POTENTIAL RELEASE SITES 50-006(a, c), 50-007, and 50-008

NMED Issue:
This RFI Report included information on the following solid waste management units (SWMUs): 50-006(a and c), 50-007 and 50-008.

1. Elevated concentrations of beryllium, chromium and nickel were found to be associated with samples collected at a pipe rack. The area is currently in use and it is unclear which SWMU this is associated with. If the rack is not currently associated with a SWMU then it is recommended that the area be given a new designation and added to the permit.

LANL Response:

Concentrations of beryllium, chromium, cadmium, silver and nickel were elevated with respect to background in some samples collected downgradient from the pipe rack. The four samples containing elevated inorganics were taken within about 75 ft of the pipe rack location. However, interviews with mechanical technicians associated with work performed at that location indicate that constituents of Ni and Be would not have their source in the pipe rack, although Ag is sometimes a component of solder, and Cd can be a trace element in electrogalvanized pipe. In addition, we investigated a nearby transportable container ("skid") that was to be used for an adjacent incinerator. The incinerator was never fired up and no wastes were handled at the skid. Some modification of the skid took place at this location, but this was limited to cutting and welding. Therefore, based on this more detailed investigation and contrary to statements made in the RFI Report, we have determined that neither the pipe rack nor the incinerator skid is the source of all, or perhaps any, of the constituents. Rather, we believe the source is the air emissions from stacks at adjacent buildings, which, as stated in the RFI Work Plan for Operable Unit 1147, were the target of this phase of sampling.

Regardless of the source of contamination, because elevated concentrations of these chemicals were found we conducted a risk assessment to ensure this area did not present a human health risk. The risk assessment shows that the risk from exposure to these chemicals is within the National Contingency Plan acceptable risk range of 1 in a million to 1 in 10,000, using an industrial land use scenario. The risk assessment is summarized below, and the full text is presented in Attachment A. This risk assessment further supports our recommendation for no further action, as stated in the RFI Report, for PRSs 50-006(c), 50-007, and 50-008. PRS 50-006(a) will be further investigated under the Field Unit 4 Canyons Study and the Material Disposal Area C investigation as stated in the RFI Report.

Summary of risk assessment:
The RCRA Facility Investigation Report for Potential Release Sites 50-006(c), 50-007, 50-008, and 50-006(a) identified elevated values of beryllium, cadmium, chromium, and silver in three of eight soil samples collected from the drainage downgradient from the pipe rack. A human health risk assessment was conducted on the characterization data of the soil samples to determine whether adverse human health effects were likely for the industrial users of the area. The risk assessment was conducted using the data of the three sampling locations closest to the pipe rack. The area where the other five samples were collected has been graded, paved, and is now a parking lot. The arithmetic mean of the data for each chemical was used to represent the most likely exposure (MLE) and the reasonable maximum exposure (RME). As a conservative check, the arithmetic mean of the three samples was compared to the mean of all eight soil samples, and it was found that the three samples chosen for the risk assessment produced higher mean values of chemical concentrations.

This is an industrial area, not open to the general public, which will stay under Laboratory control for the foreseeable future. Therefore, an industrial scenario was utilized. Toxicity values used in the risk assessment calculations were extracted from the EPA's Integrated Risk Information System and the Health Effects Assessment Summary Tables. The EPA has stated that the upper end of acceptable risk can range from 10-04 to 10-06 (one in ten thousand to one in one million occurrences of excess cancer risk in a population), depending on site-specific considerations (EPA 1990, 0559). The result of the carcinogenic evaluation at the pipe rack is a risk of 3 x 10-07 for the MLE and 2 x 10-05 for the RME, well within the EPA guidelines. The calculated noncarcinogenic hazard indices for the MLE (0.001) and the RME (0.03) are less than one, indicating exposures under the industrial exposure assumptions are not expected to result in adverse noncarcinogenic effects. The results of the human health risk assessment suggest that potential exposure to COPCs in soil downgradient from the pipe rack would not result in adverse noncarcinogenic health effects or an unacceptable cancer risk to industrial users.

NMED Issue:
2. In addition, a review of the sampling information presented for beryllium related to SWMUs 56-006(c), 50-007 and 50-008, indicates that the calculated upper tolerance limit (UTL) is too high for this metal. The highest value for beryllium was 1.1 mg/kg which should probably be the UTL for TA-50. Using the facility-wide value for this metal does not appear appropriate, and a site-specific value should be used.

LANL Response:
We assume that "56-006(c)" is meant to read "50-006(c)."
The soils around TA-50 are derived from native Bandelier Tuff and are disturbed due to construction, trenching, paving and backfilling. The LANL background data set was derived from soils overlying Bandelier Tuff specifically for the purpose of this type of comparison. It is more relevant and important to compare the distribution of beryllium values at the SWMU with the distribution of beryllium values in the LANL background data set. Histograms of the two beryllium data sets follow at the end of this response. (The SWMU histogram does not include three outliers, described below.) Comparison shows that the distribution of the LANL Background beryllium is inclusive of the SWMU beryllium values and that the mean of the SWMU beryllium distribution is indeed less than the mean of the LANL Background beryllium distribution. Fifty-two of the 55 sample values from this SWMU were within a range of 0.16 to 1.2 mg/kg with a mean of 0.53 and median of 0.5. These comparable statistical values and the picture presented by the SWMU histogram indicate that those 52 values belong to a nearly normally distributed population of beryllium values. Of the remaining 3 sample values, 1 was a nondetect (<0.08 mg/kg), and the other 2 (9.8 and 150 mg/kg) were at the pipe rack site. Use of the LANL background beryllium UTL did not cause unusually elevated sample values to be overlooked during the screening; only the samples at the pipe rack site do not belong to the beryllium population at the SWMU.

NMED Issue:
3. Further characterization of Ten Site Canyon is recommended, as well as, removal of the hummock area in Ten Site Canyon which contained high levels of radionuclides and polychlorinated biphenyls.

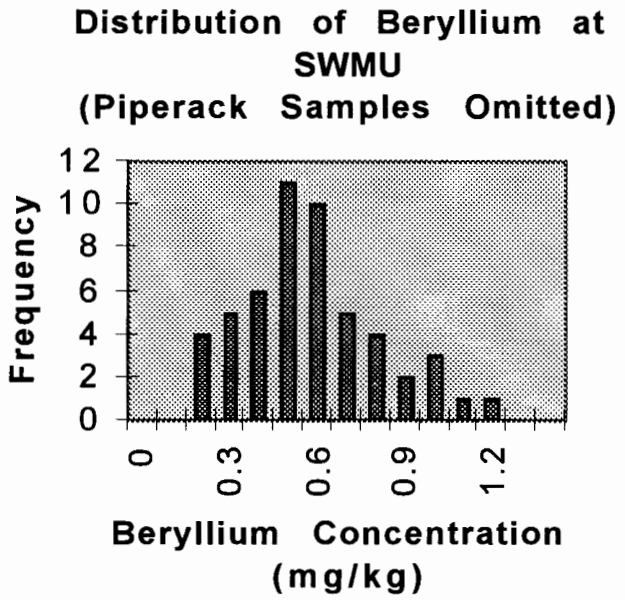
LANL Response:
The Laboratory agrees that removal and proper disposal of the material of the hummock will preclude further dissemination during large storm events of this localized contaminated pocket of radioactivity and PCBs. An Interim Action Plan was developed, and the sediment removal took place on November 13-14, 1996. NMED DOE-Oversite Bureau personnel observed the field activity and will take verification samples. Ten Site Canyon characterization will be moved to the authority of the canyons study under LANL ER Field Unit 4, as will any permanent remedy or remediation.

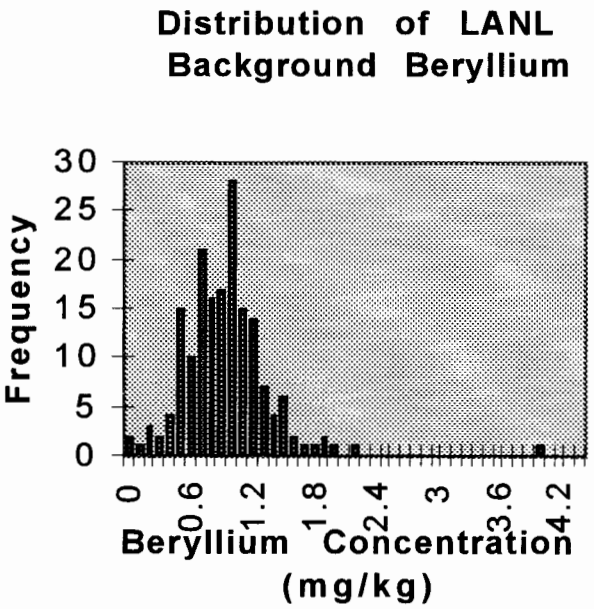
NMED Issue
4. LANL shall summarize all deviations from the approved Workplan.

LANL Response:
Stainless steel coring tool for collection of undisturbed samples. All soils around TA-50 are disturbed. Numerous activities have caused disturbance, and mixing of surface soils after potential airborne deposition would have occurred. Therefore, the stainless steel scoop method, collecting soil to a depth of 6 inches, was the more appropriate method to collect any potentially contaminated soils than use of the stainless steel coring tool.

Field laboratory for analysis of samples. The field laboratory originally proposed in the Work Plan was not used. Instead, all samples were submitted to a fixed-site laboratory. The envisioned field laboratory was not practical. Fixed-site laboratory methods are generally more reliable for large suites of analytes.

Additional samples collected at Ten Site Canyon. Field screening identified a localized area of elevated gross alpha/beta at a "hummock," a physical feature consisting of a small deposit of sediment in the stream channel. It was decided that the single sample originally planned for that area was not sufficient to characterize the hummock. Additional samples were collected upstream and downstream from the hummock.


Distribution of Beryllium at SWMU
(Piperack Samples Omitted)
Frequency
12
10
8
6
4
2
0
0
0.3
0.6
0.9
1.2
Beryllium Concentration
(mg/kg)


Distribution of LANL Background Beryllium
Frequency
30
25
20
15
10
5
0
0
0.6
1.2
1.8
2.4
3
3.6
4.2
Beryllium Concentration
(mg/kg)

ATTACHMENT A RISK ASSESSMENT DATA AND EQUATIONS: TA-50 SURFACE SOIL ISSUE

1.0 INTRODUCTION

A human health risk assessment was conducted on the characterization data of the soil samples taken downgradient from the pipe rack at TA-50 to determine whether adverse human health effects were likely for the industrial users of the area. The results indicate that potential exposure to chemicals in the soil downgradient from the pipe rack should not result in adverse carcinogenic or noncarcinogenic health effects.

The human health risk assessment presented here follows the process outlined in the policy document "Risk-Based Corrective Action Process" (Dorries 1996, 1297). The human health risk assessment process consists of four steps: identification of chemicals of potential concern (COPCs), exposure assessment, toxicity assessment, and risk characterization. The data, exposure parameters, toxicity values and profiles, risk assessment equations and conclusions are presented in the following sections.

1.1 Identification of Chemicals of Potential Concern

The RCRA Facility Investigation Report for Potential Release Sites 50-006(c), 50-007, 50-008, and 50-006(a) identified elevated values of beryllium, cadmium, chromium, and silver from eight soil samples collected from the drainage downgradient from the pipe rack. A visit to the site revealed that since the time these samples were collected the adjacent parking area has been expanded and pavement now covers the area where the five samples farthest from the pipe rack were collected. This area has had a culvert installed, the soil graded and it has been covered by asphalt. Since there is no longer a complete pathway from COPC to receptor, no health risk can be assessed from these covered sampling locations. This risk assessment is therefore conducted using the data of the three remaining sampling locations which were collected from the small unpaved area closest to the pipe rack. Although this small area is still unpaved, a large storage unit is situated on top of half of that unpaved area, and a tree, the pipe rack, a tank, and a picnic table occupy the rest of the unpaved area.

The soil sample containing the highest concentrations of each COPC is among the three remaining samples. The arithmetic mean of the sampling results for each COPC was calculated for the data set of the three remaining samples and compared to the same

calculation for the data set from original eight soil samples. For each COPC, the arithmetic mean of the three remaining soil samples is greater than the arithmetic mean for the original eight samples. This assures that the risk has not been artificially lowered by deleting the covered samples from consideration in this risk assessment. The arithmetic mean of the data for each chemical was used to represent the most likely exposure (MLE) and the reasonable maximum exposure (RME). When a chemical was reported as not detected (as represented by the "<" symbol), the detection limit was averaged in with the detected values. These values are presented in Table A-1.

TABLE A-1

SOIL SAMPLE DATA

Location ID	Sample ID	Beryllium (mg/kg)	Cadmium (mg/kg)	Total Chromium (mg/kg)	Silver (mg/kg)
	UTL[a]	1.95	2.6	19.3	N/A
	Residential SAL[b]	0.14	38	211	380
50-5062	AAA2470	0.62	<0.4	9.3	<1
50-5063	AAA2471	150	170	810	17
50-5064	AAA2472	<0.08	<0.4	1.1	410
	Arithmetic Mean	50.2	56.9	273.5	142.7

[a]UTL = Upper Tolerance Limit
[b]SAL = Screening Action Limit

1.2 Exposure Assessment

The area where the samples were collected in 1993 is located downgradient from the pipe rack in Technical Area (TA) 50, among buildings such as the Liquid Waste Treatment Plant, the Incinerator Complex, and the Waste Characterization Reduction and Repacking Facility. This is an industrial area, not open to the general public, which will stay under Laboratory

control for the foreseeable future. Therefore, an industrial scenario risk assessment was conducted.

Total chromium is assumed to be composed of one part chromium VI and six parts chromium III according to the Health Effects Assessment Summary Tables (HEAST), a standard risk assessment tool (Miller 1994, 1169). The mean of total chromium was multiplied by one-seventh in order to estimate the mean of chromium VI, and by six-sevenths in order to estimate the mean of chromium III.

The mean value of each chemical was multiplied by the dust loading factor of 9×10^{-5} g/m^3 to yield the input value for dust for the industrial worker (Dorries 1996, 1297). Table A-2 presents the data used in the risk assessment.

TABLE A-2

CONCENTRATIONS USED IN RISK ASSESSMENT CALCULATIONS

Chemical	Average On-Site Soil (mg/kg)	Average Dust (ug/m^3)
Beryllium	20.3	2×10^{-3}
Cadmium	36.6	3×10^{-3}
Chromium	117	1x 10-2^{-2}
Chromium VI	19.5	2×10^{-3}
Silver	54	5×10^{-3}

Industrial scenario exposure parameters listed in the document "Risk-Based Corrective Action Process" were used in the risk assessment (Dorries 1996, 1297). There are three exceptions. The first is that the exposure time input parameter has been modified to reflect site-specific conditions. It is not realistic to expect that an industrial worker would spend two to four hours per day in this small unpaved area surrounded by a parking lot. The most likely exposure would be a person occasionally spending an hour at the picnic table having lunch during good weather. A reasonable maximum exposure could be a person spending an hour for lunch at the picnic table each working day and an hour per day working in or around the pipe rack regardless of the weather. The second exception is the fraction ingested input

parameter was modified had to be adjusted to reflect the limited time spent at the site. The third exception is that the intake rate for inhalation of dust has been updated to reflect the values recommended in the EPA's Exposure Factors Handbook, 1989. Table A-3 presents these industrial scenario exposure parameters.

TABLE A-3

INDUSTRIAL SCENARIO EXPOSURE PARAMETERS

Pathway	Parameter (units)	Most Likely Exposure	Maximum Reasonable Exposure
All Pathways	BW[a] (kg)	70	70
	EF[b] (days/yr)	25	250
	ED[c] (yr)	9	25
Inhalation of Dust	IR[d] (m3/hr)	0.5	1.1
	ET[e] (hr/day)	0.16	1
Ingestion of Soil	IR (mg/day)	50	100
	FI[f] (unitless)	0.2	.3

[a] BW = Body weight.
[b] EF = Exposure frequency.
[c] ED = Exposure duration.
[d] IR = Intake rate.
[e] ET = Exposure time.
[f] FI = Fraction ingested from contaminated source.
[g] AF = Soil-to-skin adherence factor.
[h] SA = Skin surface area exposed.

Intake equations used in risk assessment calculate the intake of COPCs via ingestion and inhalation pathways by combining the concentration of the COPC in soil with exposure parameters for the industrial scenario. The intake results are used in subsequent calculations along with toxicity parameters to evaluate carcinogenic risk and the potential for noncarcinogenic health effects.

Intake of COPCs via soil ingestion is calculated according to equation Eq. A-1.

$$\text{Intake}_{ing} = \frac{C \times IR \times EF \times ED}{BW \times AT} \qquad \text{(Eq. A-1)}$$

where,

$Intake_{ing}$ = amount of soil ingested daily (mg/kg/day),

C = COPC concentration in soil (mg/kg),

IR = soil ingestion rate (mg/day),

EF = exposure frequency (days/yr),

ED = exposure duration (yr),

AT = averaging time (ED x 365 days/yr for noncarcinogens, 25550 days for carcinogens), and

BW = body weight (kg).

Intake of COPCs via inhalation of fugitive dust is calculated according to equation Eq. A-2.

$$Intake_{inh} = \frac{C \times PC \times IR \times ET \times EF \times ED}{BW \times AT} \qquad \text{(Eq. A-2)}$$

where,

$Intake_{inh}$ = amount of soil inhaled daily (mg/kg/day),

C = COPC concentration in soil (mg/kg),

PC = particulate concentration in air ($9 \times 10^{-5} mg/m^3$),

IR = inhalation rate (m3/hr),

ET = exposure time (hr/day),

EF = exposure frequency (days/yr),

ED = exposure duration (yr),

BW = body weight (kg), and

AT = averaging time (ED x 365 days/yr for noncarcinogens, 25550 days for carcinogens).

1.3 Toxicity Assessment

The purpose of the toxicity assessment is to present information regarding the potential for COPCs to cause adverse health effects in exposed individuals and to provide an estimate of the relationship between the extent of exposure to a chemical and the increased likelihood and/or severity of adverse health effects.

1.3.1 Toxicity Values

The toxicity value used to evaluate noncarcinogenic effects for a COPC is the reference dose (RfD). The RfD has been developed based upon the concept that a threshold dose exists below which adverse effects would not occur. RfDs exist for both chronic and subchronic exposures; chronic exposure RfDs were used in this risk assessment because of the length of the exposure periods involved (9 years). The Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST) were used, in this order, to identify RfD values.

For COPCs with carcinogenic effects, the slope factor and accompanying weight-of-evidence is used to evaluate toxicity. The slope factor is derived based upon the concept that there is no threshold of exposure below which a carcinogenic response may not occur. The slope factor is used to estimate the upper-bound lifetime probability of cancer induction as a result of exposure to a certain level of a suspected or known carcinogen. Weight-of-evidence carcinogenicity classifications are:

A = human carcinogen,

B1 = probable human carcinogen, but limited human data are available,

B2 = probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans,

C = possible human carcinogen,

D = not classifiable as to human carcinogenicity, and

E = evidence of noncarcinogenicity for humans.

Tables A-4 and A-5 present the toxicity values used in the risk assessment and the reference material in which these values are listed.

TABLE A-4

REFERENCE DOSES USED IN THE RISK ASSESSMENT CALCULATIONS

Chemical	EPA Class	Oral Reference Dose (Chronic) (mg/kg/day)	Source	Inhalation Reference Dose (Chronic) (μg/kg-day)	Source
Beryllium	B2[a]	5×10^{-3}	IRIS[b], December 1996	N/A	N/A
Cadmium	B1[c]	1×10^{-3}	IRIS[b], December 1996	5.7×10^{-5}	N/A
Chromium III	D[d]	1	IRIS, December 1996	N/A	IRIS, December 1996
Chromium VI	A[e]	5×10^{-3}	IRIS, December 1996	N/A	N/A
Silver	D	5×10^{-3}	IRIS, December 1996	N/A	N/A

[a] B2 = probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans.

[b] IRIS = Integrated Risk Information System

[c] B1 = Probable human carcinogen, but limited human data are available.

[d] D = Not classifiable as to human carcinogenicity.

[e] A = Human carcinogen.

N/A = Not available

TABLE A-5

SLOPE FACTORS USED IN THE RISK ASSESSMENT CALCULATIONS

Chemical	EPA Class	Oral Slope Factor [1/(mg/kg/day)]	Source	Inhalation Slope Factor [1/(mg/kg/day)]	Source
Beryllium	B2 [a]	4.3	IRIS[b] December 1996	8.4	HEAST[c] FY[d] 1994
Cadmium (dust)	B1[e]	N/A	N/A	6.3	IRIS January 1995
Chromium III	D[f]	N/A	N/A	N/A	N/A
Chromium VI	A[g]	N/A	N/A	290	IRIS December 1996
Silver	D	N/A	N/A	N/A	N/A

[a] B2 = Probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans

[b] IRIS = Integrated Risk Information System

[c] HEAST = Health Effects Assessment Summary Tables

[d] FY = Fiscal year.

[e] B1 = Probable human carcinogen, but limited human data are available.

[f] D = Not classifiable as to human carcinogenicity.

[g] A = Human carcinogen.

N/A = Not available

1.3.2 Toxicity Profiles for Chemicals of Potential Concern

Toxicity profiles are provided in this section for the COPCs beryllium, cadmium, chromium, and silver.

1.3.2.1 Toxicity Profile for Beryllium

Oral Reference Dose: IRIS lists the oral RfD for beryllium as 5×10^{-3} mg/kg/day. This value was derived with an uncertainty factor of 100.

Carcinogen Classification: Group B2, probable human carcinogen. The oral slope factor is listed in IRIS as $(4.3 \text{ mg/kg/day})^{-1}$, the inhalation unit risk value as $(2.4 \times 10\text{-}03 \text{ mg/m3})^{-1}$, and the inhalation slope factor as $(8.4 \text{ mg/kg/day})^{-1}$.

Uses: Beryllium is a metallic element, occurring naturally as a chemical component of certain rocks, coal and oil, soil, and volcanic dust. It is used as an aerospace structural material, as a moderator and reflector in nuclear reactors, and in a copper alloy used for springs, electrical contacts and nonsparking tools.

Health Effects: Various health effects related to beryllium exposure have been documented in human and animal investigations. The major toxicologic effects of beryllium are on the lung. Exposure to beryllium may produce an acute chemical pneumonitis, hypersensitivity, and berylliosis - a chronic granulomatous pulmonary disease. Contact dermatitis is the most common beryllium-related toxic effect. Exposure to soluble beryllium compounds may result in a delayed-type hypersensitivity reaction of papulovesicular lesions on the skin. *In vitro* studies of genotoxicity have shown that beryllium will induce morphologic transformation in mammalian cells. It will also decrease fidelity of DNA synthesis, but is negative when tested as a mutagen in bacterial systems (Amdur, et al, *Casarett and Doull's Toxicology, the Basic Science of poisons*, 1991, Pergamon Press).

Study Support: The oral RfD for beryllium is listed in IRIS as 5×10^{-3} mg/kg/day. The no observable adverse effect level (NOAEL) is listed as 5 ppm (0.54 mg/kg of body weight/day) in drinking water. The RfD value is based on a lifetime study of 52 weanling rats which received 0 or 5 ppm beryllium (as beryllium sulfate) in drinking water. At natural death, the rats were dissected and gross and microscopic changes were noted in the heart, kidney, liver, and spleen. There were no effects of treatment on these organs or on lifespan, urinalysis, serum glucose, cholesterol, and uric acid, or on numbers of tumors. Male rats experienced decreased growth rates from 2 to 6 months of age. In a similar study, doses of 0.95 mg/kg/day caused decreased body weights in female mice. Male mice exhibited slight increases in body weight.

The uncertainty factor applied to derivation of the oral RfD is 100. This factor accounts for interspecies (10X) conversion and for protection of sensitive human subpopulations (10X). The confidence level is low because only one dose level was administered. Although numerous inhalation investigations and a supporting chronic oral bioassay in mice exist, along with work that indicates a higher dose level may be a no observable effect level (NOEL), these studies are considered low to medium in quality. Therefore, the database is given a confidence level of low.

The classification of beryllium as Group B2 - Probable Human Carcinogen is based on its ability to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection. Human epidemiology studies are considered to be inadequate. The oral slope factor is listed in IRIS as 4.3 $mg/kg/day^{-1}$, the inhalation unit risk value as $(2.4 \times 10\text{-}03\ mg/m3)^{-1}$, and the inhalation slope factor as $(8.4\ mg/kg/day)^{-1}$. The estimate for the oral slope factor is derived from a study which did not show a significant increase in tumorigenic response. While this study is limited by use of only one non-zero dose group and the occurrence of high mortality and unspecified time and site of the tumors, it was used as the basis of the quantitative estimate because exposure occurred via the most relevant route.

1.3.2.2 Toxicity Profile for Cadmium

Oral Reference Dose: IRIS lists the oral RfD for cadmium in food as 1×10^{-3} mg/kg/day. This value was derived with an uncertainty factor of 10.

Carcinogen Classification: Group B1, probable human carcinogen. The EPA has not established an oral slope factor for cadmium. The EPA has established an inhalation unit risk of $1.8 \times 10^{-3}\ \mu g/m3^{-1}$ and inhalation slope factor of $(6.3\ mg/kg/day)^{-1}$

Uses: Cadmium is a metallic element, occurring primarily in zinc, copper, and lead ores. It is used in solders, dental amalgams, cathode material for nickel-cadmium storage batteries, as a color pigment for paints and plastics and in rustproof electroplating. A major nonoccupational source of respirable cadmium is cigarettes.

Health Effects: Exposure to high levels of cadmium via inhalation severely damages the lungs and can cause death. Inhalation of lower levels for a period of years results in accumulation of cadmium in the kidneys that can cause kidney disease. Long-term exposure to cadmium by inhalation may also cause fragile bones.

Long-term exposure of workers to cadmium via inhalation in an occupational setting may increase the risk of developing lung cancer. Experimental studies indicate that mice and hamsters exposed to cadmium by inhalation do not develop lung cancer; however, rats clearly do. Pregnant female rodents that inhaled high levels of cadmium produced fewer litters and the pups exhibited more birth defects than usual. Inhalation of cadmium also causes liver damage and changes in the immune system in rats and mice. Currently, it is not known whether inhalation of cadmium affects the ability of humans to reproduce or has

harmful effects on the fetus, liver, heart, nervous system, or immune system in humans (Life Systems, Inc. 1992, 1053).

Dermal contact with cadmium is not known to cause adverse health effects in animals or humans (Life Systems, Inc. 1992, 1053).

Study Support: IRIS lists the oral reference dose for cadmium in food as 1×10^{-3} mg/kg/day. The reference dose is based on the highest level of cadmium in the human renal cortex (200 μg cadmium/g wet renal cortex) that is not associated with significant proteinuria, the critical effect of interest. A toxicokinetic model was used to determine the highest level of exposure associated with the lack of a critical effect. An uncertainty factor of 10 was applied to account for intrahuman variability to the toxicity of this chemical in the absence of specific data on sensitive individuals. The level of confidence in the reference dose is high because of the many studies available on the toxicity of cadmium in both humans and animals.

The classification of cadmium as a Group B1 probable human carcinogen is based on limited evidence of its carcinogenicity in humans available from several epidemiologic studies which demonstrated a possible association with lung and prostate cancers. There is also sufficient evidence of cadmium's carcinogenicity in rats and mice by the inhalation route (lung tumors), intratracheal instillation (mammary tumors in female rats, multiple sites in males), and intramuscular or subcutaneous injection (injection site and distant site tumors). EPA has not established an oral slope factor for cadmium. EPA has established an inhalation unit risk of $(1.8 \times 10^{-3}$ μg/m3$)^{-1}$ and an inhalation slope factor of (6.3 mg/kg/day) $^{-1}$ based primarily on an epidemiologic study of cadmium smelter workers in which an increased risk of lung, trachea, and bronchus cancer mortality was observed. The supporting study used a relatively large cohort and smoking and concurrent arsenic exposures were accounted for in the quantitative analysis for cadmium.

1.3.2.3 Toxicity Profile for Chromium

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. It is important for glucose metabolism, and may be a cofactor for insulin. Chromium is present in the environment in several valent forms, the most common of which are chromium 0, chromium III, and chromium VI. Chromium III occurs naturally in the environment, whereas chromium VI and Chromium 0 (metal chromium) are generally produced by industrial processes. Chromium III or chromium VI produced by the chemical industry are used for chrome plating, the manufacture of dyes and pigments, leather, wood preservatives, and treatment of cooling tower water. Smaller amounts are used in drilling

muds, textiles, and toner for copying machines (Syracuse Research Corporation 1991, 1241).

1.3.2.3.1 Chromium III

Oral Reference Dose: 1 mg/kg/day. This reference dose was derived with an uncertainty factor of 100 and a modifying factor of 10.

Carcinogen Classification: Group D, not classifiable as to human carcinogenicity. Trivalent chromium (chromium III) is much less toxic and more abundant in nature than the hexavalent form (chromium VI). Chromium VI readily crosses all membranes and is reduced intracellularly to trivalent chromium. There is no evidence to suggest that chromium III is converted into chromium VI in biological systems (Amdur et al. 1991, 1239).

Health Effects: Respiratory effects have been observed in workers exposed to chromium III; however, other forms of chromium were present. The respiratory system is the primary target for injury following inhalation exposure in laboratory animals. Rats and mice inhaling various levels of chromium III oxide had increased lung weights, marked hyperplasia, interstitial fibrosis, and epithelial necrosis (Syracuse Research Corporation 1991, 1241).

Study Support: IRIS lists the chronic oral reference dose as 1 mg/kg/day, which is the same value listed in HEAST as the subchronic oral reference dose. These values are based on a chronic feeding study in rats. Even after feeding up to 5% of chromic oxide in the diet for 84 days, no adverse effects were observed at any dose level.

An uncertainty factor of 100 was applied to the oral reference dose. This factor accounts for the interhuman and interspecies variability of the toxicity of chromium III. The oral reference dose is limited to insoluble salts of chromium III. Confidence in the principal study is rated as low because of a lack of explicit detail on protocol and results. Low confidence in the database reflects the lack of high-dose supporting data. A modifying factor of 10 reflects uncertainty in the no observable effect level. An inhalation risk assessment for chromium III is under review by an EPA work group.

Chromium III is not believed to be carcinogenic.

1.3.2.3.2 Chromium VI

Oral Reference Dose: 5×10^{-3} mg/kg/day. This reference dose was derived with an uncertainty factor of 500.

Carcinogen Classification: Group A, human carcinogen. IRIS lists an inhalation unit risk value of $(1.2 \times 10^{-2}\ \mu g/m3)^{-1}$. The corresponding inhalation slope factor is $(290\ mg/kg/day)^{-1}$.

Health Effects: Chromate sensitive workers acutely exposed to chromium VI develop asthma and other signs of respiratory distress. Symptoms include erythema of the face, nasopharyngeal pruritus, nasal blocking, coughing and wheezing. In a retrospective mortality study, intermediate- to chronic-duration occupational exposure to chromium VI showed an increased risk of death due to noncancer respiratory disease. Occupational exposure has also been associated with adverse effects on the gastrointestinal system and severe liver injury. Additionally, chromium VI has been associated with an increased incidence of bronchogenic and nasal cancer following chronic occupational exposure.

Study Support: IRIS lists a chronic oral reference dose for chromium VI as 5×10^{-3} mg/kg/day. This value is based on a year-long study in rats that were administered hexavalent and trivalent chromium in drinking water. No significant changes in appearance, weight gain, food consumption, or histologic lesions were observed in any of the treatment groups. An uncertainty factor of 500 accounts for the expected interhuman and interspecies variability in the toxicity of the chemical in lieu of specific data, and an additional factor of 5 to compensate for the less-than-lifetime exposure duration of the principal study. The oral reference dose is limited to soluble salts of metallic chromium VI. Confidence in the principal study is low because of the small number of animals tested, the small number of parameters measured, and the lack of toxic effect at the highest dose tested. Confidence in the database is low because the supporting studies are of equally low quality, and teratogenic and reproductive endpoints are not well studied.

Chromium VI is considered to be carcinogenic only by inhalation and is classified as a Group A human carcinogen. IRIS lists an inhalation unit risk value of $(1.2 \times 10^{-2}\ \mu g/m3)^{1}$. The corresponding inhalation slope factor is $(290\ mg/kg/day)^{-1}$. The confidence in this unit risk factor is high because there is sufficient epidemiologic evidence in humans supporting this conclusion.

1.3.2.4 Toxicity Profile for Silver

Oral Reference Dose: 5×10^{-3} mg/kg/day. This reference dose was derived using an uncertainty factor of 3.

Carcinogen Classification: Group D, not classifiable as to human carcinogenicity.

Uses: Silver is a metal. It is used in jewelry, silverware, electronic equipment, dental fillings, and photographs. Silver also occurs in compounds such as silver nitrate, silver chloride, silver sulfide, and silver oxide.

Health Effects: The most serious health effect resulting from silver exposure is believed to be argyria. Argyria is a gray or blue-gray coloration of the skin that is caused by eating or breathing silver compounds over time. Exposure to dust that contains silver compounds, such as silver nitrate or silver oxide, may cause breathing problems, lung and throat irritation, and stomach pain. Mild allergic reactions have been seen in humans due to skin exposure to silver compounds. One long-term animal study suggested that high levels of silver nitrate in drinking water may have caused a slight effect on the brain. Another study found that exposure to silver nitrate or silver chloride led to enlargement of the heart. Animal studies, however, have not been complete enough to measure these effects adequately (Clement International Corporation 1994, 1344).

Study Support: The oral reference dose for silver is listed in IRIS as 5×10^{-3} mg/kg/day. This value is based on a 2- to 9-year human intravenous study. Argyria is the critical effect of silver ingestion in humans. It results in a bluish-gray discoloration of the skin from deposition of silver in the dermis and from silver-induced production of melanin. This deposition has not been associated with any adverse health effects. Data from 10 males and 2 females who were given intravenous injections of silver arsphenamine over a period of 2 to 9 years were collected. After a dose of 4, 7, or 8 g, argyria developed in some patients. Other patients developed argyria after 10, 15, or 20 g. Biospectrometric examination of skin biopsies showed a correlation between the degree of discoloration and the level of silver that was present. The lowest intravenous dose resulting in argyria was 1 g of metallic silver (an oral dose of 0.014 mg/kg/day). This was determined to be the lowest observable adverse effect level (LOAEL). A no observable adverse effect level (NOAEL) was not established.

An uncertainty factor of 3 was used to account for sensitive individuals. An uncertainty factor was not assigned for the study duration because the dose was apportioned over a lifetime of 70 years. The confidence level in the oral reference dose is low. A NOAEL was not established because the study used individuals who were being treated for syphilis and may have been in bad health. Confidence in the database was low because the supporting studies were not controlled and the amount of silver ingestion was difficult to determine. The intravenous administration also required a dose conversion that introduces uncertainty. Currently, no values are listed for an inhalation RfC.

Silver is classified as Group D, not classifiable as to human carcinogenicity. Induction of local sarcomas in animals after implantation of foils and discs of silver has been seen; however, the interpretation of these results is questionable. No evidence of human carcinogenicity has been reported even with the frequent therapeutic use of silver. Classification of a chemical as Group D precludes quantitative toxicity assessment. No slope factor is listed.

1.4 Risk Characterization

Risk characterization is the final step in the risk assessment process. Toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of risk. To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime of exposure are estimated from projected intakes and chemical-specific dose-response information. To characterize potential noncarcinogenic effects, comparisons are made between projected intakes of COPCs and toxicity values including reference doses. Major assumptions, scientific judgments, and estimates of the uncertainties embodied in the assessment are also presented.

1.4.1 Carcinogenic Risk and Noncarcinogenic Health Effects Equations

Carcinogenic risks are estimated as the incremental probability of an individual developing cancer as the result of exposure to a carcinogen. Excess cancer risks are calculated according to equation Eq. A-4.

$$\text{Risk} = \text{CDI} \times \text{SF} \qquad \text{(Eq. A-4)}$$

Where:

CDI = chronic daily intake (mg/kg/day), and

SF = carcinogenic slope factor.

A hazard quotient of one is used to evaluate potential noncarcinogenic health effects from exposure. At this value, COPC intake is equal to the reference dose, the dose at which adverse effects are not likely to be seen. Hazard quotients were calculated according to Equation A-5.

$$\text{HQ} = \frac{\text{Intake (mg/kg-d)}}{\text{RfD (mg/kg-d)}} \qquad \text{(A-5)}$$

where,

HQ = Hazard quotient, and

RfD = Reference dose.

1.4.2 Risk Assessment Results

This risk assessment was conducted for the three soil samples taken downgradient from the pipe rack at TA-50 using the data, exposure parameters, toxicity values and toxicity profiles presented in this appendix. The results for the carcinogenic risk for the MLE and RME are presented in tables A-6 and A-7, respectively, and the noncarcinogenic health effects in tables A-8 and A-9.

TABLE A-6

TA-50 CANCER RISK CALCULATED FROM SOIL SAMPLES NEAR PIPE RACK FOR MOST LIKELY EXPOSURE INDUSTRIAL SCENARIO

Chemical	Inhalation of Dust	Soil Ingestion	Total
Beryllium	2×10^{-09}	3×10^{-7}	3×10^{-07}
Cadmium (dust)	2×10^{-09}	0	2×10^{-09}
Cadmium (food)	2×10^{-09}	0	2×10^{-09}
Chromium VI	9×10^{-09}	0	9×10^{-09}
Scenario Total			**3×10^{-07}**

TABLE A-7

TA-50 CANCER RISK CALCULATED FROM SOIL SAMPLES NEAR PIPE RACK FOR REASONABLE MAXIMUM EXPOSURE INDUSTRIAL SCENARIO

Chemical	Inhalation of Dust	Soil Ingestion	Total
Beryllium	3×10^{-07}	2×10^{-05}	2×10^{-05}
Cadmium (dust)	2×10^{-07}	0	2×10^{-07}
Cadmium (food)	2×10^{-07}	0	2×10^{-07}
Chromium VI	1×10^{-06}	0	1×10^{-06}
Scenario Total			**2×10^{-05}**

The result of the carcinogenic evaluation is a risk of 3×10^{-07} for the MLE and 2×10^{-05} for the RME. The EPA has stated that the upper end of acceptable risk can range from10^{-04} to 10^{-06} (one in ten thousand to one in one million occurrences of excess cancer risk in a

population), depending on site-specific considerations (EPA 1990, 0559). Based on current site conditions, the estimated cancer risks are within or below the range of acceptable risk levels. Given the conservative nature of this evaluation and the small size of the potential exposure area, this result indicates that COPC concentrations in the soil should not pose an unacceptable cancer risk under the exposure assumptions for the industrial scenario.

In Table A-8 and A-9, hazard quotients for the COPCs are presented by pathway for the MLE and RME industrial scenarios. The calculated hazard quotients for the MLE and RME are less than one, indicating exposures are not expected to result in adverse effects. Because all of the COPCs are metals, it is possible that additive exposure could result in toxicity. However, when hazard quotients for these COPCs are summed, the resultant hazard indices are less than one, indicating adverse effects are unlikely to occur effects under the exposure assumptions for the industrial scenario.

TABLE A-8

TA-50 NON-CANCER HEALTH HAZARD CALCULATED FROM SOIL SAMPLES NEAR PIPE RACK FOR MOST LIKELY EXPOSURE INDUSTRIAL SCENARIO

Chemical	Soil Ingestion	Hazard Quotient
Beryllium	1×10^{-04}	1×10^{-04}
Cadmium (food)	6×10^{-04}	6×10^{-04}
Chromium III	2×10^{-06}	2×10^{-06}
Chromium VI	8×10^{-05}	8×10^{-05}
Silver	3×10^{-04}	3×10^{-04}
Scenario Total (Hazard Index)		**0.001**

TABLE A-9

TA-50 NON-CANCER HEALTH HAZARD CALCULATED FROM SOIL SAMPLES NEAR PIPE RACK FOR REASONABLE MAXIMUM EXPOSURE INDUSTRIAL SCENARIO

Chemical	Soil Ingestion	Hazard Quotient
Beryllium	3×10^{-03}	3×10^{-03}
Cadmium (food)	2×10^{-02}	2×10^{-02}
Chromium III	7×10^{-05}	7×10^{-05}
Chromium VI	2×10^{-03}	2×10^{-03}
Silver	8×10^{-03}	8×10^{-03}
Scenario Total (Hazard Index)		**0.03**

1.4.3 Assessment of Uncertainty in the Risk Assessment

Uncertainty is inherent in many aspects of the risk assessment process and generally arises from a lack of knowledge concerning site conditions, the toxicology of the COPCs, and the degree to which an individual will be exposed to those chemicals. Various assumptions are then made based on information presented in the scientific literature or on professional judgment. While some assumptions have significant scientific basis, others have less scientific basis. The assumptions that introduce the greatest amount of uncertainty and their effect on the carcinogenic dose and noncarcinogenic risk estimates are discussed below. This discussion is qualitative in nature because the uncertainties associated with risk assessment results are often difficult to quantify.

1.4.3.1 Site Conditions

The soil samples that comprised the basis of this risk assessment were collected in a biased manner in the drainage pathway in order to increase the probability of detecting any elevated levels of chemicals. This biased sampling approach may lead to an over estimation of contamination present within an exposure unit. This, in turn, may lead to an overestimation of human health risk.

1.4.3.2 Toxicology of the Chemicals of Potential Concern

Uncertainty is inherent in the toxicity values for each COPC. The toxicity profiles discuss the scientific studies upon which the toxicity values are based. Uncertainty factors applied to the study results account for the quality of available data and differences between study animals and human populations, and are designed to provide a health protective bias. The uncertainty factors used to derive reference doses for COPCs range from 3 for silver, 10 for cadmium, to 100 for beryllium and chromium. The health protective bias embedded in the reference dose and cancer slope factor are more likely to overestimate rather than underestimate noncarcinogenic health effects and cancer risk.

1.4.3.3 Exposure Characteristics

Uncertainties are also inherent in the exposure characteristics for individual exposures. It is very unlikely that an industrial worker will choose to spend 2 hours per day lunching and working in the area of elevated levels of COPCs on a repetitive basis. Additionally, this risk assessment assumed that exposure to COPCs could actually occur, ignoring the storage unit

which covers half of the unpaved area. Therefore, the cancer risk and potential for noncarcinogenic adverse health effects are overestimated.

1.5 Conclusions

The results of the human health risk assessment suggest that potential exposure to COPCs in soil downgradient from the pipe rack would not result in adverse noncarcinogenic health effects or an unacceptable cancer risk to industrial users.