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United States Department of the Interior

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IN REPLY REFER TO:

ALB-407

HAND DELIVERED

AUG 0 7 1991

Mr. John Gould
1606 ABW/EM
Kirtland AFB NM 87117-5000

Subject: Data Evaluation of Reclamation's "First Order" Draft Risk Assessment for the Sewage Lagoons, Golf Course Pond and Associated Ground Water (Hazardous Waste)

Dear Mr. Gould:

Recently, Mr. Mike Silva of your office contacted Steve Hansen of our office about information related to performing risk assessments for the subject sites. Mike indicated that he was interested in the supporting data used in the assessment such as reference doses, slope factors and surrogates for his own analysis. He was unaware that we had recently finished similar work for the same sites and asked if we could share that information.

The work that we accomplished was done for OEHL through contract with the USGS. Ralph Wilcox of the USGS was asked if Mike could use this draft information prior to its review and acceptance. Ralph, in turn, unsuccessfully tried to reach Dennis Lundquist of OEHL to get his OK on the matter.

In the interest of cooperation and good science, Ralph and Steve decided that the information should be accessible to your work group as long as it was used as "preliminary draft" information for analysis purposes and not for decision making support material.

We are pleased to make the enclosed material available for your use in this way. If we can be of any further assistance with this information, let us know.

Sincerely,

Harry M. Rowe

for Charles A. Calhoun
Projects Manager

Enclosure

cc: Mr. Ralph Wilcox
US Geological Survey
Pinetree Office Park
4501 Indian School Road NE, Suite 200
Albuquerque NM 87110

KAFB1152

-----> P-R-E-L-I-M-I-N-A-R-Y D-R-A-F-T (6/14/91)

F I R S T - O R D E R E S T I M A T E S

I N

R I S K A S S E S S M E N T F O R S I T E 5

S E W A G E L A G O O N S

INTRODUCTION

In order to provide rough estimates of the Site 5 carcinogenic risks and non-carcinogenic hazard quotients with probable human exposure pathways, a 'first-order' baseline risk assessment evaluation has been conducted. The intent of this first-order evaluation is to sketch the general magnitude of the risks and hazards associated with Site 5 chemicals, without going to all of the expense and time required for a detailed analysis of pathway exposure factors and compilation of all available toxicological information. It is intended that these first-order estimates will provide information to the Contractor (Kirtland Air Force Base) that can be used to decide whether more detailed study is required according to the intended use of the baseline risk assessment evaluation. For planning purposes, it is anticipated that a more detailed second-order evaluation will probably cost $15k-$20k and require 3-4 months to complete.

This report is organized into sub-sections as follows:

I. IDENTIFICATION OF POTENTIALLY HAZARDOUS CHEMICALS AT SITE 5

Table 1 - Chemicals Identified at Site 5*

Chemical	Mean Concentration (95% confidence value)** In Sludge		In Soil Beneath Sludge	
NH3N (Ammonia)	230.	mg/kg	46.1	mg/kg
KN (Potassium Nitrate)	12196.	mg/kg	72.4	mg/kg
NO3NO2N (Nitrates)	30.1	mg/kg	1119.	mg/kg
AL (Aluminum)	6405.	mg/kg	5506.	mg/kg
BA (Barium)	427.	mg/kg	119.	mg/kg
BE (Beryllium)	0.47	mg/kg	0.34	mg/kg
CD (Cadmium)	53.	mg/kg	17.	mg/kg
CA (Calcium)	115238.	mg/kg	108218.	mg/kg
CO (Cobalt)	7.42	mg/kg	-	
CU (Copper)	2111.	mg/kg	40.3	mg/kg
FE (Iron)	14244.	mg/kg	9167.	mg/kg
PB (Lead)	276.	mg/kg	-	
MG (Magnesium)	4607.	mg/kg	3259.	mg/kg
MN (Manganese)	116.	mg/kg	83.6	mg/kg
MO (Molybdenum)	12.3	mg/kg	-	
NI (Nickel)	197.	mg/kg	6.4	mg/kg
K (Potassium)	981.	mg/kg	1423.	mg/kg
AG (Silver)	280.	mg/kg	12.9	mg/kg
V (Vanadium)	33.8	mg/kg	19.3	mg/kg
ZN (Zinc)	1005.	mg/kg	54.7	mg/kg
CR (Chromium)	1155.	mg/kg	21.1	mg/kg
HG (Mercury)	4.48	mg/kg	0.16	mg/kg
NA (Sodium)	519.	mg/kg	-	
FLUORANTHENE	5.52	mg/kg	-	
PYRENE	6.17	mg/kg	-	
2-BUTANONE	0.202	mg/kg	-	
BENZENE	0.101	mg/kg	-	
TOLUENE	0.158	mg/kg	-	
XYLENES	0.158	mg/kg	-	
PHENATHRENE	0.659	mg/kg	-	
FLUORANTHENE	2.18	mg/kg	-	
BZAA [BENZO(A)ANTHRACENE]	1.52	mg/kg	-	
CHRYSENE	1.75	mg/kg	-	
BZBF [BENZO(B)FLUORANTHENE]	1.32	mg/kg	-	
BZKF [BENZO(K)FLUORANTHENE]	1.35	mg/kg	-	
BZAP [BENZO(A)PYRENE]	1.35	mg/kg	-	

* Based on data provided by USGS (1991).

** Data provided initially by USGS (1991), gave chemical concentations based on the wet weight of the sample, rather than the dry weight. Thus the risk assessment calculations for the first-order estimates are based on wet weight concentrations. To be formally correct the risk assessment calculations should be based on dry weight concentrations. Thus in subsequent refinements, i.e., second-order estimates, this correction would be made. The effect of this correction will be small (on the order of a 10% increase in effective chemical concentrations) since the moisture contents for the samples utilized were around 2%-16%, with only one exception. The single exceptional sample had a moisture content between 70% and 80%.

II. TOXICOLOGY OF CHEMICALS IDENTIFIED AT SITE 5

Table 2 - Chemical Toxicology at Site 5: In Sludge & Soil Layer Beneath Sludge

Chemical	Slope-Factor/Reference Dose Level
NH3N (Ammonia)	HEAST - RfC: 0.36 mg/m3 (chronic and sub-chronic) Currently no carcenogenic effects identified.
KN (Potassium Nitrate)	John Raucher (EPA, Dallas) said that there is no data on potassium nitrate, and that he would recommend using 'nitrates' information for a surrogate
NO3NO2N (Nitrates)	From Michael Dourson (ECAO, Cincinnatti): IRIS - RfD: 1.6E+0 mg/kg/day No carcenoginic effects have been quantified
AL (Aluminum)	No defined health hazards
BA (Barium)	HEAST - RfC: 4E-4 mg/m3 (chronic) 4E-3 mg/m3 (sub-chronic) RfD: 1E-4 mg/kg/day (chronic) 1E-3 mg/kg/day (sub-chronic) No classification for Slope-Factor
BE (Beryllium)	HEAST - RfD: 5E-3 mg/kg/day (chronic,sub-chronic) No classification for Slope-Factor
CD (Cadmium)	HEAST - RfD: Food/ 1E-3 mg/kg/day (chronic) Water/4E-4 mg/kg/day (chronic) John Rauscher advised that we use the 'water' RfD, since it is the lowest and gives the most conservative approach John Rauscher said that cadmium is only carcinogenic by inhalation, the EPA classification is: B1, and the slope factor is: 6.1E+0 mg/kg/day
CA (Calcium)	Common Essential Element (John Rauscher, EPA)
CO (Cobalt)	John Rauscher said that there is no RfD, or slope factor in HEAST (or IRIS) for cobalt
CU (Copper)	John Rauscher said that the only health effects that have been detected are gastro-intestinal irritation from drinking water, and people turning bluish with high doses for vinereal disease treatment. HEAST - RfC: 1.3 mg/l for drinking water, no RfC is available for inhalation and John felt that with this and Silver it would be real dicey to extrapolate from one intake route to another, e.g., from drinking water to inhalation
FE (Iron)	Common Essential Element, no health effects

	identified
PB (Lead)	John Rauscher said that there is no reference dose level available for lead; ECAO has developed a complicated model for intake. He can send us a copy of this model (IBM compatible), or John can run this for us. He needs the following data inputs: - (ambient plus site-caused) air lead levels - drinking water levels (model assumes 4 mg/l as default, which is a pretty good estimate for unknown values) - soil lead levels in children's play areas, and general exposure areas - paint exposure (give approximate age of houses)
MG (Magnesium)	Common Essential Element
MN (Manganese)	HEAST: RfC: 4E-4 mg/m3 (chronic,sub-chronic) No slope factor provided
MO (Molybdenum)	HEAST: No RfC level given RfD: 4E-3 mg/kg/day (chronic, sub-chronic), No slope factor available
NI (Nickel)	HEAST - RfD: 2E-2 mg/kg/day (chronic, sub-chronic) John Rauscher said that the RfD value depends on the specific chemical species, as examples: for refinery dust, RfD: 8.4E-1 whereas for Nickel/sulfide the RfD: 1.7E+0 John said that Nickel is a B2 carcinogen, i.e., probable carcinogenic effects, but there have been do data available for slope factors to date.
K (Potassium)	Common Essential Element
AG (Silver)	HEAST - RfC: Not determined for inhalation RfD: 3E-3 mg/kg/day No slope factor available
V (Vanadium)	HEAST - RfC: Not determined RfD: 7E-3 mg/kg/day No slope factor available
ZN (Zinc)	HEAST - RfC: None available RfD: 2E-1 (chronic, sub-chronic) No slope factor available
CR (Chromium)	CrIII (ECAO) - RfC: 2E-6 mg/m3 (inhalation) RfD: 1E+0 mg/kg/day No slope factor determined CrVI (ECAO) - RfC: 2E-6 mg/m3 (inhalation) RfD: 5E-3 mg/kg/day Slope Factor (inhalation):

4.1E+1

HG (Mercury)	HEAST: RfC: 3E-4 mg/m3 (chronic, sub-chronic) U.F. 30 (low) RfD: 3E-4 mg/kg/day these reference values are for neurotoxicity No slope factor listed
NA (Sodium)	Common Essential Element
FLUORANTHENE	ECAO (Pei-Fung): RfC: No data RfD: 4E-2 mg/kg/day
PYRENE	ECAO (Pei-Fung): RfC: No data RfD: 3E-2 mg/kg/day
2-BUTANONE	HEAST: RfC: 3E+0 mg/m3 (sub-chronic) 3E-1 mg/m3 (chronic) RfD: 5E-1 mg/kg/day (sub-chronic) 5E-2 mg/kg/day (chronic)
BENZENE	ECAO (Pei-Fung): RfC: 5E-3 RfD: No data Slope (inhalation): 2.9E-2 Slope (oral): 2.9E-2 mg/kg/day
TOLUENE	ECAO (Pei-Fung): RfC: 2E+0 mg/kg/day RfD: 2E-1 mg/kg/day
XYLENES	ECAO (Pei-Fung): RfC: 3E-1 mg/kg/day RfD: 2E+0 mg/kg/day

PHENATHRENE

John Rauscher said that he could not find in HEAST, Chrysene or Phenanthrene, and that we should go ahead and use Fluoranthene as a surrogate for Chrysene and Phenanthrene

FLUORANTHENE	ECAO (Pei-Fung): RfC: No data RfD: 4E-2 mg/kg/day No slope-factor available

CHRYSENE

John Rauscher suggested taht for the following four chemicals, we use BAP or BZAP, i.e., the last of the four, as a surrogate. If there is no risk with this surrogate assumption, then there is no risk, since BAP is the worst of the four chemicals. John suggested that for reference dose levels, that we use Fluoranthene for a surrogate. John said that BAP is carcenogenic by inhalation. Slope Factors for BAP are (HEAST): 6.1 (Inhalation), 11.5 (Oral)

BZAA [BENZO(A)ANTHRACENE]
BZBF [BENZO(B)FLUORANTHENE]
BZKF [BENZO(K)FLUORANTHENE]
BZAP [BENZO(A)PYRENE]

John said that Chromium III, Fluoranthene, Phenanthrene, Pyrene, Toluene, and Xylenes are most probably non-carcenogenic.

III. PATHWAYS FOR HUMAN EXPOSURE TO SITE 5 CHEMICALS

This baseline risk-assesment includes evaluation of surface-pathway exposure routes, and thus does not include consideration of sub-surface groundwater transport, either on-site, or off-site. Also, surface runoff is not a likely pathway for contaminant transport. The sewage lagoons are completely bermed at the margin, and based on the topography of the locale, the probability of sludge dislodgmment and transport by surface flood conditions is essentially zero. Thus advective surface-runoff transport was not considered in this evaluation.

Conceptually, the remaining surface-pathway exposure routes may be described as follows:

General Exposure Pathways for Human Exposures to Site 5 Chemicals

- Direct ingestion of contaminated soil, through on-site* or off-site** (re-deposited fugitive dust) activites
- Dermal absorption through direct contact with contaminated soil, through on-site or off-site activities
- Dermal absorption as a result of volitilization from on-site or off-site soil, thorough on-site or off-site activities
- Inhalation as a result of volitilization from on-site or off-site soil, through on-site or off-site activities
- Inhalation as a result of fugitive dust suspension, through on-site or off-site activities
- Ingestion of contaminated on-site or off-site vegetation
- Ingestion of contaminated 'on-site' or off-site bird/animal tissue or milk products***

* On-site exposures are defined as exposures where primary concentration of human exposure was determined by on-site initial vegetative/animal/human biological intake. Thus on-site exposure could include off-site ingestation of bird/animal tissue.

** Off-site exposures are defined as exposures where primary concentration of exposure was determined by off-site initial vegetative/invertebrate/vertebrate(bird or animal)/human biological intake.

*** With this pathway there are multiple possible sub-routes as suggested in the following:

1-direct ingestion of primary biological receptor
2-vegetation-to-vertebrate
3-vegetation-to-invertebrate-to-vertebrate
4-vegetation-to-vertebrate-to-vertebrate
5-vegetation-to-invertebrate-to-vertebrate-to-vertebrate
6-etc.

It has been requested by the Contractor (Kirtland AFB), that in this baseline risk assessment only two scenarios be evaluated, as follows:

1) Off-site human exposures during a 3-year period (from present), with existing conditions,
2) On-site human exposures during a 3-month period of site-cleanup construction activities with approximate existing conditions.

Based on these scenarios, judgement suggests that primary pathways for maximum potential human exposures to Site 5 chemicals would be restricted to the following:

Pathways with 3-year exposure and existing conditions -

A) Wind-deposited soil ingestion -
- a) Age group: child and adult
- b) Location: OFF-SITE, 1/8-3/4 miles north of site (except for possible brief incidental exposures)

B) Wind-dust inhalation -
- a) Age group: child and adult
- b) Location: OFF-SITE, 1/8-3/4 miles north of site (except for possible brief incidental exposures)

Pathways with 3-month exposures during construction cleanup -

C) Direct soil ingestion -
- a) Age group: adult
- b) Location of peak exposure: ON-SITE

D) Construction-dust inhalation -
- a) Age group: adult
- b) Location: ON-SITE

E) Wind-deposited soil ingestion -
- a) Age group: child and adult
- b) Location: OFF-SITE, 1/8-3/4 miles north of site (except for possible brief incidental exposures)

F) Windblown Construction-dust inhalation -
- a) Age group: child and adult
- b) Location: OFF-SITE, 1/8-3/4 miles north of site (except for possible brief incidental exposures)

In this baseline risk assessment, only these 6 pathways were considered. If it is determined that human exposure levels via these primary pathways is unacceptably high or near threshold values for concern, then it may be necessary to further analyze additional secondary pathways to obtain a more accurate estimate of total human exposures.

IV. GENERAL CONSIDERATIONS FOR FUGITIVE-DUST EXPOSURES TO SITE 5 CHEMICALS

Of the six basic pathways considered, five pathways involve the airborne suspension of chemical materials as fugitive dust, three involve the windborne transport, and two pathways involve the off-site re-deposition of airborne fugitive dust which originated with source suspension.

Primary quantitative uncertainties in evaluating airborne pathway exposures include:

Pathway	On-Site Suspension	Wind Transport & Dispersion	Off-Site Re-deposition
A	a) On-site rate of suspension of sludge as a function of wind speed, and size distribution of particulates?	b) Dilution in downstream wind plume, as functions of wind speed and direction?	c) Pattern of redeposition of fugitive dust particulate sludge material?
B	a) On-site rate of suspension of sludge as a function of wind speed, and size distribution of particulates?	b) Dilution in downstream wind plume, as functions of wind speed and direction?	N/A
D	a) On-site rate of suspension of sludge as a function of wind speed, and size distribution of particulates?	N/A	N/A
E	a) On-site rate of suspension of sludge as a function of wind speed, and size distribution of particulates?	b) Dilution in downstream wind plume, as functions of wind speed and direction?	c) Pattern of redeposition of fugitive dust particulate sludge material?
F	a) On-site rate of suspension of sludge as a function of wind speed, and size distribution of particulates?	b) Dilution in downstream wind plume, as functions of wind speed and direction?	N/A

Soil (sludge) erosion, dispersion, and re-distribution due to surface wind, is a complicated function of several factors, including:

- wind velocity,
- wind turbulence structure,
- wind temperature and humidity,
- cohesion of surface 'soil' material,
- shielding of surface materials by berm, fence, etc.,
- particle size and effective volume to mass ratio, i.e. effective particle density.

With present levels of understanding, the most accurate quantification of the erosion, sus usually require detailed on-site field data; and the second most accurate quantification requires detailed modelling analysis. Such field data is not available*; and as stated previously detailed modelling analysis was intentionally excluded from this analysis. To obtain conservative first-order estimates judgemental approximations were made for the erosion, dispersion, and re-deposition processes. These approximations are detailed in the next sub-section (V), of this report.

* In personal communications, Ralph Wilcox (USGS, spring 1991) has offered the observation that most of the windblown removal of lagoon sludge material occurs during the late fall and winter. During this time the tumble weeds that have grown up during the previous summer dry up and are blown across the surface of the lagoon. The scarification of surface sludge materials by these large weeds loosens and breaks up the dry sludge, and makes it available for wind erosion and suspension with prevailing wind conditions during this seasonal period. At present, according to Wilcox, all of the sludge has been removed down to the native soil level in the center section of the south lagoon. This removal has occurred during the last three years since the de-watering of the lagoons.

Wind Conditions in the vicinity of Kirtland Air Force Base have been reported (USGS, 1991) as follows:

MONTH	Wind Mean Speed (mph)	Prevailing Direction
January	8	N
February	9	N
March	10	NNW
April	10	NNW
May	10	S
June	10	S
July	9	SE
August	8	SSE
September	8	SSE
October	8	SSE
November	8	NNW
December	7	N

Thus the prevailing winds are somewhat constant in speed throughout the year, and the prevailing directions are northerly in winter and southerly in summer. Primary human exposure opportunities lie to the north of Site 5, with Air Force Base facilities within a fraction of a mile, and the City of Albuquerque within 1-1/2 miles. To the south Sandia Military Reservation facilities provide opportunities for persistent human exposures within approximately 4 miles.

It might be noted that if the primary windblown removal of material from the sludge ponds occurs during late fall and winter as suggested by Wilcox, the exposures would be primarily to personnel 4 miles away in the Sandia Military Reservation facilities. Whereas is there is an equal windblow transport potential winter and summer then the primary exposures would be to personnel occupying facilities just north of the sludge lagoons on the Air Force Base. For a worst-case scenario the latter conditions were assumed.

V. ASSUMPTIONS REGARDING HUMAN INTAKE LEVELS

3-YEAR PERIOD EXISTING CONDITIONS (OFF-SITE EXPOSURES) -

Pathway 1 - Off-Site Direct Ingestion of Sludge; 3-year Period

Assumptions:

Soil Ingestion/Day:

The Exposure Factors Handbook (EPA, 1989a) offers the following: "average soil ingestion in the population of young children (under the age of 7) is estimated at approximately 0.1 to 0.2 g/day. For calculation purposes, an estimate of 0.2 g/day is suggested as an average value. An upper-range ingestion estimate estimate among children with a higher tendency to ingest soil materials is 0.8 g/day. . . Soil ingestion rates for children who exhibit abnormal behavior soil ingestion behavior and for people older than 6 cannot be recommended because of the lack of data."

Hawley (1985) has reported the following:

Scenarios	Exposure (mg/day)	Days/year activity	Annual average (mg/day)
Young child (2-5 years old)			
Outdoor activites (summer)	250	130	90
Indoor activities (summer)	50	182	25
Indoor activities (winter)	100	182	50
			165
Older child (6 years old)			
Outdoor activities (summer)	50	152	21
Indoor activities (year-around)	3	365	3
			24
Adult			
Work in attic (year-around)	110	12	3.7
Living space (year-around)	0.56	365	0.56
Outdoor work (summer)	480	43	57
			61.26

Based on these data and values utilized in Table 3 or EPA's Risk Assessment Guidelines (1989b), the following values were assumed for child and adult ingestion rates:

Child (1-6 years old): 200 mg/day year-around

Older children/Adult (+6 years old): 100 mg/day year-around

Fraction of Soil Ingested, from Contaminated Source (Lagoons):

The re-deposition pattern for windblown transport has not been analyzed in detail, and thus as a first approximation, the very conservative assumption was made that the off-site 'soil' ingested would have the same chemical composition as the lagoonal materials; and the the fraction of contaminated soil ingested was assumed to have a value of unity.

Body Weight:

Target worst-case personnel would include adults as well as children with regard to pathway exposure. Based on EPA's recommendation, the following values were assumed for body weights:

Child: 16 kg (Table 3, EPA, Risk manual, 1989b)
Adult: 70 kg (Table 3, EPA, Risk manual, 1989b)

Exposure Frequency:

For the first-order estimates it was assumed that the exposure frequency would be 365 days/year.

Exposure Duration:

As per Contractor specification, an exposure duration of 3 years was assumed.

Averaging Time:

As per EPA guidance and procedures, the following exposure averaging period was utilized:

Carcinogenic effects: 70 year lifetime (Table 3, EPA, Risk manual, 1989b)

Non-carcinogenic effects: 3-year exposure period

Pathway 2 - Off-Site Direct Ingestion of Soil Beneath Sludge; 3-year Period

Assumptions:

SAME AS PATHWAY 1 [due to present bare ground conditions, which allow for exposure of soil to wind suspension throughout 3-year period]

Pathway 3 - Off-Site Inhalation of Sludge; 3-year Period

Assumptions:

Human Inhalation Rates:

The Exposure Factors Handbook (EPA, 1989a) offer the following (Table 3-1, page 3-4):

Summary of Human Inhalation Rates for Men, Women and Children by Activity Level (m3/hour)[a]

	Resting[b]	Light[c]	Moderate[d]	Heavy[e]
Adult male	0.7	0.8	2.5	4.8
Adult female	0.3	0.5	1.6	2.9
Average adult[f]	0.5	0.6	2.1	3.9
Child, age 6	0.4	0.8	2.0	2.4
Child, age 10	0.4	1.0	3.2	4.2

a - Values of inhalation rates for males, females, and children presented in this table represent the mean of values reported for each activity level in USEPA (1985).
b - Includes watching television, reading, and sleeping.
c - Includes most domestic work, attending to personal needs and care, hobbies, and conducting minor indoor repairs and home improvements.
d - Includes heavy indoor cleanup, perfromance of major infoor repairs and alternations, and climbing stairs.
e - Includes vigorous physical exercise and climbing stairs carrying a load.
f - Derived by taking the mean of the adult male and adult female values for each activity level.

And from page 3-7, Table 3-2 (EPA, 1989a):

Activity Pattern Data Aggregated for Three Microenvironments by Activity Level

Microenvironment	Activity level	Average hours in each microenvironment at each activity level
Indoors	Resting	9.82
	Light	9.82
	Moderate	0.71
	Heavy	0.098
	Sub-Total:	20.4
Outdoors	Resting	0.505
	Light	0.505
	Moderate	0.65
	Heavy	0.12
	Sub-Total:	1.77
In transportation vehicle	Resting	0.86
	Light	0.86
	Moderate	0.05
	Heavy	0.0012
	Sub-total:	1.77

From page 3-6 (EPA,1989a), "For continuous exposure situations, or assessments in which specific activity patterns are not known, use 20 cubic meters/day as the adult daily inhalation rate, and 30 cubic meters/day as the reasonable worst-case inhalation rate." For the first-order estimates it was assumed that the daily inhalation rate would be 20 cubic meters for adults and 30 cubic meters per day for children.

Fugitive Dust Concentration at Off-Site Exposure Locations:

As noted previously, along the centerline of the downwind plume created by the suspension of solid material from a surface source, i.e., lagoon sludge areas, the concentration of fugitive dust from this source is a complicated function of wind velocity, local vertical and horizontal atmospheric conditions in terms of temperature and humidity, uptake (erosion) rate of source material, particle size distribution and density in the fugitive dust, and vertical and horizontal wind turbulence structure, i.e., surface roughness.

Based on consideration of a 3-year period, a worst-case scenario would be for complete wind removal of all lagoon sludge and the contaminated soil layer beneath the sludge during this period.

Based on the average local wind conditions (approximately 10 ft/sec average wind speed), which is fairly constant throughout the year; and conservatively assuming an effective 10-foot windblown-sludge plume height at the downwind boundary of the lagoonal area, and assuming an in-situ sludge density of 0.5 gm/cc, the average concentration of sludge material in the plume can be calculated, based on complete removal of a 3-inch sludge layer during a 3-year period.

$$CS(mean) = \frac{3 \times 12 \times 1200 \times 12 \times (2.54)^{3} \times 0.5}{10 \times 10 \times 24 \times 3600 \times 365 \times 3 \times 1}$$

CS(mean) = 0.45 mg/cubic foot [= 15.9 mg/cubic meter]

For the contaminated soil beneath the sludge with an assumed in-situ density of 1.5 gm/cc, and a depth of 3 inches, the mean concentration of the plume at the boundary would be estimmated at:

$$CO(mean) = \frac{3 \times 12 \times 1200 \times 12 \times (2.54)^{3} \times 1.5}{10 \times 10 \times 24 \times 3600 \times 365 \times 3 \times 1}$$

CO(mean) = 1.35 mg/cubic foot [= 47.7 mg/cubic meter]

For reference, data provided by Chepil and Woodruff (1957), suggest that wind dust concentrations near the surface (6-foot elevation), can vary from 0.1 mg/cubic foot up to 100 mg/cubic foot, with the respective ranges of daytime visibility varying from 6 miles down to 100 feet (see Figure A).

The vertical (and horizontal) dimensions of the windblown plume will increase downwind from the source lagoon area, and consequently the fugitive dust concentrations will decrease. However, for simplification and to be conservative, as a first-order approximation it was assumed that the lagoonal wind dust concentrations will be the same at the downstream exposure locations as the mean concentration estimated near the lagoon boundary calculated above near the lagoonal areas. This conservative assumption also neglects the possible (permanent) re-deposition of windblown sludge material upstream from the exposure locations.

Body Weight:

The target personnel for a worst-case scenario would include adults, children, and infants. Based on EPA recommendation, the following values were assumed for body weights:

Child: 16 kg
Adult: 70 kg

Exposure Frequency:

It is assumed that the exposure period would be limited to the summer months, i.e., 183 days/year, and that during the exposure days the maximum outdoor exposure times would be 16 hours/day for both children and adults. These assumptions give an effective exposure period of: 122 days/year for both children and adults.

Exposure Duration:

As per Contractor specification, an exposure of 3 years duration was assumed.

Averaging Time:

As per EPA guidance and procedures, the following exposure averaging period was utilized:

Carcinogenic effects: 70 year lifetime (Table 3, EPA, Risk manual, 1989)

Non-carcinogenic effects: 3-year exposure period

Pathway 4 - Off-Site Inhalation of Soil Beneath Sludge; 3-year Period

Assumptions:

SAME AS PATHWAY 3 ABOVE [due to present bare ground conditions, which allow for exposure of soil to wind suspension throughout 3-year period]

3-MONTH CONSTRUCTION PERIOD (ON-SITE EXPOSURES) -

Pathway 5 - On-Site Direct Ingestion of Sludge; 3-month Period

Assumptions:

Soil Ingestion/Day:

Based on data referred to with Pathway 1, the following value was assumed for adult ingestion rates on-site during construction activities:

Adult: 100 mg/day

Fraction of Soil Ingested, from Contaminated Source (Lagoons):

Assume a value of unity for on-site exposures.

Body Weight:

The target personnel with this pathway would include only adults. Based on EPA recommendation, the following value was assumed for body weight:

Adult: 70 kg

Exposure Frequency:

To be conservative, for first-order estimates assume 7-day work week, for 90 days (3 months).

Exposure Duration:

Assume mixed (sludge and soil) ground conditions throughout construction period, thus exposure durations would be specified 3-month construction time.

Averaging Time:

As per EPA guidance and procedures, the following exposure averaging period was utilized:

Carcinogenic effects: 70 year lifetime (Table 3, EPA, Risk manual, 1989)

Non-carcinogenic effects: 3-month period

Pathway 6 - On-Site Direct Ingestion of Soil Beneath Sludge; 3-month Period

Assumptions:

SAME AS PATHWAY 5 ABOVE [due to probable mixed (sludge/soil) ground conditions throughout construction period, which allow for exposure of soil throughout 3-month period]

Pathway 7 - On-Site Inhalation of Sludge; 3-month Period

Assumptions:

Inhalation Rates:

Based on data provided with Pathway 3, assume adult male moderate outdoor activity rate of 2.0 m3/hr, or 20 m3 per 10-hour shift (Table 3-2, EPA 1989a).

Fugitive Dust Concentration at On-Site Exposure Locations:

Assume average airborne concentration levels 10 times (judgemental worst-case estimate based on rough appraisal of potential construcation activity conditions) average windblown levels assumed in Pathway 3, or C(mean)= 4.5mg/cubic foot = 158.9 mg/m3, during on-site construction activities.

Body Weight:

The target personnel with this pathway would presumably include only adult personnel. Based on EPA recommendation, the following values were assumed for body weights:

Adult: 70 kg

Exposure Frequency:

Assume and 10 hour shift, 7 days per week during 3-month (90-day) construction period, for an effective exposure period of 38 days during the 3-month period.

Exposure Duration:

Assume mixed (sludge and soil) ground conditions throughout construction peirod, thus exposure durations would be specified 3-month construction time.

Averaging Time:

As per EPA guidance and procedures, the following exposure averaging period was utilized:

Carcinogenic effects: 70 year lifetime (Table 3, EPA, Risk manual, 1989)

Non-carcinogenic effects: 3-month period

Pathway 8 - On-Site Inhalation of Soil Beneath Sludge; 3-month Period

Assumptions:

SAME AS PATHWAY 7 ABOVE, except assume average levels 5 times (judgemental worst-case estimate based on rough appraisal of potential construcation activity conditions) average windblown levels assumed with Pathway 1, CO(mean)= 6.8 mg/cubic foot = 238.4 mg/m3, during on-site construction activities.

3-MONTH (CONSTRUCTION) PERIOD (OFF-SITE EXPOSURES) -

Pathway 9 - Off-Site Inhalation of Sludge; 3-month Period

Assumptions:

SAME AS PATHWAY 7 ABOVE

Pathway 10 - Off-Site Inhalation of Soil Beneath Sludge; 3-month Period

Assumptions:

SAME AS PATHWAY 8 ABOVE

VI. FIRST-ORDER CARCINOGENIC RISK ESTIMATES

Based on the slope-factors provided in Table 2, carcinogenic risks due to lagoon contaminants are provided INDEPENDENTLY for the 3-year scenario, and the 3-month construction scenario, as follows:

3-Year Scenario (Off-Site) -

Potential Worst-Case: Carcinogenic Risk for children -

Risk[WORST OF Pathway 1 OR Pathway 2] + Risk[WORST OF Pathway 3 OR Pathway 4]

3-Month Scenario -

On-Site:

Potential Worst-Case: Carcinogenic Risk for adults -

Risk[WORST OF Pathway 5 OR Pathway 6] + Risk[WORST OF Pathway 7 OR Pathway 8]

Off-Site:

Potential Worst-Case: Carcinogenic Risk for adults -

Risk[WORST OF Pathway 1 OR Pathway 2] + Risk[WORST OF Pathway 11 OR Pathway 12]

Based on formatting suggested in Exhibit 8-2 of EPA's Risk Assessment Guidance (1989b), the following results are provided:

C A N C E R   R I S K   E S T I M A T E S

3-YEAR SCENARIO CARCINOGENIC RISKS (WORST CASE: CHILD)

Chemical	Chronic Daily Intake (CDI)	Slope Factor	Chemical Specific Risk	Total Pathway Risk	Total Exposure Risk
	mg/kg/day	(surrogate)			
Worst of Pathways 1 and 2: Off-Site Direct Ingestion					
NH3-N (Ammonia)					
KN (Pot. Nitrate)					
NO3+NO2-N (Nitrates)					
AL (Aluminum)					
BA (Barium)					
BE (Beryllium)					
CD (Cadmium)					
CA (Calcium)					
CO (Cobalt)					
CU (Copper)					
FE (Iron)					
PB (Lead)					
MG (Magnesium)					
MN (Manganese)					

MO (Molybdenum)				
NI (Nickel)				
K (Potassium)				
AG (Silver)				
V (Vanadium)				
ZN (Zinc)				
CR (Chromium)				
HG (Mercury)				
NA (Sodium)				
FLUORANTHENE				
PYRENE				
2-BUTANONE				
BENZENE	0.5E-07	0.03	0.2E-08	
TOLUENE				
XYLENES				
PHENATHRENE				
CHRYSENE				
BZAA	0.8E-06	(11.5)	1.0E-05	
BZBF	0.7E-06	(11.5)	0.8E-05	
BZKF	0.7E-06	(11.5)	0.8E-05	
BZAP	0.7E-06	11.5	0.8E-05	
				3.4E-05

- -

Worst of Pathways 3 and 4: Off-Site Inhalation Exposure

- -

NH3-N (Ammonia)				
KN (Pot. Nitrate)				
NO3+NO2-N (Nitrates)				
AL (Aluminum)				
BA (Barium)				
BE (Beryllium)				
CD (Cadmium)	0.2E-04	6.1	0.1E-03	
CO (Cobalt)				
CU (Copper)				
PB (Lead)				
MN (Manganese)				
MO (Molybdenum)				
NI (Nickel)				
K (Potassium)				
AG (Silver)				
V (Vanadium)				
ZN (Zinc)				
CR (Chromium)	0.5E-03	41.0	0.2E-01	
HG (Mercury)				
FLUORANTHENE				
PYRENE				
2-BUTANONE				
BENZENE	0.4E-07	0.03	0.1E-08	
TOLUENE				
XYLENES				
PHENATHRENE				
CHRYSENE				
BZAA	0.6E-06	(6.1)	0.4E-05	
BZBF	0.6E-06	(6.1)	0.3E-05	
BZKF	0.6E-06	(6.1)	0.4E-05	
BZAP	0.6E-06	6.1	0.4E-05	
				0.2E-01

Nearby AFB Residential Population in Area -- Estimated Cancer Risk:

0.2E-01

3-MONTH SCENARIO CARCINOGENIC RISKS

ON-SITE (WORST CASE: ADULT)

Chemical	Chronic Daily Intake (CDI)	Slope Factor	Chemical Specific Risk	Total Pathway Risk	Total Exposure Risk
	mg/kg/day	(surrogate)			
Worst of Pathways 5 and 6: On-Site Direct Ingestion					
NH3-N (Ammonia)					
KN (Pot. Nitrate)					
NO3+NO2-N (Nitrates)					
AL (Aluminum)					
BA (Barium)					
BE (Beryllium)					
CD (Cadmium)					
CA (Calcium)					
CO (Cobalt)					
CU (Copper)					
FE (Iron)					
PB (Lead)					
MG (Magnesium)					
MN (Manganese)					
MO (Molybdenum)					
NI (Nickel)					
K (Potassium)					
AG (Silver)					
V (Vanadium)					
ZN (Zinc)					
CR (Chromium)					
HG (Mercury)					
NA (Sodium)					
FLUORANTHENE					
PYRENE					
2-BUTANONE					
BENZENE	0.5E-09	0.03	0.2E-10		
TOLUENE					
XYLENES					
PHENATHRENE					
CHRYSENE					
BZAA	0.8E-08	(11.5)	0.9E-07		
BZBF	0.7E-08	(11.5)	0.8E-07		
BZKF	0.7E-08	(11.5)	0.8E-07		
BZAP	0.7E-08	11.5	0.8E-07		
				3.3E-07	

Worst of Pathways 7 and 8: On-Site Inhalation Exposure

NH3-N (Ammonia)					
KN (Pot. Nitrate)					
NO3+NO2-N (Nitrates)					
AL (Aluminum)					
BA (Barium)					
BE (Beryllium)					
CD (Cadmium)	0.2E-04	6.1	0.1E-03		
CO (Cobalt)					
CU (Copper)					
PB (Lead)					
MN (Manganese)					
MO (Molybdenum)					
NI (Nickel)					
K (Potassium)					
AG (Silver)					
V (Vanadium)					
ZN (Zinc)					
CR (Chromium)	0.5E-03	41.0	0.2E-01		
HG (Mercury)					
FLUORANTHENE					
PYRENE					
2-BUTANONE					
BENZENE	0.4E-07	0.03	0.1E-08		
TOLUENE					
XYLENES					
PHENATHRENE					
CHRYSENE					
BZAA	0.7E-06	(6.1)	0.4E-05		
BZBF	0.6E-06	(6.1)	0.4E-05		
BZKF	0.6E-06	(6.1)	0.4E-05		
BZAP	0.6E-06	6.1	0.4E-05		
				0.2E-01	

AFB Construction Workers On-Site -- Estimated Cancer Risk

					0.2E-01

3-MONTH SCENARIO CARCINOGENIC RISKS

OFF-SITE (WORST-CASE: CHILD)

Chemical	Chronic Daily Intake (CDI)	Slope Factor	Chemical Specific Risk	Total Pathway Risk	Total Exposure Risk
	mg/kg/day	(surrogate)			

Worst of Pathways 1 and 2: Off-Site Direct Ingestion

NH3-N (Ammonia)				
KN (Pot. Nitrate)				
NO3+NO2-N (Nitrates)				
AL (Aluminum)				
BA (Barium)				
BE (Beryllium)				
CD (Cadmium)				
CA (Calcium)				
CO (Cobalt)				
CU (Copper)				
FE (Iron)				
PB (Lead)				
MG (Magnesium)				
MN (Manganese)				
MO (Molybdenum)				
NI (Nickel)				
K (Potassium)				
AG (Silver)				
V (Vanadium)				
ZN (Zinc)				
CR (Chromium)				
HG (Mercury)				
NA (Sodium)				
FLUORANTHENE				
PYRENE				
2-BUTANONE				
BENZENE	0.5E-07	0.03	0.2E-08	
TOLUENE				
XYLENES				
PHENATHRENE				
CHRYSENE				
BZAA	0.8E-06	(11.5)	1.0E-05	
BZBF	0.7E-06	(11.5)	0.8E-05	
BZKF	0.7E-06	(11.5)	0.8E-05	
BZAP	0.7E-06	11.5	0.8E-05	
				3.4E-05

Worst of Pathways 7 and 8: Off-Site Inhalation Exposure

NH3-N (Ammonia)			
KN (Pot. Nitrate)			
NO3+NO2-N (Nitrates)			
AL (Aluminum)			
BA (Barium)			
BE (Beryllium)			
CD (Cadmium)	0.2E-04	6.1	0.1E-03
CO (Cobalt)			
CU (Copper)			
PB (Lead)			
MN (Manganese)			
MO (Molybdenum)			
NI (Nickel)			
K (Potassium)			
AG (Silver)			
V (Vanadium)			
ZN (Zinc)			
CR (Chromium)	0.5E-03	41.0	0.2E-01
HG (Mercury)			

FLUORANTHENE				
PYRENE				
2-BUTANONE				
BENZENE	0.4E-07	0.03	0.1E-08	
TOLUENE				
XYLENES				
PHENATHRENE				
CHRYSENE				
BZAA	0.7E-06	(6.1)	0.4E-05	
BZBF	0.6E-06	(6.1)	0.4E-05	
BZKF	0.6E-06	(6.1)	0.4E-05	
BZAP	0.6E-06	6.1	0.4E-05	
				0.2E-01

Nearby AFB Residential Population in Area -- Estimated Cancer Risk

0.2E-01

VII. ESTIMATED NON-CARCINOGENIC HAZARD QUOTIENT ESTIMATES

Based on the reference dose levels provided in Table 2, non-carcinogenic risks due to lagoon contaminants are provided INDEPENDENTLY for the 3-year scenario, and the 3-month construction scenario, as follows:

3-Year Scenario (Off-Site) -

Potential Worst-Case: Hazard Quotients for children -

([WORST OF Pathway 1 OR Pathway 2]Dose +
[WORST OF Pathway 3 OR Pathway 4]Dose)/(Reference Dose)

3-Month Scenario -

On-Site:

Potential Worst-Case: Hazard Quotients for adults -

([WORST OF Pathway 5 OR Pathway 6]Dose +
[WORST OF Pathway 7 OR Pathway 8]Dose)/(Reference Dose)

Off-Site:

Potential Worst-Case: Hazard Quotients for children -

([WORST OF Pathway 1 OR Pathway 2]Dose +
[WORST OF Pathway 11 OR Pathway 12]Dose)/(Reference Dose)

With the specified 3-year and 3-month scenarios, the maximum exposure times are less than 7 years, so only sub-chronic hazard index estimates need to be calculated. Based on formatting suggested in Exhibit 8-3 of EPA's Risk Assessment Guidance (1989b):

(S U B - C H R O N I C) H A Z A R D Q U O T I E N T E S T I M A T E S

3-YEAR SCENARIO NON-CARCINOGENIC HAZARD QUOTIENTS (WORST CASE: CHILD)

Chemical	Sub-Chronic Daily Intake (SDI)	Reference Dose (RfD)	Hazard Quotient	Pathway Hazard Quotient	Total Exposure Hazard Index
	mg/kg/day	mg/kg/day (surrogate)			
Worst of Pathways 1 and 2: Off-Site Direct Ingestion					
NH3-N (Ammonia)					
KN (Pot. Nitrate)	0.2E+00	(1.6E+00)	0.1		
NO3+NO2-N (Nitrates)	0.1E-01	1.6E+00	0.009		
AL (Aluminum)					
BA (Barium)	0.5E-02	1.0E-03	5.		
BE (Beryllium)	0.6E-05	0.5E-02	0.001		
CD (Cadmium)	0.7E-03	1.0E-03	2.		

CA (Calcium)			
CO (Cobalt)			
CU (Copper)			
PB (Lead)			
MG (Magnesium)			
MN (Manganese)			
MO (Molybdenum)	0.2E-03	0.4E-02	0.04
NI (Nickel)	0.2E-02	0.2E-01	0.1
AG (Silver)	0.4E-02	0.3E-02	1.
V (Vanadium)	0.4E-03	0.7E-02	0.06
ZN (Zinc)	0.1E-01	0.2E+00	0.06
CR (Chromium)	0.1E-01	0.5E-02	3.
HG (Mercury)	0.6E-04	0.3E-03	0.2
FLUORANTHENE	0.7E-04	0.4E-01	0.002
PYRENE	0.8E-04	0.3E-01	0.003
2-BUTANONE	0.2E-05	0.5E+00	0.000005
BENZENE			
TOLUENE	0.2E-05	0.2E+00	0.000009
XYLENES	0.2E-05	0.2E+01	0.0000009
PHENATHRENE	0.8E-05	0.4E-01	0.0002
CHRYSENE	0.2E-04	0.4E-01	0.0005
BZAA			
BZBF			
BZKF			
BZAP			

11.58

Worst of Pathways 3 and 4: Off-Site Inhalation Exposure

		Reference Concentration (RfC) mg/m3	
NH3-N (Ammonia)	0.2E-02	3.6E-01	0.02
KN (Pot. Nitrate)			
NO3+NO2-N (Nitrates)			
AL (Aluminum)			
BA (Barium)			
BE (Beryllium)			
CD (Cadmium)			
CO (Cobalt)			
CU (Copper)			
PB (Lead)			
MN (Manganese)	0.1E-02	4.0E-04	10.
MO (Molybdenum)			
NI (Nickel)			
K (Potassium)			
AG (Silver)			
V (Vanadium)			
ZN (Zinc)			
CR (Chromium)	0.1E-01	2.0E-06	20000.
HG (Mercury)	0.4E-04	3.0E-04	0.5
FLUORANTHENE			
PYRENE			
2-BUTANONE	0.2E-05	0.3E+00	0.00002
BENZENE	1.0E-06	0.5E-02	0.0007

TOLUENE	0.1E-05	0.2E+01	0.000003
XYLENES	0.1E-05	0.3E+00	0.00002
PHENATHRENE			
CHRYSENE			
BZAA			
BZBF			
BZKF			
BZAP			

20010.17

Nearby AFB Residential Population in Area -- Estimated Hazard Index

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20021.75

3-MONTH SCENARIO NON-CARCINOGENIC HAZARD QUOTIENTS

ON-SITE (WORST CASE: ADULT)

Chemical	Sub-Chronic Daily Intake (SDI) mg/kg/day	Reference Dose (RfD) mg/kg/day (surrogate)	Hazard Quotient	Pathway Hazard Quotient	Total Exposure Hazard Index
Worst of Pathways 5 and 6: On-Site Direct Ingestion					
NH3-N (Ammonia)					
KN (Pot. Nitrate)	0.2E-01	1.6E+00	0.01		
NO3+NO2-N (Nitrates)	0.6E-02	1.6E-00	0.001		
AL (Aluminum)					
BA (Barium)	0.6E-03	0.1E-02	0.6		
BE (Beryllium)	0.7E-06	0.5E-02	0.0001		
CD (Cadmium)	0.8E-04	0.4E-03	0.2		
CA (Calcium)					
CO (Cobalt)					
CU (Copper)					
PB (Lead)					
MG (Magnesium)					
MN (Manganese)					
MO (Molybdenum)	0.2E-04	0.4E-02	0.004		
NI (Nickel)	0.3E-03	0.2E-01	0.01		
AG (Silver)	0.4E-03	0.3E-02	0.1		
V (Vanadium)	0.5E-04	0.7E-02	0.007		
ZN (Zinc)	0.1E-02	0.2E+00	0.007		
CR (Chromium)	0.2E-02	0.5E-02	0.3		
HG (Mercury)	0.6E-05	0.3E-04	0.02		
FLUORANTHENE	0.8E-05	0.4E-01	0.0002		
PYRENE	0.9E-05	0.3E-01	0.0003		
2-BUTANONE	0.3E-06	0.5E+00	0.0000006		
BENZENE					
TOLUENE	0.2E-06	0.2E+00	0.000001		

XYLENES	0.2E-06	0.2E+01	0.0000001
PHENATHRENE	0.9E-06	0.4E-01	0.00002
CHRYSENE	0.2E-05	0.4E-01	0.00006
BZAA			
BZBF			
BZKF			
BZAP			
			1.16

Worst of Pathways 7 and 8: On-Site Inhalation Exposure

		Reference Concentration (RfC) mg/m3	
NH3-N (Ammonia)	0.4E-02	3.6E-01	0.04
KN (Pot. Nitrate)			
NO3+NO2-N (Nitrates)			
AL (Aluminum)			
BA (Barium)			
BE (Beryllium)			
CD (Cadmium)			
CO (Cobalt)			
CU (Copper)			
PB (Lead)			
MN (Manganese)	0.2E-02	0.4E-03	20.
MO (Molybdenum)			
NI (Nickel)			
K (Potassium)			
AG (Silver)			
V (Vanadium)			
ZN (Zinc)			
CR (Chromium)	0.2E-01	0.2E-05	40000.
HG (Mercury)	0.9E-04	0.3E-03	1.
FLUORANTHENE			
PYRENE			
2-BUTANONE	0.4E-05	0.3E+00	0.00004
BENZENE	0.2E-05	0.5E-02	0.001
TOLUENE	0.3E-05	0.2E+01	0.000005
XYLENES	0.3E-05	0.3E+00	0.00003
PHENATHRENE			
CHRYSENE			
BZAA			
BZBF			
BZKF			
BZAP			
			40021.04

AFB Construction Workers On-Site -- Estimated Hazard Index

40022.20

OFF-SITE (WORST-CASE: CHILD)

Chemical	Sub-Chronic Daily Intake (SDI)	Reference Dose (RfD)	Hazard Quotient	Pathway Hazard Quotient	Total Exposure Hazard Index
	mg/kg/day	mg/kg/day (surrogate)			
Worst of Pathways 1 and 2: Off-Site Direct Ingestion					
NH3-N (Ammonia)					
KN (Pot. Nitrate)	0.2E+00	(1.6E+00)	0.1		
NO3+NO2-N (Nitrates)	0.1E-01	1.6E+00	0.009		
AL (Aluminum)					
BA (Barium)	0.5E-02	1.0E-03	5.		
BE (Beryllium)	0.6E-05	0.5E-02	0.001		
CD (Cadmium)	0.7E-03	1.0E-03	2.		
CA (Calcium)					
CO (Cobalt)					
CU (Copper)					
PB (Lead)					
MG (Magnesium)					
MN (Manganese)					
MO (Molybdenum)	0.2E-03	0.4E-02	0.04		
NI (Nickel)	0.2E-02	0.2E-01	0.1		
AG (Silver)	0.4E-02	0.3E-02	1.		
V (Vanadium)	0.4E-03	0.7E-02	0.06		
ZN (Zinc)	0.1E-01	0.2E+00	0.06		
CR (Chromium)	0.1E-01	0.5E-02	3.		
HG (Mercury)	0.6E-04	0.3E-03	0.2		
FLUORANTHENE	0.7E-04	0.4E-01	0.002		
PYRENE	0.8E-04	0.3E-01	0.003		
2-BUTANONE	0.2E-05	0.5E+00	0.000005		
BENZENE					
TOLUENE	0.2E-05	0.2E+00	0.000009		
XYLENES	0.2E-05	0.2E+01	0.0000009		
PHENATHRENE	0.8E-05	0.4E-01	0.0002		
CHRYSENE	0.2E-04	0.4E-01	0.0005		
BZAA					
BZBF					
BZKF					
BZAP					
				11.58	
Worst of Pathways 7 and 8: Off-Site Inhalation Exposure					
		Reference Concentration (RfC)			
		mg/m3			
NH3-N (Ammonia)	0.4E-02	3.6E-01	0.04		
KN (Pot. Nitrate)					

NO3+NO2-N (Nitrates)			
AL (Aluminum)			
BA (Barium)			
BE (Beryllium)			
CD (Cadmium)			
CO (Cobalt)			
CU (Copper)			
PB (Lead)			
MN (Manganese)	0.2E-02	0.4E-03	20.
MO (Molybdenum)			
NI (Nickel)			
K (Potassium)			
AG (Silver)			
V (Vanadium)			
ZN (Zinc)			
CR (Chromium)	0.2E-01	0.2E-05	40000.
HG (Mercury)	0.9E-04	0.3E-03	1.
FLUORANTHENE			
PYRENE			
2-BUTANONE	0.4E-05	0.3E+00	0.00004
BENZENE	0.2E-05	0.5E-02	0.001
TOLUENE	0.3E-05	0.2E+01	0.000005
XYLENES	0.3E-05	0.3E+00	0.00003
PHENATHRENE			
CHRYSENE			
BZAA			
BZBF			
BZKF			
BZAP			

40021.04

- -

Nearby AFB Residential Population in Area -- Estimated Hazard Index

- -

40032.62

VIII. BACKGROUND LEVELS OF POTENTIALLY HAZARDOUS CHEMICALS AT SITE 5

The following data have been reported (Personal Communication, Ralph Wilcox, USGS, May 1991) regarding background levels of Site 5 chemicals in the surrounding native soils:

Table 3 - Background Concentration of Metals in Soil in Vicinity of Site 5 Sewage Lagoons

Metal	Background Concentration Mean	Standard Deviation	Low Value	High Value	Number of Data Points
	mg/kg				
Barium	116.0	97.7	17.0	760.0	18
	[166.0]***				
	(427.0)****				
Beryllium**	0.33	0.21	0.0	0.7	18
	0.41	0.24	0.2	1.0	18
	[0.51]				
	(0.47)				
Cadmium*	<2.1	-	-	-	18
	[<2.1]				
	(53.0)				
Chromium	8.62	5.92	4.2	27.0	17
	[11.12]				
	(1155.)				
Copper**	5.7	3.1	0.0	11.	18
	6.2	2.2	3.0	11.	18
	[7.1]				
	(2111.)				
Lead*	<21.4	-	-	-	18
	[<21.4]				
	(276.)				
Mercury*	<0.1	-	-	-	18
	[<0.1]				
	(4.48)				
Nickel**	3.9	4.0	0.0	12.0	18
	8.2	4.7	5.0	20.0	18
	[10.1]				
	(197.)				
Silver*	<3.7	-	-	-	18
	[<3.7]				
	(280.)				
Zinc	26.1	11.6	11.0	46.	18
	[30.9]				
	(1005.)				

* The background concentration is less than the mean detection limit (value listed in table) for these metals. Few concentrations above the detection

limit are reported for the metals in this category: Antimony - 0 detects; Arsenic - 2 detects, 40 mg/kg each; Cadmium - 0 detects; Lead - 0 detects; Mercury - 0 detects; Selenium - 0 detects; Silver - 0 detects; and Thallium - 0 detects.

** There are two background concentration means shown for these metals. A significant number of the 18 samples considered as representative of background metals concentrations contain concentrations less than the detection limit for these metals: Beryllium - 3 non detects; Copper - 3 non detects; and Nickel - 8 non detects. Because there is no way to know the actual concentrations in the non detect samples; concentrations in these samples are assigned maximum and minimum values, and maximum and minimum background concentration means are detemined. The maximum concentration assigned is the detection limit for a given non-detected metal in a given sample. The detection limits for some non-detect samples were greater than the largest detected values for Beryllium and Nickel. The minimum concentration assigned is 0.0 mg/kg.

*** 95% Confidence estimate of mean, based on computed standard deviation and number of samples.

**** 95% Confidence estimate of mean value for lagoon sludge material.

Table 4 - Background Concentration of Metals in Soil on Kirtland Air Force Base

Metal	Background Concentration Mean (mg/kg)	Standard Deviation	Low Value	High Value	Number of Data Points
Barium	94.5 [110.6]*** (427.)****	97.7	17.0	760.0	102
Beryllium**	0.26 0.34 [0.37] (0.47)	0.19 0.17	0.0 0.2	0.8 1.0	102 102
Cadmium*	<2.1 [<2.1] (53.)	-	-	-	102
Chromium	6.7 [7.5] (1155.)	4.9	1.2	37.	98
Copper**	5.9 6.6 [7.3] (2111.)	4.8 4.5	0.0 3.0	31. 31.	102 102
Lead*	<21.4 [<21.4] (276.)	-	-	-	102
Mercury*	<0.1	-	-	-	102

	[<0.1] (4.48)				
Nickel**	3.3 6.4 [6.9] (197.)	3.9 3.2	0.0 4.0	15.0 20.0	102 102
Silver*	<3.7 [<3.7] (280.)	-	-	-	102
Zinc	26.0 [30.0] (1005.)	25.9	7.0	270.	102

* The background concentration is less than the mean detection limit (value listed in table) for these metals. Few concentrations above the detection limit are reported for the metals in this category: Antimony - 0 detects; Arsenic - 2 detects, 40 mg/kg each; Cadmium - 0 detects; Lead - 1 detect, 49 mg/kg; Mercury - 1 detect, 0.1 mg/kg; Selenium - 0 detects; Silver - 3 detects, 7.5 to 8.6 mg/kg; and Thallium - 0 detects.

** Mean background concentrations are calculated using two different assumptions for these metals, and the results of both calculations are shown. A significant number of the 102 samples considered as representative of background metals concentrations contain concentrations less than the detection limit for these metals: Beryllium - 25 non detects; Copper - 17 non detects; and Nickel - 54 non detects. Because there is no way to know the actual concentrations in the non detect samples; concentrations in these samples are assigned maximum and minimum values, and maximum and minimum background concentration means are detemined. The maximum concentration assigned to the non detect samples are the sample detection limits. The minimum concentration assigned is 0.0 mg/kg.

*** 95% Confidence estimate of mean, based on computed standard deviation and number of samples.

**** 95% Confidence estimate of mean value for lagoon sludge material.

Assuming background organic chemical concentrations are zero, the above data suggest that except for berryllium which does not pose any significant carcinogenic or non-carcinogenic human health hazard, the background chemical concentrations are a small fraction of the concentration levels detected in the sludge materials. Thus for first-order estimates background levels may be neglected, and incremental carcinogenic risks and non-carcinogenic hazards may be estimated based on the source detection values.

IX. CONCLUSIONS

A risk assessment is by nature quantitative or probabilistic. That is, to be useful in decision-making the risk analysis must either produce a numerical estimate of the probability of occurrence of a hazardous event, or the general 'likehood' of it's occurrence. With many potentially hazardous chemicals (e.g., metals), e.g. chromium, a certain amount of the chemical is required for basic human health, but above this level or minimum requirement, a level can be reached above which additional intake may produce negative health effects on the body. In such cases, the positive or negative effects of a given exposure require quantification. For some other chemicals this is not so imperative, e.g., a chemical that is very carcinogenic at all levels of exposure. However, even with these chemicals there must be quantitative data to define the fact that it is 'very carcinogenic'. With this perspective, and the first-order nature of this assessment, the following summary of results deals only with quantified carcinogenic risks, and non-carcinogenic hazards associated with the Site 5 chemicals. In a second-order evaluation, there would be a summary of all qualitative information in the chemical toxicology section (Sub-Section II), and in the conclusions section (Sub-Section IX), there would be a discussion of potential carcinogenic risks and non-cardinogenic hazards where available non-quantitaitive toxicology information is suggestive of such health effects.

Primary Carcinogenic Risk Contaminant -

3-YEAR SCENARIO

Exposure Pathway--------> OFF-SITE INHALATION (CHILD)

Chemical----------------> CHROMIUM

Estimated Risk----------> 0.02 (Very high, probably unacceptable)

Potential Inaccuracies in First-Order Estimates:

1) In the first-order estimates it was assumed that all of the chromium reported is CR(VI). Whereas typically the CR(VI) concentration is a small fraction of the total CR concentration, the primary form of CR being CR(III), which has not been shown to be carcinogenic.

2) In the first-order estimates very conservative assumptions were used in estimating the fugitive-dust exposure concentration. In fact, with more detailed windblown transport modelling, the fugitive-dust exposure concentration may be less than 1% of the value assumed, due to reduced uptake at the source, and dilution with downwind transport.

3) The hours per day and number of days/year of exposure are thought to be conservative. In fact, most of the windblown transport probably occurs during a few days of the most severe wind conditions, and during these days the outdoor conditions are such that the human exposure times are a fraction of the 16 hours/day assumed. Thus even though the fugitive dust concentration is higher on some days, the net estimated intake and risk could be significantly reduced.

Since factors 2 and 3 apply to all of the Site 5 chemicals, possible factoral reductions in intake and risk associated with chromium, would also apply to other chemicals of concern.

3-MONTH SCENARIO

Exposure Pathway--------> A) ON-SITE INHALATION (ADULT)
B) OFF-SITE INHALATION (CHILD)

Chemical----------------> CHROMIUM

Estimated Risk----------> A) ON-SITE ADULT: 0.02 (Very high, probably unacceptable)
B) OFF-SITE CHILD: 0.02 (Very high, probably unacceptable)

Potential Inaccuracies in First-Order Estimates:

Potential Inaccuracies in First-Order Estimates:

1) In the first-order estimates it was assumed that all of the chromium reported is CR(VI). Whereas typically the CR(VI) concentration is a small fraction of the total CR concentration, the primary form of CR being CR(III), which has not been shown to be carcinogenic.

2) In the first-order estimates very conservative assumptions were used in estimating the fugitive-dust exposure concentration. In fact, with more detailed windblown transport modelling, the fugitive-dust exposure concentration may be less than 1% of the value assumed, due to reduced uptake* at the source, and dilution with downwind transport.

Since factor 2 apply to all of the Site 5 chemicals, possible factoral reductions in intake and risk associated with chromium, would also apply to other chemicals of concern.

* During construction activities for example, if the sludge and soil layers were kept in a moist condition, during disturbance and loading activities, the airborne intakes of fugitive dust could probably be reduced to near zero.

Primary Non-Carcinogenic Hazard -

3-YEAR SCENARIO

Exposure Pathway------------------> OFF-SITE INHALATION (CHILD)

Chemical-------------------------> CHROMIUM

Estimated Hazard Quotient---------> 20,000 (Very high, probably unacceptable)

Potential Inaccuracies in First-Order Estimates:

1) In the first-order estimates it was assumed that all of the chromium reported is CR(VI). Generally, the CR(VI) is a fraction of the total CR, the primary form being CR(III), however, CR(VI) and CR(III) have the same (inhalation) Reference Dose, so this factor would not affect accuracy.

2) In the first-order estimates very conservative assumptions were used in estimating the fugitive-dust exposure concentration. In fact, with more detailed windblown transport modelling, the fugitive-dust exposure concentration may be less than 1% of the value assumed, due to reduced uptake at the source, and dilution with downwind transport.

3) The hours per day and number of days/year of exposure are thought to be

conservative. In fact, most of the windblown transport probably occurs during a few days of the most severe wind conditions, and during these days the outdoor conditions are such that the human exposure times are a fraction of the 16 hours/day assumed. Thus even though the fugitive dust concentration is higher on some days, the net estimated intake and risk could be significantly reduced.

Since factors 2 and 3 apply to all of the Site 5 chemicals, possible factoral reductions in intake and hazards associated with chromium, would also apply to other chemicals of concern.

3-MONTH SCENARIO

Exposure Pathway------------> A) ON-SITE INHALATION (ADULT)
B) OFF-SITE INHALATION (CHILD)

Chemical--------------------> CHROMIUM

Estimated Hazard Quotient---> A) ON-SITE ADULT: 40,000 (Very high, probably unacceptable
B) OFF-SITE CHILD: 40,000 (Very high, probably unacceptable

Potential Inaccuracies in First-Order Estimates:

1) In the first-order estimates it was assumed that all of the chromium reported is CR(VI). Generally, the CR(VI) is a fraction of the total CR, the primary form being CR(III), however, CR(VI) and CR(III) have the same (inhalation) Reference Dose, so this factor would not affect accuracy.

2) In the first-order estimates very conservative assumptions were used in estimating the fugitive-dust exposure concentration. In fact, with more detailed windblown transport modelling, the fugitive-dust exposure concentrations downwind may be less than 1% of the value assumed, due to reduced uptake (on-site re-deposition), and dilution with downwind transport.

3) The hours per day and number of days/year of exposure are thought to be conservative. In fact, most of the windblown transport probably occurs during a few days of the most severe wind conditions, and during these days the outdoor conditions are such that the human exposure times are a fraction of the 16 hours/day assumed. Thus even though the fugitive dust concentration is higher on some days, the net estimated intake and risk could be significantly reduced.

Since factors 2 and 3 apply to all of the Site 5 chemicals, possible factoral reductions in intake and risk associated with chromium, would also apply to other chemicals of concern.

While it is anticipated that more detailed (second-order) analysis will probably reduce the carcinogenic risks and non-carcenogenic hazard quotients, the second-order estimates may still be above the acceptable levels, e.g., incremental carcenogenic risks < 0.000001; and non-carcinogenic hazard quotients < 1.0.

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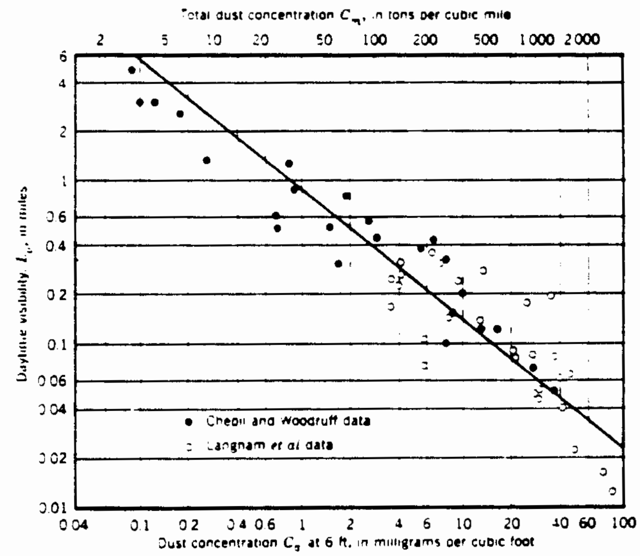

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FIG. ~~2.195~~.—Relation between Daytime Visibility and Dust Concentration near Surface (Chepil and Woodruff, 1957)