Health Consultation

HURRICANE RESPONSE SAMPLING ASSESSMENT FOR THE AGRICULTURE STREET LANDFILL

NEW ORLEANS

ORLEANS PARISH, LOUISIANA

EPA FACILITY ID: LAD981056997

AUGUST 29, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

Louisiana Department of Health and Hospitals
Office of Public Health
Section of Environmental Epidemiology and Toxicology
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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List of Acronyms

ASL	Agriculture Street Landfill
ATSDR	Agency for Toxic Substances and Disease Registry
COC	contaminant of concern
CREG	cancer risk evaluation guide
CSF	cancer slope factor
CV	comparison value
DRO	Diesel Range Organics
EMEG	Environmental Media Evaluation Guide
ft	feet
HANO	Housing Authority of New Orleans
LDEQ	Louisiana Department of Environmental Quality
LDHH	Louisiana Department of Health and Hospitals
LOAEL	lowest-observed-adverse-effects-level
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	minimum risk level
NPL	National Priorities Listing
OPH	Office of Public Health
ppm	parts per million
RECAP	Risk Evaluation/Corrective Action Program
RfD	reference dose
SEET	Section of Environmental Epidemiology and Toxicology
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient
US EPA	United States Environmental Protection Agency

Summary and Statement of Issues

The August 29, 2005 landfall of Hurricane Katrina and the September 24, 2005 landfall of Hurricane Rita resulted in extensive flooding throughout New Orleans, Louisiana. When the floodwaters drained, sediments were left behind. The United States Environmental Protection Agency (US EPA), in coordination with the Louisiana Department of Environmental Quality (LDEQ), sampled these sediments and soils at the Agriculture Street Landfill site to determine whether this material contained any contaminants that would pose a health hazard to exposed individuals.

Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), the Louisiana Department of Health and Hospitals/Office of Public Health/Section of Environmental Epidemiology and Toxicology (LDHH/OPH/SEET) has developed the following health consultation. The primary goals of this document are to determine whether sediments introduced by floodwaters at the Agriculture Street Landfill posed a threat to human health and to establish what further public health actions, if any, may be needed.

Background and Site History

The Agriculture Street Landfill (ASL) site is located in New Orleans, Louisiana, approximately three miles south of Lake Ponchartrain and 2.5 to 3.0 miles north-northeast of the city's central business district. The site is bounded to the north by Higgins Boulevard and to the south and west by Southern Railroad right-of-ways. The eastern boundary extends from a cul-de-sac at the southern end of Clouet Street near the railroad tracks to Higgins Boulevard between Press and Montegut Streets (see Figure 1) [1, 2]. The area included in the site was authorized as a landfill in 1909. In 1921, the City of New Orleans approved the ASL as the primary receiving point of the city's garbage. Refuse brought to the site over the years reportedly included household waste and commercial wastes as well as ash from the incineration of municipal waste and from open burning [1].

Community development around the site began in 1948. That year, residents began to complain of odors and smoke from dump fumes at the site, and the landfill was closed in 1952 because of public concerns [1]. It was reopened for approximately a year in 1965 for use as an open burning and disposal area for debris left in the wake of Hurricane Betsy and officially closed in 1966, though some operations were reported as late as 1967 [1,2].

Though forty-eight acres of the site remain undeveloped, forty-seven acres of the ASL had been developed for residences, Moton School (on the eastern part of the site), a community center (at the southeast corner of Benefit and Press Streets), and an electrica1 substation [1,2]. A recreational center used for indoor basketball is located on the southeastern portion of the site, northwest of the intersection of Feliciana and Industry Streets. A playground is located north of the recreational center [2].

Figure 1. The Agriculture Street Landfill site boundaries (with sampling locations for October 1-2, 2006)

Adapted from: CH2M HILL, Inc. Hurricane Katrina Response: Agriculture Street Landfill, New Orleans, Site Inspection and Sampling Results. CH2M HILL Technical Memorandum 06-8459. 2006 Jan 30.

The ASL was added to the National Priorities Listing (NPL) on December 16, 1994. Early investigations at the site indicated the presence of contaminants above background and/or regulatory levels in the soil. In 1997, remedial actions were taken to protect residents around the site. Actions on the undeveloped property included clearing of vegetation, grading of soil, placement of a geotextile mat and marker, and covering the area with 12 inches of clean fill. At the residential properties and community center, the top 24 inches of soil and waste material were excavated. A geotextile lining was installed and covered with twenty-four inches of clean fill.

On August 29, 2005, the passage of Hurricane Katrina left multiple levees in New Orleans breached and/or overtopped, leading to extensive flooding throughout the parish, including the ASL. When the floodwaters were drained from the parish, they left sediment deposits throughout the previously flooded areas. On September 24, 2005, Hurricane Rita, made landfall on the coast of southwestern Louisiana, and levees that had already been compromised were breached and overtopped again. This flooding event did not include the ASL site.

Demographics

As of June 2006, the ASL site remained uninhabited since the hurricanes. Census 2000 results reported a population of 1,116 within the census blocks that encompassed the site. The largest ethnic group at the site at that time was African-American (98.0%), followed by Hispanic (1.4%), those identifying themselves as belonging to two or more races (0.4%), and Caucasian (0.2%). Twenty-seven point six percent (27.6%) of the population age 25 years or older in 2000 had earned at least a high school diploma. The median household income was $16,250.

Discussion

Data Used

Data from multiple sampling events was assessed for this health consultation. Nine samples of flood-deposited sediments were collected on September 25, 2005 as part of the EPA's characterization of post-hurricane conditions experienced by first responders. These samples were analyzed for a range of metals and semivolatile organic compounds. On October 1 and 2, 2005, at the request of EPA, the CH2M HILL, Inc. environmental consulting company conducted a site inspection and collected soil samples. These samples were only analyzed for lead and arsenic content. Sampling was conducted by Weston Solutions on October 28, 2005 to characterize what appeared to be water seepage from cracks in soils at the site; these reports of seepage later proved to be due to broken residential pipes near the site [2]. A re-sampling event of one of the sample locations was performed by LDEQ on November 19, 2005. Sampling was also performed by EPA and LDEQ on February 16-17, 2006, to re-examine levels of benzo(a)pyrene at the site.

Exposure Pathways

A site inspection conducted in October 2005 indicated that the geotextile layers at the site had not been disturbed by the September 2005 flooding event [2]. A second site inspection conducted in June 2006 confirmed that there were no signs of damage to the remedial measures at the ASL site due to the hurricanes (personal communication, LDEQ site representatives). Therefore the main exposures considered in the assessment of this site is incidental (accidental) ingestion of flood-deposited sediments or soils located above the geotextile layers installed during previous remediation activities. Lesser exposures to contaminants present in these media may occur through dermal contact or through inhalation of soil or sediment particles. Relative to incidental ingestion, these routes will not be a significant source of contaminant absorption. Exposure may also occur through pica, a practice of eating significant quantities of soil that happens among children ages 6 years and younger. Children may eat as much as a teaspoon of soil at a time, though this level of consumption does not occur on a daily basis. The pica value used in the evaluation process was determined to be protective of children eating sediment or soil.

Evaluation Process

Chemicals detected at the ASL site were screened against highly protective health-based comparison values. These values, which are derived from human and animal studies, are calculated with safety margins or uncertainty factors to account for variations in sensitivity within a human population and for differences between human and animal studies. These values are used for screening purposes only and do not determine whether adverse health effects will occur. Appendix A details the screening process and the assessment process that followed if contaminant concentrations exceeded these screening values. The following contaminants were identified as contaminants of concern (COCs) and were therefore assessed to determine if they were a potential health hazard.

Aluminum

Aluminum is the most abundant metal and the third most abundant element, after oxygen and silicon, in the earth's crust. Aluminum forms compounds with other chemicals in naturally occurring soils, rocks, and clays. Aluminum compounds are also used in industrial practices such as water treatment and abrasives, and in consumer products such as antacids and antiperspirants [3].

The highest dose of aluminum possible at the ASL site would be a dose absorbed by a child engaging in pica (5000 mg of soil or sediment per day). This dose of 2.1 mg/kg/day is over thirty times lower than the lowest dose observed to cause adverse health effects (the lowest observed adverse effects level, or LOAEL) [3]. Therefore, this dose would cause no adverse health effects from the aluminum. Ingestion of aluminum from ASL site sediments or soils should pose **no apparent public health hazard** to residents.

Arsenic

Arsenic also occurs naturally in soil and rocks and is widely distributed in the earth's crust. About 90% of chemically manufactured arsenic compounds are used for wood preservation. Other arsenicals are used in pesticides, in lead-acid automobile batteries, and in semiconductors and light-emitting diodes [4]. A comprehensive sampling effort by Louisiana State University identified the average background level of arsenic in Louisiana soils as 12 mg/kg, or 12 ppm [5].

Children engaging in pica at the ASL site would be exposed to a maximum possible dose of 0.009 mg/kg/day. This dose is more than three times lower than the LOAEL for health effects from 3- to 22-years of ingestion of arsenic [4]. Therefore, this dose of arsenic and lower doses would cause no adverse noncancer health effects.

Though arsenic is classified by the EPA as a human carcinogen, the doses of arsenic that would be absorbed by residents incidentally ingesting small quantities of on-site sediments or soils over a lifetime are below those of concern for increased cancer risk. The maximum arsenic cancer risk from incidental soil ingestion at the site is 6.00×10^{-5}. This cancer risk is below the upper risk limit of 1.00×10^{-4} that would be predicted for a normal human population (see Appendix A). Ingestion of arsenic from soil or sediments at the ASL site therefore should pose **no apparent public health hazard** to residents.

Unspecified Petroleum Hydrocarbons and Diesel Range Organics

Unspecified petroleum hydrocarbons refers to an undefined mix of hydrocarbons. Diesel range organics (DRO) refers to those semivolatile hydrocarbons for which the boiling point ranges roughly correspond to that of diesel fuel. No health-based screening information is currently available for unspecified petroleum hydrocarbons or DRO. These contaminants are assessed as specific petroleum hydrocarbon fractions such as benzene, toluene, hexane, total xylenes, and polycyclic aromatic hydrocarbons (PAHs) [7]. An assessment of the PAH concentrations detected at the site is described in the following paragraphs.

Polycyclic Aromatic Hydrocarbons

PAHs are a class of more than 100 different compounds that generally exist as complex mixtures of compounds. Because they are formed during the incomplete combustion of coal, oil, wood, and other organic substances, PAHs are widespread in the environment. They are also found in petroleum-based products such as coal tar and asphalt as well as in the manufacture of medicines, dyes, plastics and pesticides [8].

Individuals ingesting ASL soils or sediments would not be exposed to doses that would cause noncancer health effects. The lowest PAH dose observed to cause health effects in experimental mice was 40 mg/kg/day [8]. The PAH doses calculated at the ASL site were more than 150 times lower than this dose. Even if children were to engage in pica at the site, their exposure dose would be less than 0.02 mg/kg/day.

Available evidence indicates that mixtures of PAHs can cause cancer in humans. The comparison value used to screen PAHs is the cancer risk evaluation guide (CREG). A CREG is an estimate of the contaminant concentration expected to cause no more than one excess cancer per 1,000,000 people exposed over a lifetime, which is within the expected cancer risk for a normal population. The cancer risks specific to the ASL site were calculated as described in Appendix A.

The highest concentrations of PAHs were detected at the north end of the site during the September 25, 2005 sampling event. These concentrations were more than 10 times higher than others detected at the site. The average PAH concentration found at the north end of the site (from Benefit Street northward) was 25.9 ppm. Incidental ingestion of soil containing this concentration would yield a cancer risk of 2.70×10^{-4} or 27 excess cancers per 10,000 people exposed over a lifetime. This is over 2.5 times the EPA's predicted cancer risk range of 1×10^{-4} to 1×10^{-6} (one excess cancer per 10,000 people to one excess cancer per 1,000,000 people) for a normal population (see Appendix A). Incidental ingestion of soil containing the average PAH concentration from the rest of the site, 0.08 ppm, would yield a cancer risk of 8×10^{-7} or 8 excess cancers per 10,000,000 people. This is lower the EPA's predicted cancer risk range.

One of the samples containing the highest concentration of PAHs was resampled on November 19, 2005. Levels of benzo(a)pyrene detected at this sample site decreased from 13.9 ppm in September 2005 to 0.25 ppm in November 2005. Benzo(a)pyrene levels were also observed to be lower in the February 16-17, 2006 sampling event than they were in the September sampling event. The average concentration for this contaminant decreased from 8.40 ppm in September 2005 to 1.32 ppm in February 2006. This suggests that degradation of PAHs in the ASL soils is occurring over time. However, no data is available for dibenzo(a,h)anthracene, which presented the highest of the benzo(a)pyrene equivalents at the north end of the site in September 2005. Without data to confirm that total PAH concentrations have degraded below levels of concern, the incidental ingestion of soil containing this contaminant poses an **indeterminate public health hazard**.

Zinc

One of the most common elements in the earth's crust, zinc is an essential element and is commonly found in small quantities in nutritional supplements. Natural zinc levels in the environment can be increased by mining activities, burning of coal or waste, or waste streams from metal manufacturing industries. Zinc may also be present in fertilizer added to enrich soil for plant growth [9].

The highest dose of zinc possible at the ASL site would be a dose absorbed by a child engaging in pica. This dose of 1.1 mg/kg/day is lower than the LOAEL for health effects from ingestion of zinc [9]. Ingestion of zinc from ASL sediments therefore should pose **no apparent public health hazard** to residents.

Community Health Concerns

Residents of New Orleans who are eager to move back to their homes and begin the rebuilding process have heard media reports about the post-hurricane city being a “toxic soup”. This representation of the city’s environmental condition has gained widespread exposure. Residents are particularly worried about the possibility that the protective measures at the ASL site have been compromised. Citizens whose homes are near the site fear returning to an area where they believe floodwaters may not only have introduced new health hazards but may also have brought old contamination to the surface of the site. This health consultation is designed to address these community concerns about the status of the ASL site.

Child Health Considerations

Children are more likely to come into contact with soils than adults. Children eat small quantities of soil when they ingest food items that fall to the ground or floor, when they eat with dirty hands, or when they put dirty hands into their mouths. They are also more likely to eat larger quantities of soil (soil pica) during playtime activities. The ATSDR assumes a soil pica ingestion rate of 5000 mg per day, or approximately 1 teaspoon of soil per day, for children 6 years and younger. Children are unlikely to actually eat this amount of soil every day, but this assumption allows health assessments to be highly protective of more extreme cases of soil pica as well as cases of occasional soil ingestion.

A child’s lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Children are more susceptible to the toxic effects of PAHs and other contaminants than the general population because their bodies do not have mature detoxification mechanisms.

Children are dependent on adults for access to housing and medical care, and for risk identification. Adults need as much information as possible to make informed decisions regarding their children’s health.

Conclusions

The majority of the contaminants detected in flood-deposited sediments and soils at the ASL site pose **no apparent public health hazard** to residents at the site. PAH concentrations of concern were found at the north end of the site. Benzo(a)pyrene concentrations appear to have undergone degradation from the first sampling event to the most recent sampling event, but no follow-up data is available for the other PAHs detected in the initial site sampling event. Therefore the PAH concentrations pose an **indeterminate public health hazard** at the site.

Recommendations

Exposures to contamination in soils at the ASL site can be minimized by preventing young children from eating soil or from putting their hands in their mouths when they play in the soil. Parents should minimize the amount of time that children six years and under spend playing on bare soil. Children should be encouraged to wash their hands before they eat and before they put their fingers in their mouths after playtime. During post-hurricane rebuilding and recovery activities at the site, people should practice good hygiene methods such as washing their hands before eating or before touching their mouths.

Public Health Action Plan

Completed Actions:

- After high concentrations of PAHs were detected at the north end of the ASL site in September 2005, that portion of the site was resampled in November 2005 and in February 2006.

Proposed Actions:

- The Housing Authority of New Orleans (HANO) is currently determining which actions would be appropriate to further address remaining contamination issues at the ASL site. It is recommended that EPA and LDEQ consult with HANO to determine the appropriate course of action for the areas of elevated PAHs at the site.
- The information produced within this health consultation should be made available to the community members of the Agriculture Street Landfill site in New Orleans, Louisiana.
- The importance of good hygiene practices and ways to minimize the ingestion of soil by children should be communicated to community members returning to the Agriculture Street Landfill site.

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8. Agency for Toxic Substances and Disease Registry. Toxicological profile for polycyclic aromatic hydrocarbons. Atlanta: US Department of Health and Human Services; 1995 Aug

9. Agency for Toxic Substances and Disease Registry. Toxicological profile for zinc. Atlanta: US Department of Health and Human Services; 2005 Aug.

Certification

This Hurricane Response Sampling Assessment for the Agriculture Street Landfill public health consultation was prepared by the Louisiana Department of Health and Hospitals under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures at the time the health consultation was begun. The editorial review was conducted by the Cooperative Agreement Partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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Appendix A: Evaluation Process

Screening Process

Comparison values were initially used to determine which samples needed to be closely evaluated. Comparison values are media-specific concentrations of chemicals that are used by health assessors to select environmental contaminants for further evaluation. Comparison values are not used as predictors of adverse health effects. The following comparison values were used in the evaluation of the Agriculture Street Landfill sediment and soil samples:

> *Environmental media evaluation guides* (EMEGS) are estimated contaminant concentrations at which noncarcinogenic health effects are unlikely. They are calculated from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk levels (MRLs).

> C*ancer risk evaluation guides* (CREGs) are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in 1 million exposed persons over a lifetime. CREGs are calculated from the United States Environmental Protection Agency's (US EPA's) cancer slope factors (CSFs).

Contaminants exceeding the comparison values were identified as contaminants of concern (COCs) for further assessment. Tables A-1 and A-2 list the COCs identified through the screening process.

Noncancer Health Effects

Exposure doses were estimated for incidental consumption and for childhood pica (consumption of up to 5000 mg per day) of sediment/soil under residential exposure conditions. For polycyclic aromatic hydrocarbons (PAHs), toxicity equivalency factors (TEFs) were used to weight each PAH's toxicity relative to the toxicity of benzo(a)pyrene, the most well-studied PAH. Table A-3 lists the TEFs for the PAHs detected at the site. The TEF for benzo(a)pyrene is set to 1. PAHs which are more carcinogenic than benzo(a)pyrene have higher TEFs, and PAHs which are less carcinogenic than benzo(a)pyrene have lower TEFs. Multiplying the actual concentration of each PAH by its TEF produces a toxicity equivalence quotient (TEQ). The total PAH TEQ at each sample location was used to evaluate the health effects of the PAH mixtures present. Table A-4 lists total PAH TEQs for each of the September 25, 2005 samples.

The following equation was used to calculate exposure doses:

$$\text{Sediment Ingestion Exposure Dose (mg/kg/day)} = \frac{\text{C x IR x EF x CF}}{\text{BW}}$$

Table A-1. Contaminants of concern detected in samples at the Agriculture Street Landfill site

Contaminant of Concern September 25, 2005	Concentration Range (mg/kg*) Low	 High	CV† (mg/kg)	CV reference
aluminum	6150	7480	4000	intermediate EMEG‡ pica child
arsenic	5.61	27.6	0.5 10	CREG§ Acute EMEG pica child
diesel range organics	121	2390	650	LDEQ RECAP¶ for residential areas
unspecified petroleum hydrocarbons	452	8550	none available	none available
PAH** TEQ††	0.0003	48.39	0.1	CREG benzo(a)pyrene
zinc	391	3670	600	intermediate EMEG pica child
October 1-2, 2005				
arsenic	1.08	7.73	0.5	CREG
October 28, 2005				
aluminum	3320	5990	4000	intermediate EMEG pica child
November 19, 2005				
benzo(a)pyrene	0.25	0.25	0.1	CREG
February 16-17, 2006				
benzo(a)pyrene	0	15.6	0.1	CREG

*mg/kg = milligrams per kilogram
†CV = comparison value
‡ EMEG = environmental media evaluation guide

§CREG = cancer risk evaluation guide
¶LDEQ RECAP = Louisiana Department of Environmental Quality Risk Evaluation/Corrective Action Program

** PAH = polycyclic aromatic hydrocarbon

††TEQ = toxicity equivalency factor

Table A-2. Ranges of arsenic detected in October 1-2, 2005 soil samples from the Agriculture Street Landfill site

Sample type	Concentration Range (mg/kg*) Low	High	CV† (mg/kg)	CV reference
surface top soil (≤ 0.25 ft. ‡)	1.17	7.21	0.5	CREG§
surface soil (> 0.25 ft but ≤ 1 ft.)	1.08	7.73	0.5	CREG
subsurface Soil (>1 ft.)	1.17	7.51	0.5	CREG

*mg/kg = milligrams per kilogram
†CV = comparison value
‡ft. = feet
§CREG = cancer risk evaluation guide

Table A-3. Toxicity Equivalency Factors (TEFs) for polycyclic aromatic hydrocarbons

Compound	TEF*
Dibenz[a,h]anthracene	5
Benzo(a)pyrene	1
Benz[a]anthracene	0.1
Benzo[b]fluoranthene	0.1
Benzo[k]fluoranthene	0.1
Indeno[1,2,3-c,d]pyrene	0.1
Anthracene	0.01
Benzo[g,h,i]perylene	0.01
Chrysene	0.01
Acenaphthene	0.001
Acenaphthylene	0.001
Flouranthene	0.001
Fluorene	0.001
Phenanthrene	0.001
Pyrene	0.001

*TEF = toxicity equivalency factor

TEFs Adapted from: Agency for Toxic Substances and Disease Registry. Toxicological profile for polycyclic aromatic hydrocarbons. Atlanta: US Department of Health and Human Services; 1995 Aug

Table A-4. Total Toxicity Equivalency Quotients (TEQs) for polycyclic aromatic hydrocarbons from the September 25, 2005 sampling event

Sample ID	Total TEQ (mg/kg*)
10019	0.15
10020	0.01
10022	0.22
10023	0.0003
10024	0.03
10029	48.39
10030	0.07
10031	23.09
10032	32.08

*mg/kg = milligrams per kilogram

Table A-5: Equation variables for calculation of a sediment ingestion dose

Variable	Value used*
C = Concentration in sediment	Chemical-specific (mg/kg) †
IR = Ingestion rate	200 mg/day (child 1-6 years) 5000 mg/day (pica child) 100 mg/day (adult)
CF = Conversion factor	1.00E-06 kg/mg
EF = Exposure factor	1 (unitless)
BW =Body weight	10 kg (infants) 16 kg (children 1-6 years) 70 kg (adults)

*All values used can be retrieved from the following reference: US Environmental Protection Agency. Risk assessment guidance for Superfund. Volume I: Human health evaluation manual (Part A). Interim final. Washington, DC: US Environmental Protection Agency; 1989. EPA/540/1-89/002.

†mg/kg = milligrams per kilogram

Table A-5 lists the variables of the exposure dose formula and their corresponding values. The calculated exposure doses were compared to the appropriate health guideline values. Health guideline values are doses below which adverse health effects are unlikely. These values are based on valid toxicological studies with appropriate safety factors built in to account for uncertainty such as that caused by differences in human sensitivities and animal to human differences. The health guideline values used in the evaluation of ASL sediment and soil samples are listed below:

> A *reference dose* (RfD) is an estimated daily lifetime exposure to a hazardous substance that is not likely to cause adverse noncancer health effects to human populations. RfDs are developed by EPA and may be found at http://www.epa.gov/iris.

> A *minimum risk level* (MRL) is an estimated daily human exposure to a hazardous substance that is not likely to cause adverse noncancer health effects over a specified duration of exposure. Developed by the ATSDR, MRLs are not intended to be used as predictors of adverse health effects. MRLs may be found at http://www.atsdr.cdc.gov/mrls.html.

Calculation of Carcinogenic Risk

Because of the uncertainties involved in estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant carcinogenic data, describing carcinogenic risk in words as well as in numeric terms.* The estimated risk of developing cancer resulting from exposure to the contaminants within the sediment was calculated by multiplying the exposure dose over a 70-year (lifetime) period by EPA's *cancer slope factor* (CSF; available at http://www.epa.gov/iris) for each particular contaminant. The results estimate the worst-case maximum increase in the risk of developing cancer after chronic exposure to the contaminant. This estimation is accurate within one order of magnitude; a calculated cancer risk of 2 excess cancers per 10,000 people might actually be 2 excess cancers per 1,000 people or 2 excess cancers per 100,000 people. The range of predicted cancer risks for a normal population is estimated to be from 1 x 10^{-4} to 1 x 10^{-6} (one excess cancer per 10,000 people to one excess cancer per 1,000,000 people).

* Agency for Toxic Substances and Disease Registry. Cancer policy framework. Atlanta: US Department of Health and Human Services; 1993.