

Health Consultation

HURRICANE RESPONSE SAMPLING ASSESSMENT FOR THE
SOUTHERN SHIPBUILDING CORPORATION

SLIDELL, ST. TAMMANY PARISH, LOUISIANA

EPA FACILITY ID: LAD008148015

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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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HEALTH CONSULTATION

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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

ATSDR	Agency for Toxic Substances and Disease Registry
COC	contaminant of concern
CREG	cancer risk evaluation guide
CSF	cancer slope factor
CV	comparison value
EMEG	Environmental Media Evaluation Guide
EPA	Environmental Protection Agency
ft	feet
IR	Ingestion Rate
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
ROD	Record of Decision
SEET	Section of Environmental Epidemiology and Toxicology
SF	Slope Factor
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient

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 Slidell, Louisiana. The United States Environmental Protection Agency (EPA), in coordination with the Louisiana Department of Environmental Quality (LDEQ), sampled soils at the Southern Shipbuilding 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 goal of this document is to determine whether exposure to the soil affected by floodwaters at the Southern Shipbuilding site pose a threat to human health and to establish what further public health actions, if any, may be needed.

Background and Site History

The Southern Shipbuilding Corporation site is located in Slidell, Louisiana, on approximately 54 acres of wooded land at 999 Canulette Road. The site is adjacent to Bayou Bonfouca, approximately one-half mile downstream of U.S. Highway 433 bridge and approximately 1.8 miles downstream of the Bayou Bonfouca NPL site [1]. Southern Shipbuilding Corporation is bounded to the north by Bayou Bonfouca, to the east by wooded acreage, and to the south and west by a residential community of Slidell [2] (see Figure 1).

Southern Shipbuilding Corporation, located within St. Tammany Parish, is a former barge/ship cleaning, building, docking and repair facility. Barge/ship manufacturing and repair activities were conducted at the site from 1919 to August 1993. From 1919 through 1954, Canulette Shipbuilding owned the site; it was then sold to J & S Shipbuilding. In 1957, the site was sold to Southern Shipbuilding Corporation [1]. The property is currently owned by Equity Development Systems Limited (EDS) in New Orleans, Louisiana [2]. Operations such as gas-freeing, the blowing of air or steam through the tanks to remove volatiles, and barge cleaning were conducted at the site from approximately 1919 to 1971. The wastes were disposed of in two surface impoundments designated as the North and South impoundments. Water from the North Impoundment was channeled to the South Impoundment. As the water level rose in the South Impoundment, it was piped into seven baffle ponds which filtered the wastes. The effluent from the seventh baffle pond discharged into Bayou Bonfouca.

The discharge of the pond effluent and sanitary wastewater into Bayou Bonfouca was regulated under a National Pollutant Discharge Elimination System (NPDES) permit which started in March 1978 and terminated in September 1984. The NPDES permit was reissued by EPA in October 1987 and expired by October 1992.

In July, 1985, the Southern Shipbuilding site was brought to the attention of EPA by the Louisiana Department of Environmental Quality (LDEQ). A preliminary assessment was completed by EPA in November 1987. LDEQ sampled the surface impoundments and the sediments of Bayou Bonfouca in November and December 1992. The sampling results indicated that polynuclear aromatic hydrocarbons (PAHs) were present in the impoundments and in the

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bayou sediments. In August, 1993, additional sampling was performed by EPA as part of a site inspection. These sampling results confirmed the presence of PAHs in the impoundments and in the sediments from Bayou Bonfouca. Procedures to add the site to the National Priority List (NPL) were initiated, and the Southern Shipbuilding Corporation was added to the NPL on May 26, 1995 [1].

The site was divided into two operable units (OU) for investigational and response purposes. OU 1 included the area around the graving dock and the surface impoundments, and OU 2 consisted of the rest of the site (See Figure 2, EPA 1997). In OU 1, materials containing polynuclear aromatic hydrocarbon concentrations (PAHs) above 10 parts per million (ppm) benzo(a)pyrene (BAP) equivalents and graving dock sediments containing tributyltin concentrations greater than 80 parts per billion (ppb) were removed and incinerated. Soils containing PAH concentrations between 1 and 10 ppm BAP equivalents which were not addressed by incineration, along with residual ash, were excavated and disposed of on-site under the clay cap. Following the above remedies, the ROD for OU1 was signed by EPA on July 20, 1995.

The remedial action goals established for OU 2 were based on a risk assessment assuming future use as light industrial. Soils containing concentrations of arsenic greater than 30 ppm, lead greater than 2,000 ppm, and polychlorinated biphenyls greater than 10 ppm were excavated and disposed off-site. Materials which contained asbestos were also excavated and disposed of off-site. All affected areas were backfilled and re-graded [2]. For OU 2, the remedy called for No Further Federal Remedial Action since the known waste area had been previously addressed through extensive removal actions of site wastes. EPA signed the ROD for OU 2 on September 15, 1997 which allowed the site to have continued light industrial use. The entire site was deleted from the NPL list on June 16, 1998 [1].

There are no EPA mandated Operation and Maintenance (O&M) requirements for the site. The landfill clay cap is inspected annually and the remedy is evaluated every five years to ensure that it is protective of public health and the environment (EPA, 1997). Presently, the site is not used for any activity other than routine and minimal maintenance of the fence and grounds. The site owner has indicated, however, that he plans to have the property rezoned and to redevelop the site for commercial and residential purposes. If the proposed land use is approved for rezoning, further evaluation of the site and the necessary administrative and remedial actions will occur. An amended ROD would also need to be initiated and approved by the EPA since the 1997 ROD had called for no further action [2].

Site inspections were conducted by the EPA and State Remedial Project Managers (RPMs) in April and July 2005. These inspections revealed the structural integrity of the cap and fence around the perimeter of the site to be sound, intact, and secure. The EPA and State RPMs found that the cap's perimeter was vegetated with grass, and weeds covered some of the interior areas. As of July 2005, the site inspection and other site documentation revealed the site to be protective of human health and the environment [2].

However, Hurricane Katrina caused catastrophic destruction due to high winds and a storm surge at the site. A site inspection was conducted by representatives from LDEQ, USEPA, and CH2MHILL, Inc on September 28, 2005. On the day of the site visit, the site was deserted. The fence, which was along the south and southeast sectors of the site perimeter, appeared to have been impacted by the hurricane. The fence was still standing and leaned slightly outward,

however, some areas were ripped open. The downed trees and debris were laid flush against the fence which had created a natural barrier to site access. The remainder of the fence around the perimeter appeared to remain intact with locks on the gated entrances. There was no evidence of trespassing along the areas which exhibited fence damage along the site's perimeter, nor inside the facility. The cap appeared to be intact, and no exposed waste was observed. Vegetation and debris were observed in several places in the capped area on the west side of the site. Along the eastern edges of the capped areas, and to a lesser extent, along the southern edge of the capped area, erosion of the surface soil was observed. The site appeared to currently be used as a storage area for unused and/or scrap equipment and materials, and most of the buildings and equipment on site appeared to be severely dilapidated. One of the buildings that had previously been standing had collapsed, reportedly as a result of Hurricane Katrina.

Demographics

Census 2000 results record a parish population of 191,268. The largest ethnic group in the parish at that time was Caucasian (87.0%), followed by African American (9.9%), American Indian and Alaska Native (0.4%), Asian (0.7%), with 0.6% of the population reporting as Other. Eighty-three point nine percent (83.9%) of the population age 25 years or older in 2000 had earned at least a high school diploma. The median household income in 1999 was \$47,883 [3].

As of the beginning of 2005, approximately 27,000 residents lived in the surrounding area of the Southern Shipbuilding site. The nearest residence potentially impacted by the site is approximately 400 feet from the site, to the southwest [2].

Discussion

Environmental Data

Data from multiple sampling events were assessed for this health consultation. On September 17, 2005, some residents around Baldwin Drive were concerned that flood sediments from the bayou had brought contamination from the former NPL superfund site into their neighborhoods. Due to these concerns, LDEQ collected a single sediment sample at the end of Baldwin Drive which was analyzed for semivolatile organic compounds [4].

As part of EPA's characterization of post-hurricane conditions experienced by first responders, two soil samples were collected on September 30, 2005. These samples were collected from the areas where soil erosion had been observed during the site inspection and were analyzed for a range of metals and semivolatile organic compounds [1].

On October 3, 2005, LDEQ collected four soil samples and one background soil sample, all of which were analyzed for PAHs [4].

Exposure Pathways

To determine whether a child or adult would be exposed to metals or certain semi-volatiles, SEET evaluated the environmental and human components that lead to exposure. An exposure pathway contains the following five elements: a source of contamination, transport through some kind of environmental medium, a point of exposure, a route of exposure, and a receptor

population. ATSDR categorizes an exposure pathway as a completed or potential exposure pathway if the exposure pathway cannot be eliminated. Completed pathways require that the five elements exist and indicate that exposure to a contaminant has occurred in the past, is presently occurring, or will occur in the future. Potential pathways, however, indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present.

The nearest residence potentially impacted by the site is approximately 400 feet to the southwest. Trespassing and/or recreational usage may potentially occur due to the residents living nearby, so there is the potential for oral and/or dermal exposure to the flood-deposited soils [2].

The main exposures considered in the assessment of this site are incidental (accidental) ingestion or dermal contact of flood-deposited soils. Exposure may also occur through pica, a practice of eating significant quantities of dirt that happens mainly among children. The pica value used in the evaluation process is therefore protective of children eating soil and is highly conservative for normal, incidental exposures.

Evaluation Process

No semivolatile contaminants were detected in the September 17, 2005 sediment sample. All of the contaminants detected in the October 3, 2005, soil samples were below the Risk Evaluation/Corrective Action Program (RECAP) screening values [4]. The following contaminants were identified as contaminants of concern (COCs) in the September 30, 2005 soil samples and were therefore assessed to determine if they were a potential health hazard. Appendix A details the screening process and the assessment process that followed if contaminant concentrations exceeded these screening values.

Arsenic

Arsenic 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 [5]. 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 [6].

Children engaging in pica at the Southern Shipbuilding site would be exposed to a maximum possible dose of 9.6×10^{-4} mg/kg/day. This dose is more than thirty times lower than the LOAEL for health effects from ingestion of arsenic [5]. 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 soil 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 6.60×10^{-6} . 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 at the Southern Shipbuilding site therefore should pose **no apparent public health hazard** to residents.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a class of more than 100 different compounds which generally exist as complex mixtures of compounds. Because they are found in and 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 [7].

The PAHs present in soil at the Southern Shipbuilding site were detected at concentrations below those that would cause noncancer health effects. Available evidence indicates that mixtures of PAHs can cause cancer in humans. Incidental ingestion of soil containing this concentration would yield a cancer risk of 2.6×10^{-6} or 26 excess cancers per 10,000,000 people (average used). This is below the EPA's predicted cancer rate of 1×10^{-4} (one excess cancer per 1,000 people) for a normal population. The incidental ingestion of soil containing this contaminant poses **no apparent public health hazard** to residents.

Vanadium

Vanadium is a naturally occurring element in the earth which occurs in fuel oils and coal. One manmade form, vanadium oxide, is most often used by industry. Much smaller amounts are used in making rubber, plastics, ceramics, and certain other chemicals [8].

The highest dose of vanadium possible at the Southern Shipbuilding site would be a dose absorbed by a child engaging in pica. This maximum dose of 0.0045 mg/kg/day is lower than the LOAEL for health effects from ingestion of vanadium [8]. Ingestion of vanadium from Southern Shipbuilding soils therefore should pose **no apparent public health hazard** to residents.

Community Health Concerns

Residents are worried about the possibility that the protective measures at the Southern Shipbuilding site have been compromised. Citizens whose homes are near the site fear returning to an area at which 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 Southern Shipbuilding 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

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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

Evaluation of the sediment and soil sampled by EPA during its post-hurricane investigation suggests that there is **no apparent public health hazard** from exposure to soil from the Southern Shipbuilding site.

Recommendations

There are no recommendations to be made at this time regarding Southern Shipbuilding soil. LDHH/OPH/SEET will examine future Southern Shipbuilding data as needed or required.

Public Health Action Plan

The information produced within this health consultation should be made available to the community members and stakeholders within St. Tammany Parish, Louisiana.

Preparers of this Report

Louisiana Department of Health and Hospitals
Office of Public Health
Section of Environmental Epidemiology and Toxicology
Telephone Number: toll-free (888) 293-7020

Kathleen Golden
Environmental Health Scientist Supervisor

ATSDR Senior Regional Representative

George Pettigrew
Division of Regional Operations
Agency for Toxic Substances and Disease Registry - Region 6

ATSDR Technical Project Officer

Jeff Kellam
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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7. Agency for Toxic Substances and Disease Registry. Toxicological profile for polycyclic aromatic hydrocarbons. Atlanta: US Department of Health and Human Services; 1995 Aug.
8. Agency for Toxic Substances and Disease Registry. Toxicological profile for vanadium. Atlanta: US Department of Health and Human Services; 1992 July.

Certification

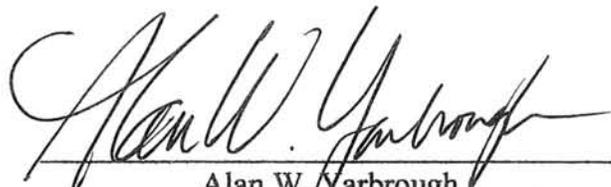
This Hurricane Response Sampling Assessment for the Southern Shipbuilding Corporation public health consultation was prepared by the Louisiana Department of Health and Hospitals under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved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



Jeffrey Kellam

Technical Project Officer, Division of Health Assessment and Consultation (DHAC)

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



Alan W. Yarbrough

Cooperative Agreement Team Leader, DHAC, ATSDR

Figures

Figure 1. The Southern Shipbuilding site boundaries with sampling locations for September 30, 2005.



Adapted from: CH2M HILL, Inc. Hurricane Katrina Response: Southern Shipbuilding, Slidell, Site Inspection and Sampling Results. CH2M HILL Technical Memorandum 06-8459. 2005 Dec .

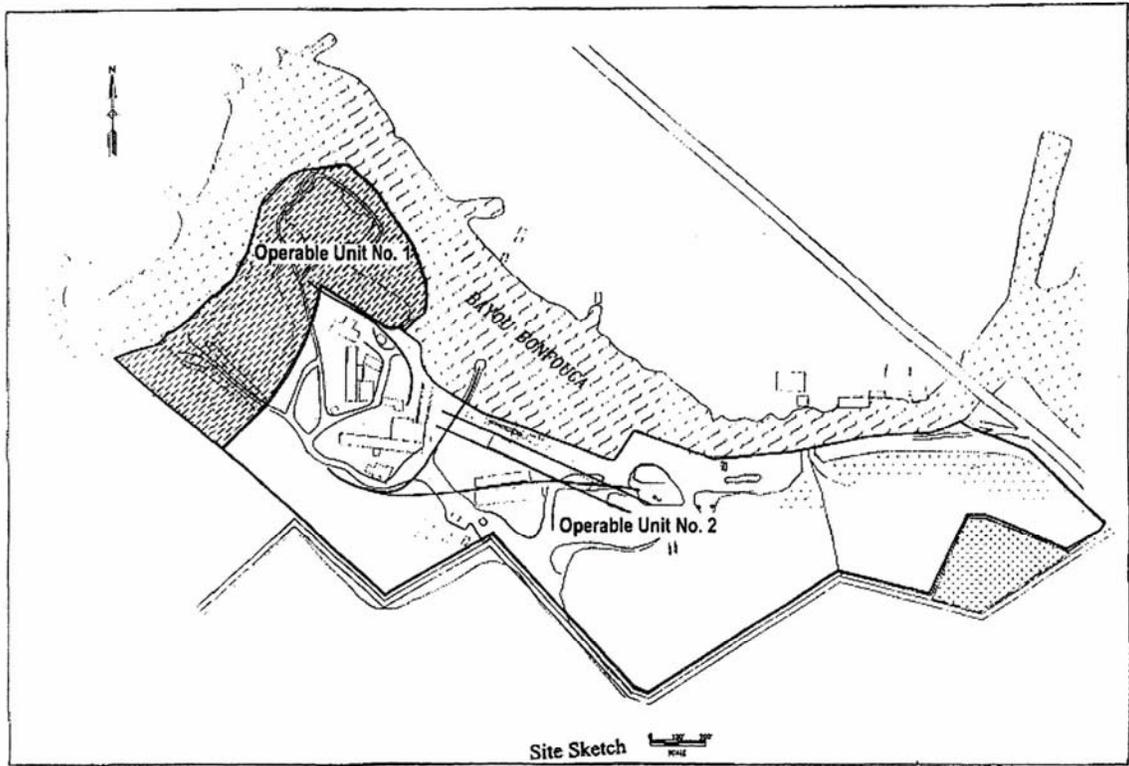
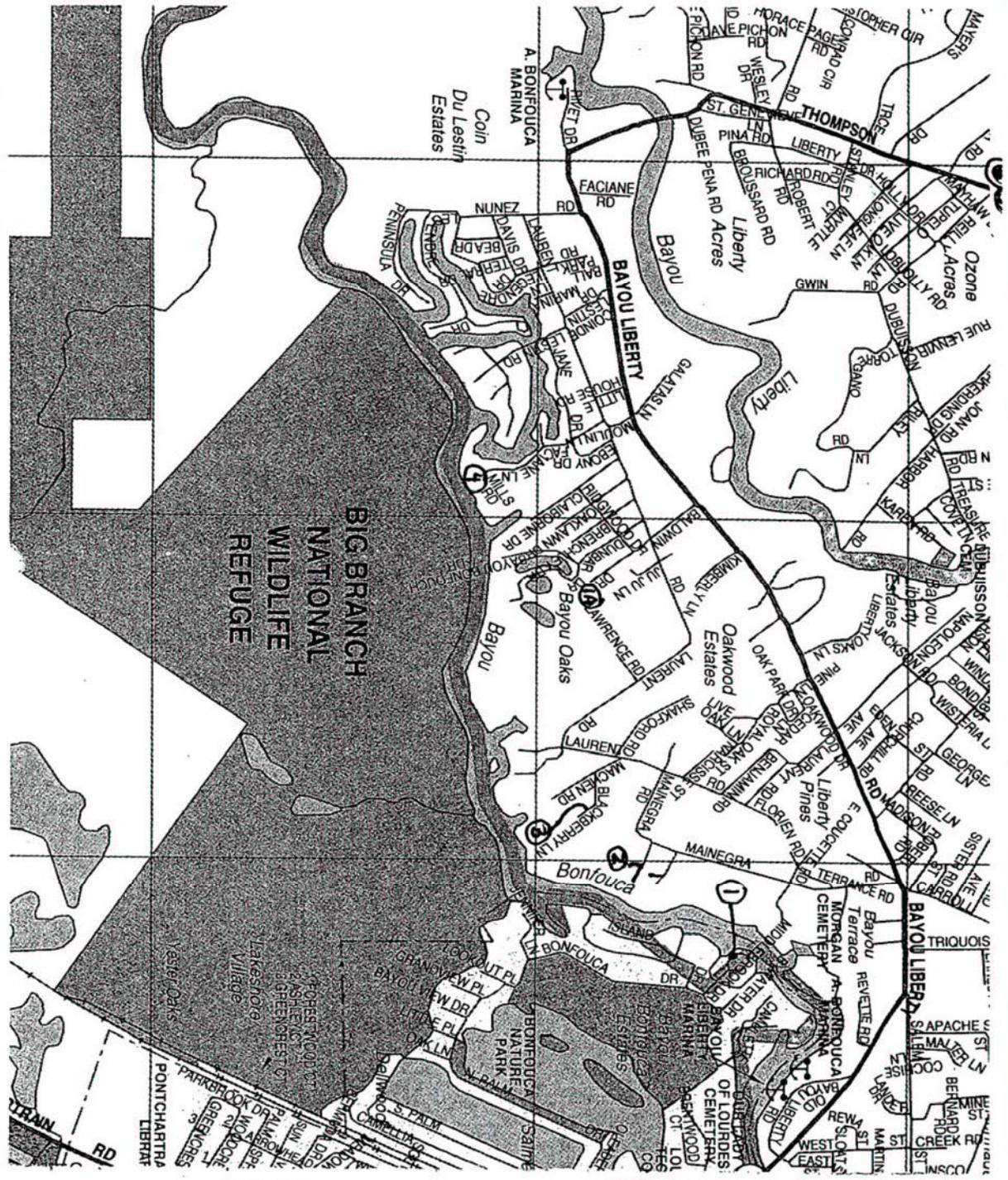


Figure 2 Operable Units

Adapted from: Region 6 EPA. Second Five-Year Report for Southern Shipbuilding Corporation Superfund Site, Slidell, St. Tammany Parish, La. 2005 September .

Figure 3: LDEQ Post Katrina Sampling Locations : September 17, 2005 (Sample 1A) and October 3, 2005 (Samples 1 – 4)



Adapted from LDEQ's Surveillance Division Citizens Complaint Investigation Report, October 2005.

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 Southern Shipbuilding Corporation 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).

Cancer 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 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 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 30, 2005 samples.

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Table A-1. Contaminants of concern detected in samples at the Southern Shipbuilding site

Contaminant (s) of Concern September 17, 2005	Ditch Sediment Sample 1690S17001 (1A)	Reporting Limits [†] (mg/kg)	CV (mg/kg)	CV Reference
Semivolatile Organics	All chemicals are nondetect (ND)	0.330 0.830	0.33	LDEQ/RECAP Soil industrial

Contaminant of Concern September 30, 2005	11279	11280	Concentration Range (Mg/kg) Low - High		CV [†] (mg/kg)	CV reference
arsenic	1.36	3.07	1.36	3.07	0.5 10	CREG [§] Acute EMEG pica child
PAH ^{**} TEQ ^{††}	0.142	0.361	0.142	0.361	0.1	CREG benzo(a)pyrene
vanadium	9.29	14.4	9.29	14.4	600	intermediate EMEG pica child

Contaminant of Concern October 3, 2005	051003-001 Soil (mg/kg)	051003-002 Soil (mg/kg)	051003-003 Soil (mg/kg)	051003-004 Soil (mg/kg)	Reporting Limits [†] (mg/kg)	CV (mg/kg)	CV Reference
Benzo(a)pyrene	0.012	0.012	0.052	0.0037	0.00333	0.33	LDEQ/RECAP Soil industrial

* mg/kg = milligrams per kilogram

[†]CV = comparison value

[‡]EMEG = environmental media evaluation guide

[§]CREG = cancer risk evaluation

[¶]LDEQ RECAP = Louisiana Department of Environmental Quality Risk Evaluation/Corrective Action Program

** PAH = polycyclic aromatic hydrocarbon

^{††}TEQ = toxicity equivalency factor

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Table A-2. 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-3. Total Toxicity Equivalency Quotients(TEQs) for polycyclic aromatic hydrocarbons from the September 30, 2005 sampling event

Sample ID	Total TEQ (mg/kg*)
11279	2.00
11280	2.32

*mg/kg = milligrams per kilogram

Table A-4: Equation variables for calculation of a soil ingestion noncancer risk dose

Variable	Value used*
C = Concentration in soil	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

The soil ingestion non-cancer risk can be estimated as follows:

$$IDs = [(C) (IR) (EF) (CF)] / (BW)$$

Where:

IDs = soil ingestion non-cancer risk (mg/kg/day)

C = contaminant concentration (mg/kg)

IR = soil ingestion rate (mg/day)

EF = exposure factor (unitless) = (exposure frequency) (exposure duration)/(exposure time)

BW = body weight (kg)

CF = conversion factor (10⁻⁶ kg/mg); is required to convert the soil contaminant concentration from mg/kg soil to mg/mg soil

Table A-5: Equation variables for calculation of a soil ingestion cancer risk dose

Variable	Value used*
C = Concentration in soil	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)
SF = Cancer Slope Factor	Chemical specific (mg/kg/day) ⁻¹ Benzo(a)pyrene = 7.3 mg/kg/day ⁻¹ Arsenic = 1.5 mg/kg/day ⁻¹

* 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

The soil ingestion non-cancer risk can be estimated as follows:

$$IDs = [(C) (IR) (EF) (CF) / (BW)] * (SF)$$

Where:

IDs = soil ingestion non-cancer risk (mg/kg/day)

C = contaminant concentration (mg/kg)

IR = soil ingestion rate (mg/day)

EF = exposure factor (unitless) = (exposure frequency) (exposure duration)/(exposure time)

BW = body weight (kg)

CF = conversion factor (10⁻⁶ kg/mg); is required to convert the soil contaminant concentration from mg/kg soil to mg/mg soil

SF = Cancer Slope Factor (mg/kg/day)⁻¹

Tables A-4 and 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 Southern Shipbuilding 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

The estimated risk of developing cancer resulting from exposure to the contaminants within the soil was calculated for both ingestion and dermal exposure 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 1×10^{-6} to 1×10^{-4} (one excess cancer per 1,000,000 people to one excess cancer per 10,000 people).

Table A-6: Equation variables for calculation of a soil dermal non- cancer risk dose

Variable	Value used*
C = Concentration in soil	Chemical-specific (mg/kg) [†]
A = Soil Adherence Concentration	0.2 mg/cm ² (child 1-6 years) 0.07 mg/cm ² (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)
AF = Absorption Factor	0.1 (unitless)

* 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

The soil dermal non-cancer risk can be estimated as follows:

$$DDs = (C) (A) (EF) (CF) (AF) / (BW)$$

Where:

IDs = soil dermal non-cancer risk (mg/kg/day)

C = contaminant concentration (mg/kg)

A = Soil Adherence Concentration

AF = Absorption factor (unitless)

IR = soil ingestion rate (mg/day)

EF = exposure factor (unitless) = (exposure frequency) (exposure duration)/(exposure time)

BW = body weight (kg)

CF = conversion factor (10⁻⁶ kg/mg); is required to convert the soil contaminant concentration from mg/kg soil to mg/mg soil

Table A-7: Equation variables for calculation of a soil dermal cancer risk dose

Variable	Value used*
C = Concentration in soil	Chemical-specific (mg/kg) [†]
A = Soil Adherence Concentration	0.2 mg/cm ² (child 1-6 years) 0.07 mg/cm ² (adult)
CF = Conversion factor	1.00E-06 kg/mg
EF = Exposure factor	1 (unitless)
AF = Absorption Factor	0.1 (unitless)
BW =Body weight	10 kg (infants) 16 kg (children 1-6 years) 70 kg (adults)
SF = Cancer Slope Factor	Chemical specific (mg/kg/day) ⁻¹ Benzo(a)pyrene = 7.3 mg/kg/day ⁻¹ Arsenic = 1.5 mg/kg/day ⁻¹

* 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

The soil dermal cancer risk can be estimated as follows:

$$DDs = [(C) (A) (EF) (CF) (AF) / (BW)] * (SF)$$

Where:

DDs = soil dermal cancer risk (mg/kg/day)

C = contaminant concentration (mg/kg)

A = Soil Adherence Concentration

AF = Absorption factor (unitless)

EF = exposure factor (unitless) = (exposure frequency) (exposure duration)/(exposure time)

BW = body weight (kg)

CF = conversion factor (10⁻⁶ kg/mg); is required to convert the soil contaminant concentration from mg/kg soil to mg/mg soil

SF = Cancer Slope Factor (mg/kg/day)⁻¹