Health Consultation

ORGANIC CHEMICAL RESIDUE IN SCHOOLYARD SOILS

GOODYEAR AND BURROUGHS-MOLLETTE ELEMENTARY
SCHOOLS AND RISLEY MIDDLE SCHOOL
AND
EDO-MILLER PARK/LANIER FIELD

CITY OF BRUNSWICK, GLYNN COUNTY, GEORGIA

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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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CITY OF BRUNSWICK, GLYNN COUNTY, GEORGIA

Prepared by:

Glynn County Board of Health and
Georgia Department of Human Resources
Division of Public Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
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Brunswick, Glynn County, Georgia

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SUMMARY

The Georgia Division of Public Health (GDPH) and Glynn County Health Department (GCHD) reviewed recent environmental sampling data for the Brunswick area to assess whether exposure to the levels of contaminants found in soil are a public health hazard. This health consultation was prepared under a cooperative agreement with the Agency for Toxic Substances and Disease Registry.

In Glynn County, Georgia, the former industrial production of the pesticide toxaphene has been associated with low-level contamination of soil throughout the Brunswick area. Soil sampling data collected during the late 1980's and 1990's suggested that elevated levels of this pesticide were present in soil on public and private property, schoolyards and recreational facilities. Concentration estimates, however, varied considerably between regulatory and independently contracted studies, and although the potential sources and distribution routes for toxaphene in soil have been defined, attempts to evaluate the amount, level of exposure, or human health consequences have remained controversial and inconclusive. More recent investigations of three public schoolyards and one park suggest that concentrations of toxaphene in soil are lower than previous estimates, and soil data showed elevated levels of benzo(a)pyrene and total polycyclic aromatic hydrocarbons (PAHs).

This document contains information about the environmental transport and extent of human exposure to contaminants found in soil at three schoolyards and a park, conclusions about the health risks posed to children and other residents, and recommendations intended to protect public health. A health consultation is specifically designed to provide the community with information about the public health implications from exposure to regulated substances at a specific site, and to identify populations for which further health actions are needed. It is not intended to serve the purpose of or influence any other environmental investigation such as a risk assessment, or to address liability, remediation, or other non-health issues.

The GDPH and GCHD have determined that the Goodyear Elementary School is an **Indeterminate Public Health Hazard** because there are insufficient data to determine whether the site has had an adverse impact on human health. In order to protect students and workers, confirmation soil sampling, analyses and additional evaluation are needed to determine the level of contaminants present and extent of soil affected. The limited data available do not indicate that humans are being or have been exposed to levels of contamination that would be expected to cause adverse health effects.

The GDPH and GCHD have determined that Burroughs-Mollette Elementary, Risley Middle School and Edo-Miller Park are **No Apparent Public Health Hazard** because human exposures to contaminated soil that may be occurring, or have occurred in the past, are at levels below those considered to be a health hazard for children, employees or other workers.

GDPH and GCHD recommend that:

1. Additional limited evaluation of surface and subsurface soil at Goodyear Elementary School should be conducted to determine the vertical and horizontal extent of contamination.

2. At Goodyear Elementary School, the new soil cap's placement and design should be evaluated by a Professional Engineer.
3. Until the results from additional soil analyses have been evaluated, the following precautionary measures should be put into place at Goodyear Elementary School: (1) maintain substantial ground cover to minimize exposures to children and workers, and (2) Implement a Health and Safety Plan to protect on-site workers performing activities related to excavation, lawn maintenance, and utility repairs.

GLOSSARY OF ACRONYMS

ATSDR Agency for Toxic Substances and Disease Registry

BAP benzo(a)pyrene

EPA United States Environmental Protection Agency

GCHD Glynn County Health Department

GDHR Georgia Department of Human Resources

GDPH Georgia Division of Public Health

GEPD Georgia Environmental Protection Division

mg/kg milligrams per kilogram

ppm parts per million

PAH polycyclic aromatic hydrocarbons

PCB polychlorinated biphenyl

STATEMENT OF ISSUES AND BACKGROUND

The Georgia Department of Human Resources, Division of Public Health (GDPH), and Glynn County Health Department (GCHD) were asked by residents to review soil sampling data to determine if concentrations of toxaphene measured in soil posed a health hazard to children who access the playgrounds at Goodyear and Burroughs-Mollette Elementary Schools, Risley Middle School, and Edo-Miller Park/Lanier Field. In response, this health consultation was prepared under a cooperative agreement with the Agency for Toxic Substances and Disease Registry.

Site History

The city of Brunswick is located in southeastern Georgia in Glynn County on St. Simons Sound and the Atlantic Intracoastal Waterway. Located near the center of the county is Hercules, Incorporated (Hercules), a mid-size industrial complex that has been the focus of concern for residents of the area for several decades.

Hercules is a global manufacturer of chemical specialty products. Situated on 350 acres in Brunswick, Georgia, Hercules began operations in 1920. With over four hundred employees, the plant operates around the clock, seven days a week. Hercules is nearly the only one of its kind in the world today that transforms pine stumps into industrial chemicals ultimately used in hundreds of consumer products such as solvents, adhesives, sealant, cleansers, chewing gum, toothpaste, citrus drinks, and many other consumer products.

The Hercules, Incorporated facility viewed from Edo-Miller Park/Lanier Field.

Hercules manufactured an industrial form of the insecticide toxaphene in Brunswick from the mid 1940's until 1982 [1]. The industrial product or formula known as "technical grade toxaphene" contained the original pesticide conjugate mixture or "active ingredient" and about six hundred additional chemical impurities. Toxaphene was one of the most heavily used insecticides in the United States until 1982, when it was banned for most uses; all uses were banned in 1990. It was used in the southern United States primarily to control insect pests on cotton and other crops and livestock, and to kill unwanted fish in rivers and lakes.

Toxaphene is strongly sorbed by soil and breaks down slowly in soil (half of the toxaphene in soil will break down in about ten years) [2]. Breathing, eating, or drinking excessive amounts of toxaphene could damage the lungs, nervous system, and kidneys [2]. There is no toxicological information on how exposure to low levels of toxaphene can affect people; however, studies show that animals that ate food or drank water-containing toxaphene had effects on the liver, kidneys, adrenal glands, and immune system. It is not known whether toxaphene can affect reproduction or cause birth defects in people. Animal studies have reported that toxaphene affects the development of newborn animals when their mothers are exposed during pregnancy [2]. The Department of Health and Human Services has determined that toxaphene may reasonably be anticipated to be a human carcinogen (causes cancer).

Environmental Sampling History

Environmental investigation results indicate some localized toxaphene contamination and a limited potential for human exposure to toxaphene in soil, sediment, surface water and groundwater throughout Brunswick. This health consultation will address toxaphene contamination of soil only; specifically, at three schools and a park located near Hercules.

Closure and Post Closure Environmental Investigations were conducted at Hercules in the mid to late 1980’s to address contamination issues at the Hercules main industrial facility and satellite operations associated with the former production of toxaphene. Elevated levels of toxaphene were found in soil, sediment, and groundwater samples collected at the main factory, solid waste disposal facility(s) and former wastewater discharge points [3]. Presently, the Georgia Environmental Protection Division (GEPD) and United States Environmental Protection Agency (EPA) are addressing toxaphene issues at the Hercules 009 Landfill, Terry Creeks Dredge Spoil Area/Hercules Outfall, and the former Hercules production facility.

Although the laboratory analysis of toxaphene is relatively well defined under controlled conditions, interferences commonly associated with environmental samples reduce laboratory efficiency and the ability to perform accurate analyses. This is because soils, sediment and groundwater contain interferences that reduce the ability of laboratory test equipment to efficiently and accurately identify some complex chemical mixtures like toxaphene. Before moving on with the toxaphene assessment in Brunswick, the EPA and GEPD recognized a need for standardized procedures. In 1991, a Toxaphene Task Force was assembled with the objective to develop practical and acceptable methods for the identification and quantification of toxaphene in environmental samples. The Task Force was comprised of technical personnel representing EPA, GEPD, and Hercules.

In 1993, GEPD reported low levels of toxaphene in soil on properties bordering the Hercules main production facility [4]. In 1995 and 1996, residential yards in the vicinity of the Hercules facility were sampled for toxaphene. Forty samples were collected to determine whether any off-site toxaphene concentrations are associated with the facility [5].

Although toxaphene was not detected in most of the yards, eight yards were found to contain toxaphene concentrations ranging from 0.9 to 2.6 parts per million (ppm) [5]. Newfields, Inc, a Hercules contractor, concluded that from a statistical analysis of these data, no pattern or trend of toxaphene dispersal from the facility was discernable [5]. The Glynn County School Board initiated an investigation to determine if toxaphene was also present on public school properties and a park located near this facility.

In 1996, the results of soil samples collected from two schoolyards, Goodyear and Burroughs-Mollette Elementary Schools, suggested that toxaphene or "toxaphene-like" compounds were present in the schoolyard soils [6]. However, because of controversy associated with the unconfirmed analytical data, a definitive evaluation could not be made.

In April 1996, GEPD collected soil samples for toxaphene analysis from four schools at the request of the Glynn County School Board. Toxaphene was not detected in any of the samples [7]. The EPA collected soil samples in June 1996 from nine elementary and three middle schools, and from ten parks in the Brunswick area. Toxaphene was not detected in any of the samples [7]. The Agency for Toxic Substances and Disease Registry (ATSDR) reviewed the surface soil analytical data and determined that the sampling event did not indicate the presence of contaminants in surface soil that would result in exposures to contaminants at levels of public health concern [8].

Also in 1996, GEPD contracted for an investigation of the potential health impacts from acute exposure to contaminated soil. Failure to identify characteristic toxaphene congeners in any of these samples should be noted. In addition, acute toxicity was limited to lower level invertebrates only. No adverse health effects were observed for higher order life forms (vertebrates), even at concentrations three times above soil contaminant levels [9].

In December 1996 and in April 1997, EPA and GEPD collected approximately 180 surface soil samples from the residential areas of Brunswick. Although a few soil samples were found to contain contaminants, the concentration levels of the contaminants were low enough that the agencies concluded that they did not pose an imminent danger to the public or the environment [7].

In 1997, ATSDR began a public health assessment of the nearby Terry Creek Dredge Spoil Areas/Hercules Outfall National Priorities List (Superfund) site. An extensive review of existing residential and schoolyard soil data was conducted, and ATSDR recommended soil sampling for toxaphene of residential yards that receive, or have received, silty runoff from ditches on the Hercules plant site. No other conclusions or recommendations pertaining to soil contamination were included in the public health assessment published in August 2002 [10].

In 2001, the Glynn Environmental Coalition (GEC), a community activist group, and the Glynn County School Board collaborated on a study to determine if toxaphene was present in soils at three schoolyards and a park at levels hazardous to public health. The project was supported by the GCHD, and funded by the GEC and the Glynn County School Board. In October 2002, soil sampling and analyses were conducted by the Skidaway Institute of Oceanography using the most currently accepted procedures and Best Available Technology [11]. The Skidaway Institute is an autonomous research unit of the University System of Georgia located in Savannah, Georgia. More information about the Skidaway Institute of Oceanography can be found at *www.skio.peachnet.edu*.

In July 2002, the GCHD asked the Georgia Department of Human Resources (GDHR), Division of Public Health to provide a health consultation examining the public health implications of the results of the Skidaway Institute findings. The results of this study are discussed in this health consultation. This health consultation was prepared by staff from the GCHD with technical assistance provided by GDHR, under a cooperative agreement with ATSDR.

Site Description

Goodyear Elementary School

Goodyear Elementary School is located at 3000 Roxboro Road (Figure 1). The school is located approximately 0.5 miles from Hercules, and bordered by an urban residential neighborhood. Archived records dating back to 1962 were available from the Georgia Department of Education for this school. Information pertaining to the pre-1962 era was limited and did not contain construction information, but did suggest that the school accommodated workers and a student body in grades one through six. Between 1975 and 1998, the student body shifted to grades one through five. Student enrollment was 538 during the 1994-1995 school year and 477 in 2001-2002. In 1997 and 1998, with exception of the gymnasium, Goodyear was demolished and completely re-built. Construction activities included elevating site grade for the new buildings with several hundred cubic yards of fill dirt. The school re-opened for the 1999-2000 school year. Aerial photographs taken during the construction period suggest approximately 60% of facility soil was disturbed during the activities [12]. Visual inspection by GCHD staff indicates an estimated 70% of the site soil surface area is either under buildings or impervious surfaces, with the remaining 30% accessible to children. In response to the Skidaway Study results published in October 2002, the Glynn County School Board installed a thin soil cap (approximately 5 inches deep) over the suspected contaminated areas. T*he new soil cap's placement has not been verified for accuracy*. The cap is located on areas that comprise most of the common areas accessible to children and workers, and is generally bare soil. The rest of the site has partial turf cover throughout most of the year, with bare soil predominant in the winter months.

The new soil cap at Goodyear Elementary School.

Burroughs-Mollette Elementary School

Burroughs-Mollette Elementary School is located at 1900 Lee Street (Figure 1). The school is located approximately 0.25 miles from Hercules, and bordered by an urban residential neighborhood. Archived records available from the Georgia Department of Education date back to 1964 when the school was built. Since construction, it has accommodated workers and a student body from kindergarten through grade five. Student enrollment was 865 during the 1994-1995 school year and 684 during 2001-2002. The school common grounds and play areas are expansive and schoolyard soil is covered with lush turf and other vegetation throughout most of the year, with some bare soil during the winter months.

Play area near grid cell location BM-13 at Burroughs-Mollette Elementary School.

Risley Middle School

Risley Middle School is located at 2900 Albany Street (Figure 1). The school is located less than 0.25 miles from Hercules, and bordered by an urban residential neighborhood. Archived records dating back to 1962 were available from the Georgia Department of Education. Information pertaining to the pre-1962 era was limited and did not contain construction information, but did suggest that the school accommodated workers and a student body in grades ten through twelve. In 1975 and 1976, the student body shifted to grades five through six, then grades six through eight. Risley had an enrollment of 769 reported in 1994-1995 and 514 in 2001-2002. The school common grounds and play areas are expansive and schoolyard soil is covered with fairly thick turf grass and other vegetation throughout most of the year, with some bare soil during the winter months.

Common grounds and play areas at Risley Middle School are expansive and schoolyard soils are covered in turf grass and other vegetation.

Edo-Miller Park/Lanier Field

Edo-Miller Park/Lanier Field (Edo-Miller Park) is located on L Street (Figure 1). The Park is located less than 0.25 miles from Hercules, and bordered by Hercules, GA Highway 17, and an urban residential neighborhood. The park was opened for public use in the early 1950s, and then acquired by the Glynn County School Board in the mid-1980s for exclusive use by the school system. The park is used from February through July, and closed the remainder of the year. The park is completely surrounded by a locked fence, and there is no public access when the facility is not in use. There is a soccer field, a baseball field, an area of trees and other vegetation, and turf-grass covered open areas throughout most of the year, with some bare soil during the winter months.

Edo-Miller Park/Lanier Field has bleachers and a ballpark.

Study Methodology

During the latter months of 2001 and early 2002, ninety-four composite samples were collected and field-screened for chlorinated organic chemicals by the Skidaway Institute staff at the four sites described above. The total land area for the four sites, which includes buildings and impervious surfaces, is estimated to be approximately 900,000 ft^2. Sample locations were determined by overlaying each site with grids laid out using 100 feet X 100 feet cells (Figures 2 – 5). From each grid cell, composite samples were prepared by collecting and mixing together five shallow (0-3 inches), discrete soil samples of equal volume. Each composite sample, representing a total area of soil equivalent to 10,000 ft^2 was then screened using enzyme-linked immunosorbent assay (ELISA) for the presence of toxaphene. Composite samples that field-screened "ELISA positive" were shipped to and analyzed at the Skidaway Institute of Oceanography laboratory by other procedures using Best Available Technology (BAT).

Laboratory analysis suggested that although the ELISA procedure was non-specific in screening for toxaphene, it did prove to be a good indicator for detecting the presence of several unrelated chlorinated pesticides, polyclyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), as well as the intended target contaminant, toxaphene.

HUMAN EXPOSURE PATHWAYS

GCHD determines exposure to environmental contamination by examining exposure pathways. An exposure pathway is generally classified by environmental medium (e.g., water, soil, air, food). A completed exposure pathway exists when people are actually exposed through ingestion or inhalation of, or by skin contact with a contaminated medium. An exposure pathway consists of five elements: a source of contamination; transport through an environmental medium; a point of exposure; a route of exposure; and a receptor population.

GCHD categorizes an exposure pathway as a completed or potential exposure pathway if the exposure pathway cannot be eliminated. In completed exposure pathways, all five elements exist, and exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In potential pathways, at least one of the five elements is missing but could exist. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring 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.

Completed Exposure Pathways

Table 1 identifies the completed exposure pathways for the areas of concern. At the schools and park investigated, a completed exposure pathway exists for contaminated soil.

Table 1. Completed Exposure Pathway

Pathway	Exposure Pathway Elements					Time
	Sources	Medium	Point of Exposure	Route of Exposure	Exposed Population	
Surface soil	Various: air disposition from vehicle and industrial emissions; contaminated fill dirt	Surface soil	Surface soil, dust, soil gas	Ingestion Inhalation Dermal	Students, employees, visitors, trespassers, and workers who access sites	Past Present Future

This health consultation evaluates exposure to contaminated soil through ingestion at the three schools and the park. Ingestion is defined as *direct ingestion* or actively and passively eating soil particles; and, *indirect ingestion*, or inhalation of dust particles that are then expelled from the respiratory tract and swallowed (ingested). Because of the large particle size of contaminated soil (diameter greater than 5 micrometers), soil dust is usually ingested However, it is important to note that the other routes of exposure; inhalation of very small particles and vapors, and dermal absorption, may contribute additional exposure to contaminants at these sites, but are considered to be minimal and not of health concern.

Other pathways for the contaminants of concern at these sites may pose additional exposures, but are not considered in this health consultation. See Appendix A for information on additional exposure pathways.

People usually ingest contaminated soil by putting their hands, food, or other objects covered with soil particles into their mouths. Particle size, ground cover, soil conditions, seasonal variation, behavior patterns, a person’s age, outdoor activity, and a variety of other factors influence what dose or amount of a contaminant a person receives during exposure to contaminated soil. After visiting the schools and park on several occasions, GCHD staff noted that each of the properties have substantial ground cover (e.g., grass) during the summer months, and mature trees and shrubs. Turf cover at all four sites was reduced during the winter months. Bare soil was noted in areas at Goodyear Elementary School, particularly in the vicinity of the soil cap.

Because young children access the sites daily, they are at the greatest risk for exposure to contaminated soil at levels of health concern. Therefore, this health consultation addresses children's exposures only. Adults who have repeated contact with soil at these properties may also be exposed to contaminants. Maintenance and renovation workers are encouraged to strictly follow a health and safety plan when contacting soil at these sites. Visitors and trespassers may also be exposed to contaminated soil.

Comparison Values

In preparing this document, GCHD used the Agency for Toxic Substances and Disease Registry's (see Appendix B for more information about this Agency) established comparison values to screen contaminant levels and select chemicals of concern--a chemical that exceeds one or more comparison value--that warrant further evaluation. **Comparison values (CVs)** are concentrations of chemicals that can reasonably (and conservatively) be regarded as harmless, assuming default conditions of exposure. The CVs generally include ample safety factors to ensure protection of sensitive populations. Because CVs do not represent thresholds of toxicity, exposure to contaminant concentrations above CVs will not necessarily lead to adverse health effects. Further discussion of CVs used in this document are in Appendix C.

Because the levels of some contaminants exceeded CVs, the potential health risks from exposure to these contaminants were examined. Children are the population of concern at these sites; therefore, exposure doses were calculated for both children with and without *pica* behavior. *Pica* or *geophagy* is defined as a craving to eat nonfood items, such as dirt, paint chips, clay and dirt. *Pica* is very rare, and usually does not occur for an extended period of time. Pica is seen more in young children than adults, with 10-32% of children aged 1 to 6 exhibiting these behaviors [13]. Children with *pica* should be given special consideration at these sites, and are potentially at greater risk for adverse health effects from exposure to contaminated soil.

Health Guidelines

When a contaminant exceeds a CV, the toxicological evaluation presented in a health consultation requires a comparison of the exposure dose (i.e., amount of the contaminant believed to enter the body at the person's body weight for an estimated duration of time) with an appropriate health guideline.

Noncancer Health Risks

The doses calculated for exposure to individual chemicals are then compared to an established health guideline, such as an ATSDR minimal risk level (MRL) or an EPA reference dose (RfD), in order to assess whether adverse health impacts from exposure are expected. Health guidelines are chemical-specific values that are based on available scientific literature and are considered protective of human health.

Cancer Risks

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated risk for developing cancer from exposure to contaminants discussed in this health consultation was calculated by multiplying the site-specific adult exposure doses by EPA's chemical-specific cancer slope factors (CSFs), available at *www.epa.gov/iris*. This calculation estimates a theoretical excess cancer risk expressed as a proportion of the population that may be affected by a carcinogen during a timeframe of exposure (e.g., adult [lifetime]: 70 years). For example, an estimated risk over 1 x 10^{-6} predicts the probability of additional cancer cases over background of one in a population of 1 million (the theoretical lifetime cancer risk). An increased lifetime cancer risk is not a specified estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime in his or her lifetime following exposure to a particular contaminant.

Appendix C contains an explanation of the CVs, MRLs, RfDs, and CSFs, and the equations used to estimate the exposure doses used in this health consultation.

RESULTS

Benzo(a)pyrene (BAP) and total polycyclic aromatic hydrocarbons (PAHs) were found in the composite soil samples at levels close to or exceeding CVs in this study (Table 2). PAHs, including BAP, are a group of over 100 different chemicals that are formed during the incomplete burning of coal, petroleum products, garbage, or other organic substances like tobacco. The U.S. Department of Health and Human Services has determined that some PAHs, including BAP, may reasonably be expected to cause cancer.

Benzo(a)pyrene (BAP)

Levels of BAP close to or above one CV were reported in four soil samples obtained from each of the three school sites (two elevated levels were found at Goodyear). These samples were found to spatially represent BAP impacted soil ranging from approximately 10,000 ft^2 at both Burroughs-Mollette and Risley Schools, to 30,000 ft^2 at Goodyear School. No BAP levels exceeding a CV were found at Edo-Miller Park.

Total Polycyclic Aromatic Hydrocarbons (PAHs)

There are no CVs for total PAHs. BAP is the only PAH found with a CV that was exceeded. No sample contained greater than 9.7% BAP. Total PAHs were found at levels exceeding a regulatory level[1] at two sites, spatially representing areas at Goodyear (150,000 ft^2) and Risley (20,000 ft^2).

Results for all contaminant levels found at each site that exceeded a health, applicable comparison values, and the sample grid cell locations, are listed in tables in Appendix D.

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[1] Soil concentration that triggers notification requirements for the purposes of Rule 391-3-19-04(3)(b): Georgia Department Of Natural Resources, Environmental Protection Division, Hazardous Site Response Rules.

Site-specific Maximum Concentrations

Goodyear Elementary School

Appendix D, Table D-1, lists the maximum level detected for each contaminant analyzed, the applicable CVs, and grid cell location at Goodyear Elementary School (GY). The levels of BAP found suggested a need to further evaluate the potential for adverse health effects from exposure at the GY-10, GY-18 and GY-19 grid cell locations. The highest BAP concentration in soil reported for GY-10 (2.10) parts per million [ppm]) represents the highest BAP level found at this site, as well as throughout the entire study area (Table 2). Levels of BAP close to the lowest CV of 0.10 ppm were also detected in a composite sample taken from GY-18 and GY-19 (0.096 ppm).

The soil concentration of total PAHs (21.70 ppm) found in the sample collected from grid cell GY-10 exceeds the applicable CV (5.0 ppm) and represents the highest total PAH level found at this site, as well as throughout the entire study area (Table 2). **However, because total PAHs concentrations are represented in every other grid cell locations throughout the study area, and no other grid cell locations have levels near this level of total PAHs, this level is considered an outlier. In addition, grid cell GY-10 is located near one of the classroom buildings and not in an area of frequent access.**

There were no detectable levels (>0.010 ppm) of toxaphene found in any soil sample collected at the GY site.

Burroughs-Mollette Elementary School

Appendix D, Table D-2, lists the maximum level detected for each contaminant analyzed, the applicable CVs, and grid cell location at Burroughs-Mollette Elementary School (BM). The level of BAP found (0.120 ppm) suggested a need to further evaluate the potential adverse health effects from exposure at the BM-13 grid cell location (Table 2).

Toxaphene was detected below the lowest CV for toxaphene (0.60 ppm) in four samples collected from BM-17 (0.020 ppm), BM-20 (0.018 ppm), BM-24 (0.030 ppm) and BM-27 (0.030 ppm).

Risley Middle School

Appendix D, Table D-3, lists the maximum level detected for each contaminant analyzed, the applicable CVs, and grid cell location at Risley Middle School (RIS). The level of BAP found (0.570 ppm) suggested a need to further evaluate the potential adverse health effects from exposure at the RIS-35 grid cell location (Table 2).

The soil concentration reported for total PAHs (7.30 ppm) at RIS-35 exceeds the applicable CV (Table 2).

Toxaphene was detected below the lowest CV (0.60 ppm) in samples collected from RIS-07 (0.030 ppm), but not at any other location at this site.

Edo-Miller Park/Lanier Field

Appendix D, Table D-4, lists the maximum level detected for each contaminant analyzed, the applicable CVs, and grid cell location at Edo-Miller Park/Lanier Field (Table 2).
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Toxaphene concentrations were detected below the lowest CV (0.60 ppm) in samples collected from EMF 7-14 (0.38 ppm), EMF 1-1a-6a (0.19 ppm), EMF-2a-3a-4a (0.05 ppm) and EMF 30-37 (0.04 ppm).

Table 2 summarizes the maximum concentration levels of BAP and PAHs identified in soil at each site that exceeds the lowest CVs for ingestion (or regulatory level).

Table 2. Comparison Of Soil Sample Results To Applicable Comparison Values For Ingestion

Chemical Compound	Site	Grid Cell Location(s)	Maximum Soil Concentration (ppm)	CV	Type of CV
benzo(a)pyrene	Goodyear	GY-10 (GY-18, GY-19)	2.10 (0.096)	0.10	CREG
benzo(a)pyrene	Burroughs-Mollette	BM-13	0.12	0.10	CREG
benzo(a)pyrene	Risley	RIS-35	0.57	0.10	CREG
total PAHs[1]	Goodyear	GY-10	21.70	5.00	NC[2]
total PAHs[1]	Risley	RIS-35	7.30	5.00	NC[2]

ppm: parts per million
CREG: Cancer Risk Evaluation Guide ($1x10^{-6}$ excess cancer risk)
[1] Includes all isomeric forms
[2] NC: Notification Concentration (state regulatory level)
* Source: ATSDR Soil Comparison Values (1/10/05)

Site-specific Exposure Doses

Table 3 compares the calculated exposure doses of BAP and PAHs from exposure to contaminated soils to applicable health guidelines (MRLs and RfDs). Calculations are based on the maximum concentrations of each chemical that exceeds a CV as listed in Table 2.

Because of the nature of school attendance, a conservative time period of 10 years (kindergarten through eighth grade), 5 days/week, 36 weeks/year, was used as the length of time a child would attend the schools, while also frequenting the park, and is considered protective for potential maximum exposure. Children with *pica* were considered to receive potential maximum exposure in 1 year; 5 days/week, for 36 weeks/year, and added to the dose over nine years for a child without *pica*. Appendix C contains an explanation of the equations used to estimate the exposure doses used in this health consultation.

Table 3. Comparison Of Maximum Soil Concentrations To Applicable Health Guidelines

Chemical Compound	Location	Maximum Soil Concentration (ppm)	Health Guideline* (mg/kg/day)	Estimated Exposure Dose (child)	Cancer Risk (child)	Estimated Exposure Dose (*pica* child)	Cancer Risk (*pica* child)
benzo(a)pyrene	Goodyear (GY-10)	2.10	NA	0.000008	9×10^{-6}	0.0003	1×10^{-5}
benzo(a)pyrene	Burroughs-Mollette (BM-13)	0.12	NA	0.0000005	5×10^{-7}	0.00002	6×10^{-7}
benzo(a)pyrene	Risley (RIS-35)	0.57	NA	0.000002	2×10^{-6}	0.00009	3×10^{-6}
total PAHs[1]	Goodyear (GY-10)	21.70	NA	0.000085	NA	0.003	NA
total PAHs[1]	Risley (RIS-35)	7.30	NA	0.00003	NA	0.001	NA

ppm: parts per million
mg/kg/day: milligrams per kilogram per day
NA: Not applicable
[1] Includes all isomeric forms
* Source: ATSDR, Health Guidelines (1/10/05)

The chemicals of concern, BAP and total PAHs, do not have health guidelines, and there is no CSF for total PAHs.

Because total PAHs concentrations are found in every other grid cell locations throughout the study area, and no other grid cell locations have levels near the level of total PAHs found in GY-10, **this level is considered an outlier**. In addition, grid cell GY-10 is located near one of the classroom buildings and not in an area of frequent access. RIS-35 is located in the front of the school near the bus lane and not in an area where children play.

The estimated cancer risks for exposure to BAP at Goodyear Elementary and Risley Middle Schools exceed the lifetime cancer risk of 1×10^{-6}. In other words, the cancer risk from exposure to BAP may be increased if a child with or without *pica* is exposed to BAP at the highest contaminant levels detected for 5 days/week, 36 weeks/year for 10 years (child without *pica*) or one year (child with *pica*). However, this exposure scenario is extremely unlikely because it is based on a worst-case scenario, that is, continual exposure via ingestion to the highest levels detected, and actual exposure is probably much lower. Furthermore, because of the transitory nature of school attendance, prolonged exposure to site contaminants is unlikely, so the risk of contracting cancer from site related contaminants is likely to be further reduced.

Pica is extremely rare and usually only occurs in children at a much younger age than those attending elementary or middle school. As with any situation where a child exhibits *pica*, that child should be given special consideration, and is potentially at greater risk for adverse health effects from exposure to contaminated soil.

Toxicological Evaluation

Benzo(a)pyrene (BAP)

An evaluation of the available soil data from Goodyear Elementary and Risley Middle Schools indicate that the calculated exposure dose to BAP is 9 x 10^{-6} (Goodyear) and 2 x 10^{-6} (Risley) mg/kg/day for children, and if a child exhibits *pica* characteristics, the estimated dose is 1 x 10^{-5} (Goodyear) and 3 x 10^{-6} (Risley) mg/kg/day. A health guideline has not been established for BAP, however, a NOAEL of approximately 150 mg/kg/day has been established for rats with intermediate exposure to BAP, when reproductive effects were looked at [14]. Non-carcinogenic adverse health effects from soil ingestion are not expected to result from past, current, and future exposure to soil at Goodyear Elementary or Risley Middle Schools. Although concentrations of BAP in soil that may have existed in the past are unknown, adverse health effects from past exposure to BAP are not likely because the likely site-specific exposure doses would also be low.

The International Agency for Research on Cancer and the EPA classifies BAP as probably carcinogenic to humans (limited human evidence; sufficient evidence in animals). Human data specifically linking BAP to a carcinogenic effect are lacking.

Contaminant Frequency

In an effort to assure that maximum potential exposures to contaminated soil are being adequately assessed, the issue of additive exposures was examined. This section of the health consultation looks at whether there may be an increased risk for exposure to contaminants at levels of health concern because a number of grids have low levels of contaminants, and children commonly access many grid locations. The frequency of each contaminant found at each site is summarized in Table 4.

Toxaphene

Toxaphene was detected, but below CVs in 38% of samples collected at Burroughs-Mollette Elementary School, 16% of samples collected at Risley Middle School, and 67% of samples from Edo-Miller Park, this pesticide could not be identified in any samples collected at Goodyear Elementary School. Toxaphene was used regularly throughout Brunswick for pest control for many years, and these trace level residues may have originated from past applications. Soil manipulation and site grade renovations at Goodyear Elementary School during reconstruction, included the addition of fill dirt from an outside source. These activities may explain the absence of toxaphene at this site.

Other Contaminants of Concern

Chlordane, cis-nonachlor, trans-nonachlor, fluoranthene, pyrene, chrysene, total PCBs and total PAHs were all found in the majority (equal to or greater than 50%) of samples taken at all four sites.

Table 4. Frequency Of Organic Chemical Residue In Soil Samples for All Sites

Chemical Compound	Goodyear Elementary School	Burroughs-Mollette Elementary School	Risley Middle School	Edo-Miller Park
Percent Frequency (%) / Total Samples (n)				
chlordane	100% (10)	100% (10)	100% (6)	100% (9)
oxychlordane	40% (10)	10% (10)	17% (6)	67% (9)
toxaphene	0% (10)	38% (8)	16% (6)	67% (9)
total polychlorinated biphenyl (PCBs)[2]	91% (11)	80% (10)	100% (7)	100% (9)
heptachlor	60% (10)	0% (10)	17% (6)	0% (9)
heptachlor-epoxide	50% (10)	0% (10)	33% (6)	0% (9)
cis-nonachlor	70% (10)	70% (10)	50% (6)	100% (9)
trans-nonachlor	100% (10)	80% (10)	67% (6)	78% (9)
2-methyl-naphthalene	9% (11)	0% (10)	0% (7)	0% (8)
1-methly-naphthalene	9% (11)	0% (10)	0% (7)	0% (8)
biphenyl	9% (11)	0% (10)	0% (7)	0% (8)
acenapthene	18% (11)	0% (10)	0% (7)	0% (8)
fluorine	27% (11)	0% (10)	14% (7)	0% (8)
fluoranthene	100% (11)	90% (10)	100% (7)	63% (8)
1-methlyphenanthrene	36% (11)	10% (10)	71% (7)	25 % (8)
anthracene	55% (11)	0% (10)	29% (7)	25% (8)
phenanthrene	89% (9)	0% (3)	100% (7)	0% (8)
pyrene	100% (11)	70% (10)	100% (7)	63% (8)
benzo(a)anthracene	100% (11)	20% (10)	86% (7)	13% (8)
chrysene	91% (11)	80% (10)	86% (7)	55% (8)
benzo(b)fluoranthene	73% (11)	90% (10)	86% (7)	34% (8)
benzo(k)floranthene	36% (11)	40% (10)	29% (7)	0% (8)
benzo(e)pyrene	82% (11)	50% (10)	86% (7)	13% (8)
benzo(a)pyrene	18% (11)	20% (10)	43% (7)	13% (8)
indenol(1,2,3,c,d,)pyrene	45% (11)	10% (10)	43% (7)	26% (8)
dibenzo(a,h)anthracene	9% (11)	0% (10)	14% (7)	0% (8)
benzo(g,h,i)perylene	45% (11)	10% (10)	28% (7)	13% (8)
total polycyclic aromatic hydrocarbons (PAHs)	100% (11)	100% (10)	100% (7)	100% (8)

Source: Frohlich, Marco; Maruya, Keith; *Determination of toxaphene in Brunswick (GA), public access area soils by immunoassay and gas chromatography*, Skidaway Institute of Oceanography, Savannah, Georgia; October 23, 2002.

Maximum Potential Concentration in Composite Sub-samples

Because of the frequency of low levels of several contaminants found at some locations at all four sites, and because the samples analyzed were composite samples, an increased risk for exposure may exist above what was calculated during the previous toxicological examination.

The maximum potential chemical concentrations for individual sub-sample “aliquots” were also taken into consideration. Each composite sample represents average contaminant values obtained from sample sets comprised of five discrete soil samples or aliquots per grid. Sample variability and/or potential “under quantification” in isolated samples is also possible. Therefore, in addition to those results discussed above, contaminant levels may also exceed CVs at other grid cell locations. Theoretical contaminant levels were extrapolated from selected sample grid locations with the highest group-specific soil contaminants. As a result, additional grids with contaminants in soil potentially exceeding applicable CVs were identified for the pesticides chlordane and heptachlor epoxide at Goodyear Elementary School, total PAHs at Boroughs-Mollette Elementary School, BAP at Risley Middle School, and for toxaphene at Edo-Miller Park. Based on the theoretical contaminant levels, potential doses were calculated using the exposure factors described above for children and for children with *pica*. These theoretical contaminant levels and potential exposure doses constitute a “worst case” scenario, and are summarized in Table 5 and discussed below.

Goodyear Elementary School

Based on the incidence and distribution of various chemicals identified in composite and aggregate composite soil samples collected at the Goodyear (GY) site, one additional area of concern was identified in the sample grid (Figure 2).

In addition to BAP at GY-10, GY-18 and GY-19, and PAHs at GY-10, soil concentrations for chlordane (0.795 ppm) and heptachlor-epoxide (0.49 ppm) may also exceed comparison values for the soils inside and adjacent to grid cell GY-16 (Table 5). These actual soil concentrations reported for chlordane and heptachlor-epoxide represent the highest contaminant specific levels found at this site, as well as throughout the entire study area.

Burroughs-Mollette Elementary School

Based on the incidence and distribution of various chemicals identified in composite and aggregate composite soil samples collected at the Burroughs-Mollette (BM) site, one additional area of concern was identified in the sample grid (Figure 3).

In addition to elevated BAP and total PAHs levels at BM-13, the level for total PAHs (0.640 ppm) in soils inside and adjacent to grid cell BM-46 may exceed the applicable comparison value. The maximum actual soil concentration reported at BM-46 for total PAHs is well below the levels found at Goodyear Elementary School.

Risley Middle School

Based on the incidence and distribution of various chemicals identified in composite and composite aggregate soil samples collected at the Risley Middle School (RIS) site, one additional area of concern was identified in the sample grid (Figure 4).

In addition to BAP and total PAH concentrations exceeding their lowest comparison values at Grid RIS-35, elevated BAP levels above the applicable CV may also exist in grid cells RIS-02 (0.045 ppm) and RIS-06 (0.045 ppm).

Edo-Miller Park/Lanier Field

Based on the incidence and distribution of various chemicals identified in composite and composite aggregate soil samples collected at the Edo-Miller Park/Lanier Field (EMF) site (Figure 5), toxaphene concentrations in discrete samples collected EMF 7-14 may also exceed the applicable CV for this pesticide.

Theoretical contaminant levels and potential exposure doses are summarized in Table 5 and discussed below.

Table 5: Comparison Of Maximum Theoretical Soil Contaminant Concentrations To Applicable Health Guidelines

Chemical Compound	Location	Maximum Soil Concentration (ppm)	Health Guideline* (mg/kg/day)	Estimated Exposure Dose (child)	Cancer Risk (child)	Estimated Exposure Dose (*pica* child)	Cancer Risk (*pica* child)
benzo(a)pyrene	Goodyear (GY-10)	10.50 (potential)	NA	0.00004	4×10^{-5}	0.002	5×10^{-5}
total PAHs[1]	Risley (RIS-35)	73.0 (potential)	NA	0.0002	NA	0.01	NA
chlordane	Goodyear (GY-16)	3.975 (potential)	0.0006_C	0.000015	8×10^{-7}	0.0006	9×10^{-7}
heptachlor-epoxide	Goodyear (GY-16)	0.2450 (potential)	0.000013_C	0.0000001	1×10^{-6}	0.00004	1×10^{-6}
toxaphene	Edo-Miller Park (EMF-7-14)	3.80 (potential)	0.001_I	0.000015	$2 \text{ X } 10^{-6}$	0.0006	$3 \text{ X } 10^{-6}$

ppm: parts per million
mg/kg/day: milligrams per kilogram per day
[1] Includes all isomeric forms.
$_C$ Based on chronic exposure
$_I$ Based on intermediate exposure
* Source: ATSDR, Health Guidelines (1/10/05)

The pesticides chlordane and heptachlor epoxide found at Goodyear Elementary School; and toxaphene found at Edo-Miller Park, are the only contaminants exceeding a CV that have a health guideline. The estimated exposure doses to chlordane and toxaphene for children with and without *pica* to the highest potential levels of these contaminants found, do not exceed the health guideline. Therefore, noncancer health effects are not likely to result from exposure to these chemicals. Of these chemicals, only toxaphene levels might result in one excess cancer case in a population of one million children without *pica*, if exposure occurs 5days/week, 36 weeks/year for 10 years.

The estimated cancer risks for potential exposure to BAP at Goodyear Elementary School and toxaphene at Edo-Miller Park exceed the acceptable cancer risk of 1×10^{-6} for children with and without *pica*, using previously described exposure scenarios. However, these exposure doses are extremely unlikely because it is based on a worst-case scenario, that is, continual exposure via ingestion to the highest levels detected, and actual exposure is probably much lower. In addition, *pica* is extremely rare and usually only occurs in children at a much younger age than those attending elementary school.

CHILD HEALTH CONSIDERATIONS

The ATSDR Child Health Initiative recognizes the unique vulnerabilities of young children exposed to chemicals in the environment. Because of their size, body weight, frequent hand to mouth activity, and developing systems, children require special emphasis in communities faced with soil contamination. They are more likely to come into contact with dust and soil on the ground because they play outdoors, and they often bring food and toys into contaminated areas. Also, they receive higher doses of exposure because children's growing bodies absorb more of the chemicals. Because their bodies are more sensitive to the damaging effects of many contaminants, children can sustain permanent damage if exposures occur during critical growth stages.

At the schools and park studied for this health consultation, children may have been, are currently being, and may in the future be exposed to contaminated soil at low levels if they access specific “hot spots” at Goodyear Elementary School repeatedly for an extended period of time. As a precautionary measure, those responsible for the young children accessing these properties should exercise caution and implement interim measures to limit the children’s exposure to bare soil. For example, the schools should plant grass or other ground cover, or cover bare soil with several inches of clean fill dirt.

STRENGTHS AND LIMITATIONS

Site Evaluation: The Skidaway project was successful in identifying chemical contamination in soil at levels above acceptable health risk criteria. The study provided an excellent opportunity to qualitatively characterize these sites by identifying: 1) the applicable chemicals of concern and, 2) the general vicinity where contaminants are located. This study did not however; include background sampling and analysis data, sub-surface soil data, or define the vertical and horizontal distribution of on-site contamination.

Data Reliability: Field sampling protocol as well as laboratory procedure must be evaluated through a series of comprehensive system and performance audits. This review process is essential in order to make valid interpretations for environmental and health based decisions. Information pertaining to site-specific Quality Assurance protocol was not provided in the Skidaway Report.

Synergistic Effects: Defined as a biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of two or more chemicals acting together may produce an effect that is greater than the effects of the chemicals acting by themselves. Health issues pertaining to exposure to the synergistic effects of chemical compounds are recognized and acknowledged by the GCHD. Given the diversity and frequency of occurrence of the contaminants suggested by this study, it is believed that the resultant health impact may be at added health risk because of synergistic effects; however, the human health impacts of exposure to chemical mixtures remain impossible to calculate.

It is extremely difficult to develop an experiment that provides information on the toxicity of possible combinations. Scientists use three general classes of joint interactions: additivity, synergy and antagonism. There are also three possible results in assessing the risk of chemical mixtures: overestimation, correct estimation, and underestimation. New approaches to risk assessment that will help address these issues in the future include a ranking scheme using toxic equivalency factors and computer modeling.

Multiple Chemical Sensitivity: The adverse health effects experienced by some individuals from multiple chemical sensitivity (MCS) are recognized, but not discussed in this document because of the inherent difficulties in determining the causes of the sensitivity. Some physicians acknowledge MCS as a medical disorder that is triggered by exposures to chemicals in the environment, often beginning with a short term, high level chemical exposure (like a chemical spill) or with a longer term, low level exposure (like the conditions existing at the sites in this health consultation). After the initial exposure, low levels of chemicals can trigger physical reactions in MCS patients. These patients report a range of symptoms that often include headaches, rashes, asthma, depression, muscle and joint aches, fatigue, memory loss, and confusion [for more information, visit *www.mcsrr.org*].

Other Sensitive Populations: The adverse health effects from exposure to environmental contaminants in some children with certain preexisting conditions and medical ailments are recognized, but not discussed in this document because of the inherent difficulties in determining the causes of the sensitivity.

CONCLUSIONS

The GDPH and GCHD have determined that the Goodyear Elementary School is an **Indeterminate Public Health Hazard** because there are insufficient data to determine whether the site has had an adverse impact on human health. In order to protect students and workers, confirmation soil sampling, analyses and additional evaluation are needed to determine the level of contaminants present and extent of soil affected. The limited data available do not indicate that humans are being or have been exposed to levels of contamination that would be expected to cause adverse health effects.

The GDPH and GCHD have determined that Burroughs-Mollette Elementary, Risley Middle School and Edo-Miller Park are **No Apparent Public Health Hazard** because human exposures to contaminated soil that may be occurring, or have occurred in the past, are at levels below those considered to be a health hazard for children, employees or other workers. In addition:

1. Several soil sampling and analyses events conducted since the late 1980s in the Brunswick area have been inconclusive for determining the extent of toxaphene contamination, and resulting public health implications of exposure to toxaphene-contaminated soil.

2. In response to the Skidaway Study results published in October 2002, the Glynn County School Board installed a thin soil cap (approximately 5 inches deep) over a suspected contaminated area at Goodyear Elementary School. The new soil cap's placement has not been verified for accuracy. The cap is located on areas that comprise most of the common areas accessible to children and workers, and is generally bare soil.

3. Contaminants in surface soil from some locations at Goodyear Elementary School may be at high enough levels and widespread enough to impact the health of children, school employees or workers who repeatedly access the site under extreme exposure scenarios.

4. Contaminants in surface soil at the other two schools and park examined are not at high enough levels nor widespread enough to impact the health of children, school employees or workers who repeatedly access the sites under normal circumstances.

5. Levels of BAP above one CV were reported in soil samples obtained from each of the three school sites. Total PAHs were found above a regulatory value at Goodyear Elementary and Risley Middle Schools.

6. The highest concentrations in soil reported for BAP and total PAHs were found at Goodyear Elementary School.

7. The soil concentration of total PAHs (21.70 ppm) found in one sample collected from Goodyear Elementary School represents the highest total PAH level found at this site, as well as throughout the entire study area. **However, because total PAHs concentrations are represented in every other grid cell locations throughout the study area, and no other grid cell locations have levels near this level of total PAHs, this level is considered an outlier.**

8. The estimated cancer risks for exposure to BAP at Goodyear Elementary and Risley Middle School are greater than one in one million for children, and for children with *pica*, who receive the potential maximum exposure to contaminated soil in specific grid cell locations for 5 days/week, 36 weeks/year, for 10 years. This exposure scenario is extremely unlikely.

9. Toxaphene was not found at levels exceeding the CV in any soil samples.

10. The maximum potential chemical concentrations for individual sub-sample "aliquots" were also taken into consideration. The estimated theoretical excess cancer risks for exposure to total PAHs at Goodyear Elementary and Risley Middle Schools and toxaphene at Edo-Miller Park are greater than one in one million for children, and for children with *pica* using criteria for exposure as established in this report. However, this "worst case" exposure scenario is extremely unlikely.

RECOMMENDATIONS

Additional limited evaluation of surface and subsurface soil at Goodyear Elementary School should be conducted to determine the vertical and horizontal extent of contamination.

At Goodyear Elementary School, the new soil cap's placement and design should be evaluated by a Professional Engineer.

Until the results from additional soil analyses have been evaluated, the following precautionary measures should be put into place at Goodyear Elementary School: (1) maintain substantial ground cover to minimize exposures to children and workers, and (2) Implement a Health and Safety Plan to protect on-site workers performing activities related to excavation, lawn maintenance, and utility repairs.

PUBLIC HEALTH ACTION PLAN

Actions Completed

GCHD has met with residents and the Glynn County School Board upon request to gather health related concerns. This health consultation serves to address those concerns.

GCHD staff has conducted several site visits to assess ground cover conditions throughout the year.

Actions Planned

GDPH and GCHD will review soil sampling results from Goodyear Elementary School to determine if soil contaminant levels pose a health threat to students and faculty.

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CERTIFICATIONS

The Glynn County Health Department and the Georgia Department of Human Resources prepared this Organic Chemical Residue In Brunswick Schoolyard Soils, Glynn County, Georgia health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation were begun.

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Technical Project Officer, SPAB, DHAC

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

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Chief, SSAB, DHAC, ATSDR

FIGURES

FIGURE 1. LOCATION OF SCHOOLS AND PARK

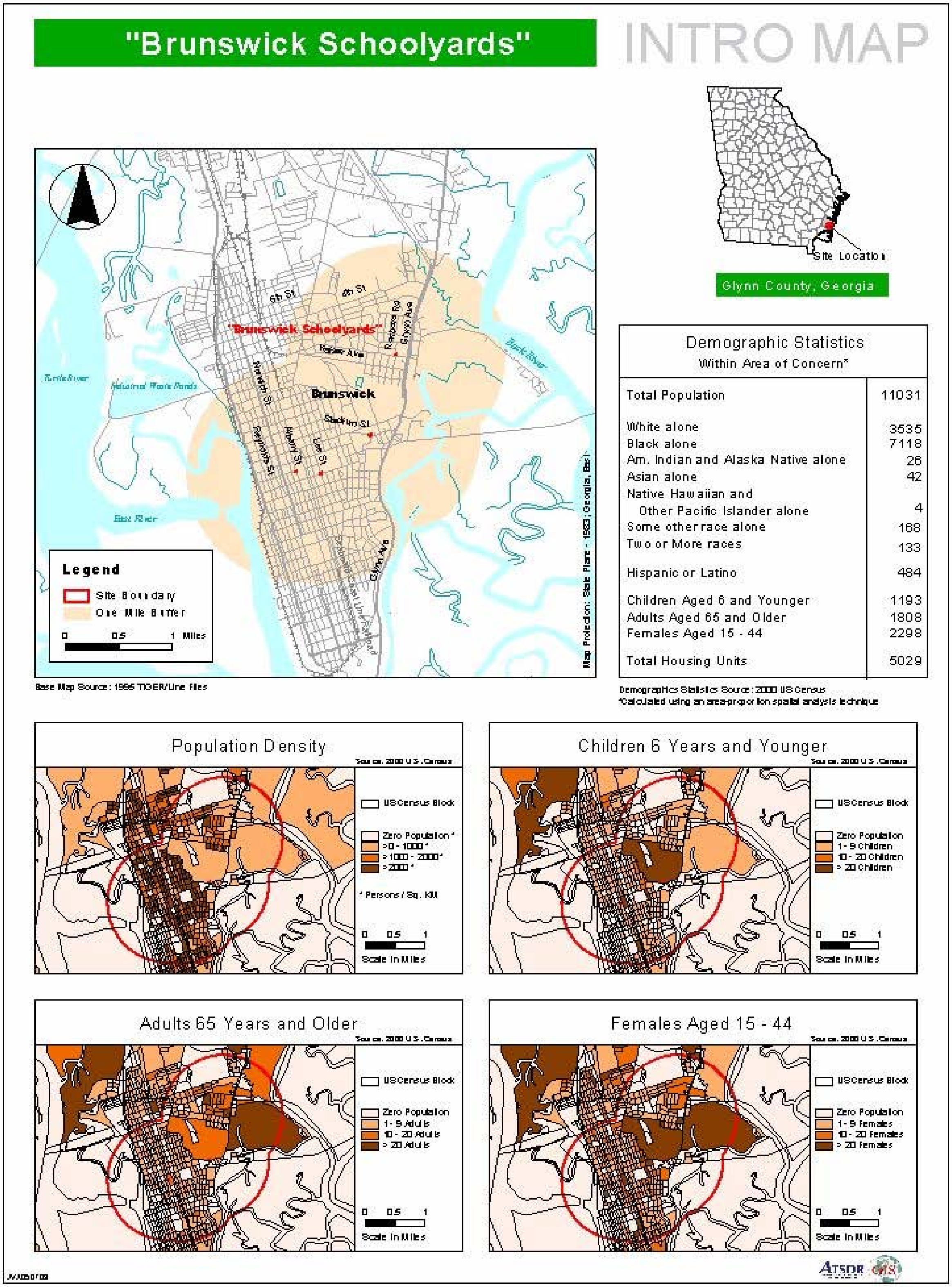


FIGURE 2. GOODYEAR ELEMENTARY SCHOOL
Sample Grid Locations and Preliminary ELISA Site Screening Data

Reprint: Frohlich, Marco, Maruya, Keith; *Determination of toxaphene in Brunswick (GA), public access area soils by immunoassay and gas chromatography*, Skidaway Institute of Oceanography, Savannah, Georgia, 2002.

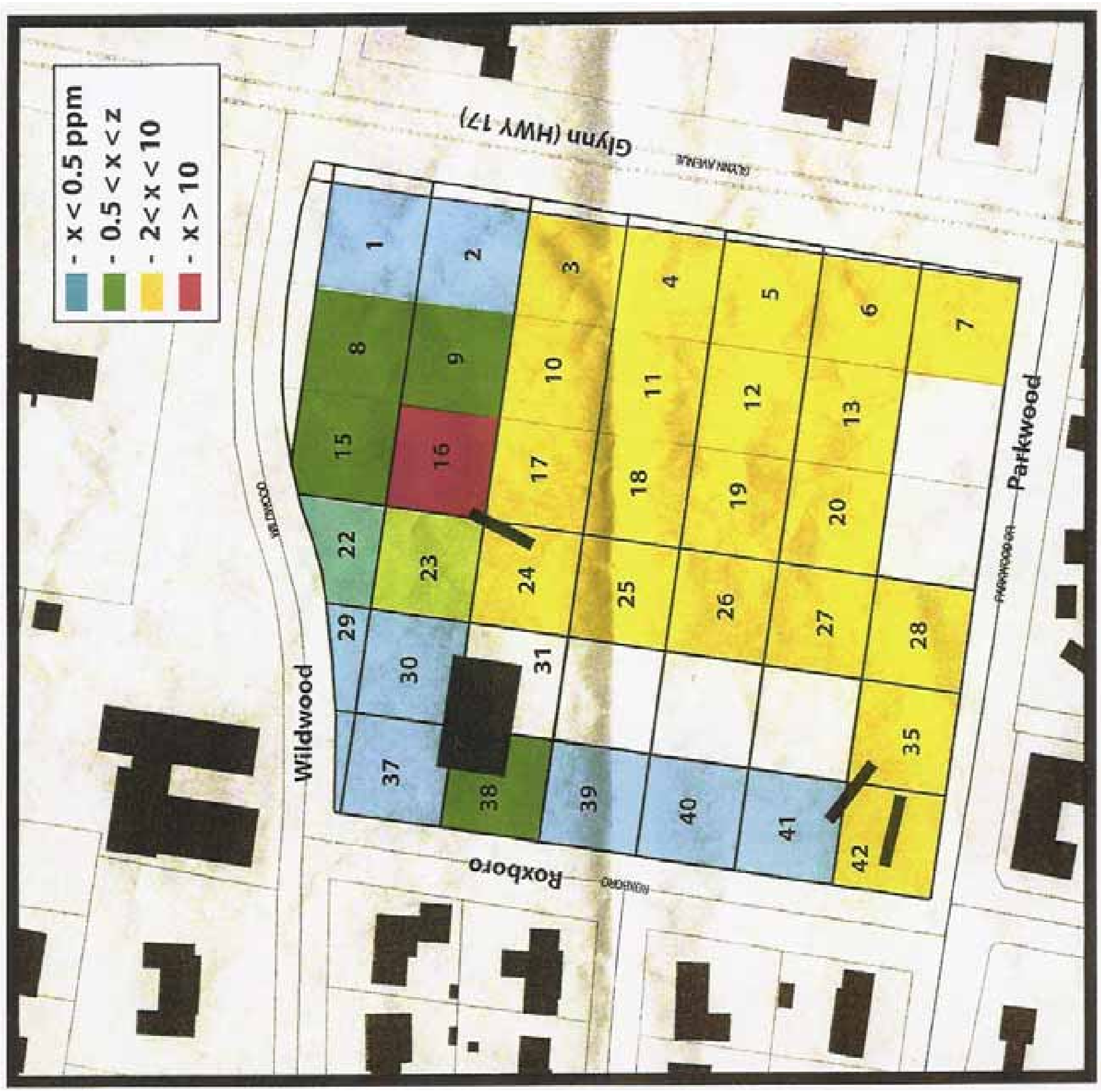


FIGURE 3. BURROUGHS-MOLLETTE ELEMENTARY SCHOOL
Sample Grid Locations and Preliminary ELISA Site Screening Data

Reprint: Frohlich, Marco, Maruya, Keith; *Determination of toxaphene in Brunswick (GA), public access area soils by immunoassay and gas chromatography*, Skidaway Institute of Oceanography, Savannah, Georgia, 2002.

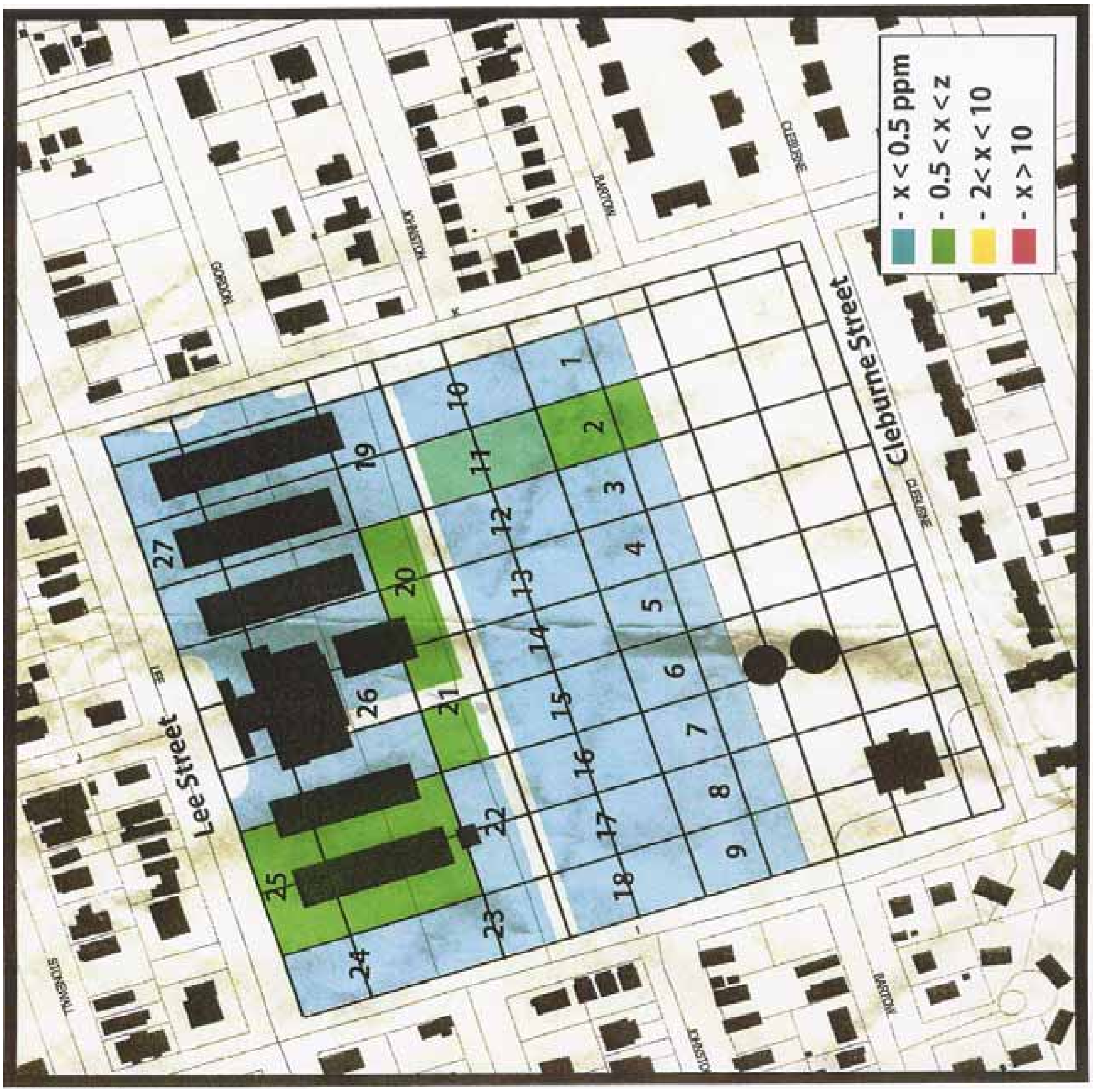


FIGURE 4. RISLEY MIDDLE SCHOOL
Sample Grid Locations and Preliminary ELISA Site Screening Data

Reprint: Frohlich, Marco, Maruya, Keith; *Determination of toxaphene in Brunswick (GA), public access area soils by immunoassay and gas chromatography*, Skidaway Institute of Oceanography, Savannah, Georgia, 2002.

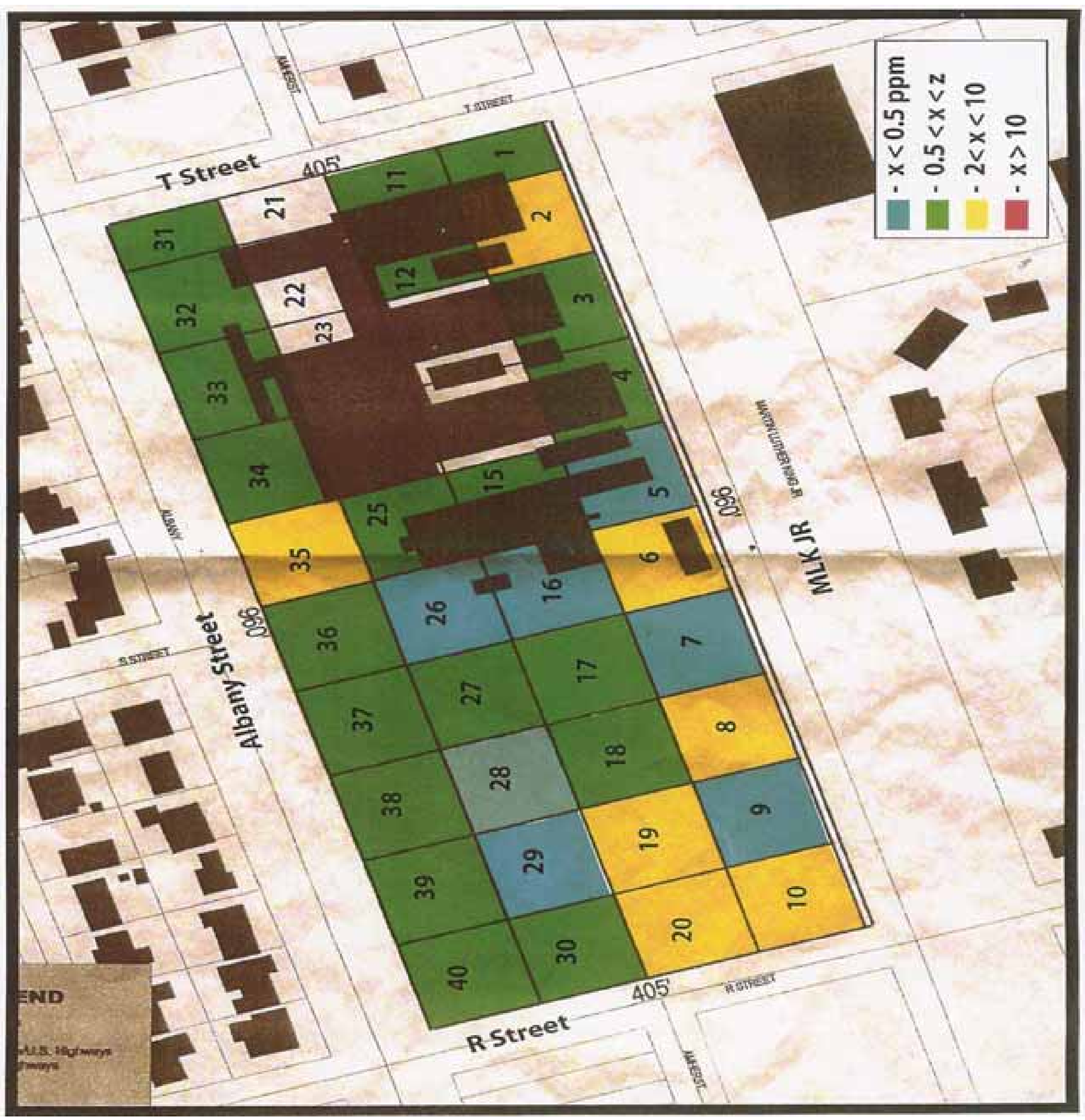
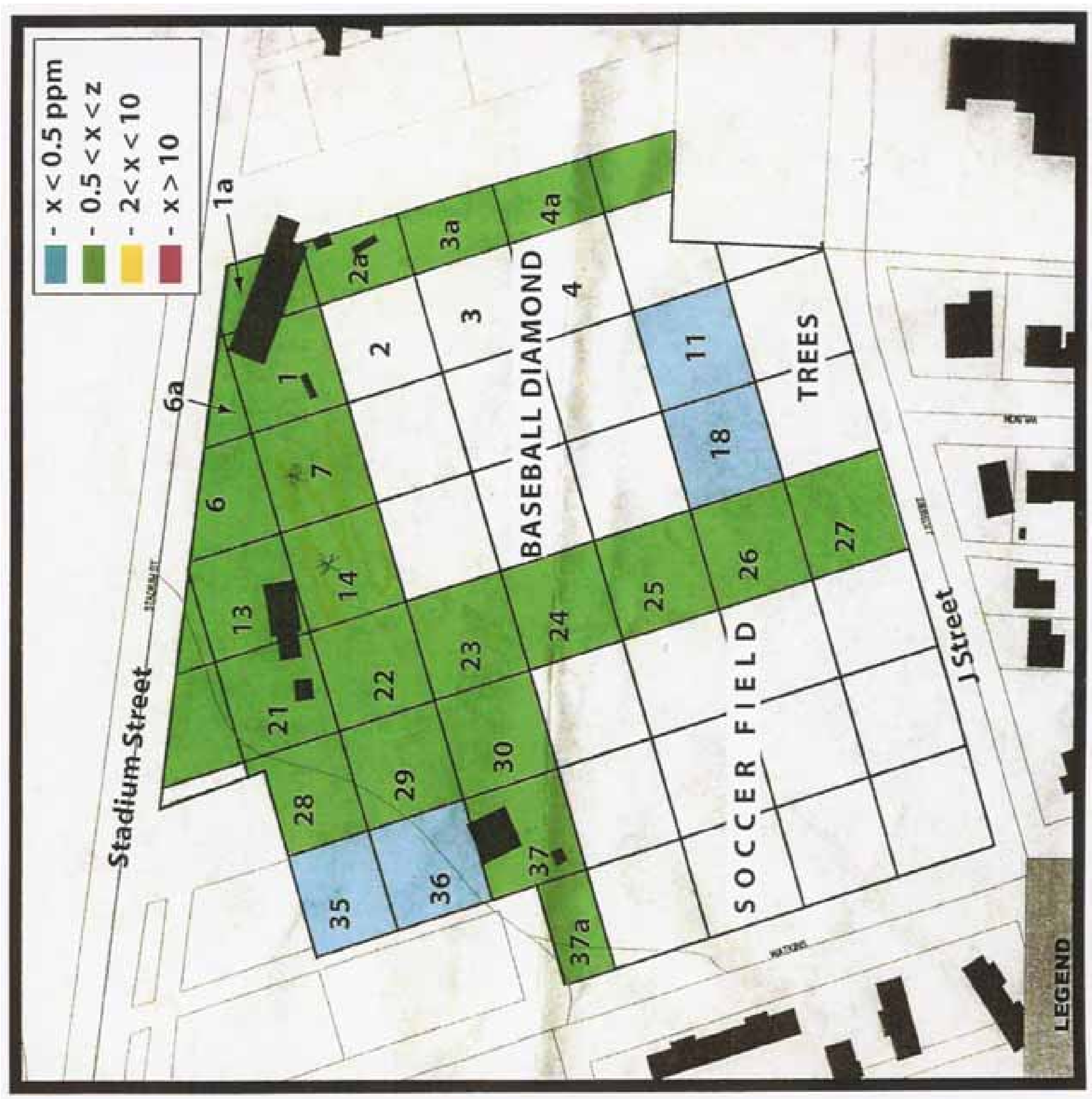


FIGURE 5. EDO-MILLER BALL PARK
Sample Grid Locations and Preliminary ELISA Site Screening Data

Reprint: Frohlich, Marco, Maruya, Keith; *Determination of toxaphene in Brunswick (GA), public access area soils by immunoassay and gas chromatography*, Skidaway Institute of Oceanography, Savannah, Georgia, 2002.



APPENDICES

APPENDIX A: POTENTIAL SOURCES OF CONTAMINANTS OF CONCERN*

CONTAMINANT	SOURCES
Benzo(a)pyrene	See polycyclic aromatic hydrocarbons (PAHs).
Chlordane	Chlordane was used as a pesticide on crops like corn and citrus and on home lawns and gardens from 1948 to 1988. All uses of chlordane were banned in 1983 except to control termites. In 1988, all uses were banned. • Crops grown in soil that contains chlordane. • Contaminated soil. • Fish or shellfish caught in water that is contaminated by chlordane. • Air near homes treated for termites with chlordane.
Heptachlor epoxide	Heptachlor epoxide was used extensively in the past for killing insects in homes, buildings, and on food crops, especially corn. Use slowed in the 1970s and stopped in 1988. • Crops grown in soil that contains heptachlor. • Contaminated soil. • Fish, dairy products, and fatty meats from animals exposed to heptachlor in their food. • Breast milk (from mothers who had high levels of exposure).
Polycyclic aromatic hydrocarbons (PAHs)	PAHs are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, roofing tar, medicines, dyes, plastics, and pesticides and organic substances like tobacco or charbroiled meat. • Air containing PAHs in the workplace of coking, coal tar, and asphalt production plants; smokehouses; and municipal trash incineration facilities. • Air containing PAHs from cigarette smoke, wood smoke, vehicle exhausts, asphalt roads, or agricultural burn smoke. • Grilled or charred meats; contaminated cereals, flour, bread, vegetables, fruits, meats; and processed or pickled foods. • Contaminated water or cow's milk. • Contaminated soil. • Breast milk (from mothers who had high levels of exposure).
Toxaphene	Toxaphene is an insecticide that was one of the most heavily used insecticides until all uses were banned in 1990. It was used primarily in the southern United States to control insect pests on cotton and other crops. It was also used to control insect pests on livestock and to kill unwanted fish in lakes. People who breathe air near a hazardous waste site where toxaphene was disposed could be exposed to it. • Contaminated soil. • Fish and shellfish caught in water that is contaminated by chlordane. • Contaminated water. • Contaminated air.

* Source: Agency for Toxic Substances and Disease Registry, ToxFaqs™

APPENDIX B: AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

What is the Agency for Toxic Substances and Disease Registry (ATSDR)?

ATSDR is the principal federal public health agency involved with hazardous waste issues. The agency helps prevent or reduce the harmful effects of exposure to hazardous substances on human health. The Superfund Law created ATSDR, an agency of the U.S. Department of Health and Human Services, in 1980.

Where is ATSDR located? How big is it?

ATSDR's headquarters are in Atlanta, Georgia. The agency has 10 regional offices and an office in Washington D.C. The multi- disciplinary staff of approximately 400 includes epidemiologists, physicians, toxicologists, engineers, public health educators, health communication specialists, and support staff.

What does ATSDR do?

ATSDR conducts a number of activities to help prevent or reduce the harmful effects of exposure to hazardous substances, including:

- Advises federal and state agencies, community members, and other interested parties on the health impacts of Superfund sites and other petitioned sites.
- Identifies communities where people might be exposed to hazardous substances in the environment.
- Determines the level of public health hazard posed by a site.
- Recommends actions that need to be taken to safeguard people's health.
- Conducts health studies in some communities that are located near Superfund sites or in locations where people have been exposed to toxic materials.
- Funds research conducted by colleges, state agencies, and others who study the relationship between hazardous waste exposure and illnesses.
- Educates physicians, other health care professionals, and community members about the health effects of--and how to lessen exposure to--hazardous substances.
- Provides technical support and advice to other federal agencies and state and local governments.
- Maintains registries of people who are exposed to the most dangerous substances.

What can ATSDR do to help a community that may be exposed to hazardous substances?

ATSDR helps communities in a variety of ways, including:

- Helps communities by working with them to resolve their health concerns.
- Determines whether the community is or was exposed to hazardous substances.
- Visits the community to hear residents voice their health concerns.
- Educates residents about any health hazards posed by environmental contaminants.
- Works with local health care providers to ensure they have the information needed to evaluate possible exposures to hazardous substances in their community.
- Visits a community to draw blood or to collect urine to determine if people have been or are being exposed to a hazardous substance when such actions are required.
- Can provide medical monitoring in communities exposed to hazardous substances if such action is needed.

What can't ATSDR do to help a community?

- ATSDR does not have the legal authority to conduct certain activities, such as the following:
- Cannot provide medical care or treatment to people who have been exposed to hazardous substances, even if the exposure has made them ill.
- Cannot provide funds to relocate affected residents or to clean up a site.
- Cannot close down a plant or other business, but can make recommendations to the U.S. Environmental Protection Agency (EPA).

How is ATSDR's role in helping communities different from EPA's role?

Unlike EPA, ATSDR is not a regulatory agency. ATSDR is a public health agency that advises EPA on the health aspects of hazardous waste sites or spills. ATSDR makes recommendations to EPA when specific actions are needed to protect the public's health. For example, ATSDR might recommend providing an alternative water supply, removing contaminated material, or restricting access to a site. EPA usually follows these recommendations. However, ATSDR cannot require EPA to follow its recommendations.

How does ATSDR become involved with a site? How can I get ATSDR involved with a site?

ATSDR is required by the Superfund law to become involved with all sites that are on or proposed for the National Priorities List (NPL). Specifically, ATSDR conducts public health assessments of NPL sites, as well as of all sites proposed for the NPL. EPA, states, local governments, or other federal agencies may request ATSDR's help with a site, such as in cases of accidental spills or releases. Anyone may request or "petition" that ATSDR to do a health consultation. Most requests for health consultations come from EPA and state and local agencies. Anyone may also petition ATSDR to conduct a public health assessment of a site. For more information about how to petition ATSDR to conduct a public health assessment, call ATSDR's toll-free information line, 1-888-42-ATSDR (1-888-422-8737), or send an e-mail request to ATSDRIC@cdc.gov

How does ATSDR work with states and local health departments?

ATSDR has cooperative agreements (partnerships) with 23 states to conduct site-related public health assessments or health consultations, health studies, and health education. In states that have co-operative agreements, ATSDR provides technical assistance and oversees site evaluations and related activities done by state staff. ATSDR also assists local health departments.

Does ATSDR assist communities located near hazardous waste sites that are not on the NPL?

Yes. More than half of the sites ATSDR has worked at are not on the NPL.

What information does ATSDR provide through its Internet web site?

Information that can be accessed through ATSDR's web site includes these items: information about ATSDR; a database containing information on all sites where ATSDR has worked; short, easy-to-read fact sheets on 60 of the most common contaminants at Superfund sites; and links to related sites.

APPENDIX C: EXPLANATION OF TOXICOLOGICAL EVALUATION

Step 1--The Screening Process

In order to evaluate the available data, GCHD used comparison values (CVs) to determine which chemicals to examine more closely. CVs are contaminant concentrations found in a specific environmental media (for example: air, soil, or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, soil, or water that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. The CV is used as a screening level during the health consultation process where substances found in amounts greater than their CVs might be selected for further evaluation. CVs are not intended to be environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based CVs are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factors for ingestion exposure, or inhalation risk units for inhalation exposure. Non-cancer CVs are calculated from ATSDR's minimal risk levels, EPA's reference doses, or EPA's reference concentrations for ingestion and inhalation exposure. When a cancer and non-cancer CV exist for the same chemical, the lower of these values is used as a conservative measure. The chemical and media-specific CVs used in the preparation of this health consultation are listed below:

An **Environmental Media Evaluation Guide (EMEG)** is an estimated comparison concentration for exposure that is unlikely to cause adverse health effects, as determined by ATSDR from its toxicological profiles for a specific chemical.

A **Cancer Risk Evaluation Guide (CREG)** is an estimated comparison concentration that is based on an excess cancer rate of one in a million persons exposed over a lifetime (70 years), and is calculated using EPA's cancer slope factor.

Step 2--Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific scenarios, using assumptions regarding an individual's likelihood of accessing the site and contacting contamination. Usually little or no information is available for a site to know exactly how much exposure is actually occurring, so assessors assume that maximum exposure is taking place. That assumption would include any worse case scenarios where someone received a maximum dose. Actual exposure is likely much less than the assumed exposure.

A brief explanation of the calculation of estimated exposure doses used in this health consultation are presented below. Calculated doses are reported in units of milligrams per kilogram per day (mg/kg/day).

Ingestion of contaminants present in soil

Exposure doses for ingestion of contaminants present in soil were calculated using the maximum detected concentrations of contaminants in milligrams per kilogram (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated soil:

$$ED_s = \frac{C \times IR \times EF \times CF}{BW}$$

where;
ED_s = exposure dose soil (mg/kg/day)

C = contaminant concentration (mg/kg)
IR = intake rate of contaminated medium (based on default values of 100 mg/day for adults; 200 mg/day for children, and 5000 mg/day for a children with *pica*)
EF = exposure factor (based on frequency of exposure, exposure duration, and time of exposure)., Children with *pica* were considered to receive potential maximum exposure in 1 year, 5 days/week, 36 weeks/year. The exposure factor used is 0.49, based on exposure for 5 days/week, 36 weeks/year for 10 years*. The exposure factor used for children with *pica* is 0.049 based on exposure for 1 year using a pica characteristic value (5000 mg/day) plus 9 years at child default value (200 mg/day) for 5 days/week, 36 weeks/year.
CF = kilograms of contaminant per milligram of soil (10^{-6} kg/mg)
BW = body weight (based on average rates: for adults,70 kg; children, 25 kg; children with *pica*,16 kg)

** Because of the nature of school attendance, a conservative time period of 10 years (kindergarten through eighth grade) was used as the length of time a child would attend the schools, while also frequenting the park, and is considered protective for potential maximum exposure.*

Non-cancer Health Risks

The doses calculated for exposure to individual chemicals are then compared to an established health guideline, such as an ATSDR minimal risk level (MRL) or an EPA reference dose (RfD), in order to assess whether adverse health impacts from exposure are expected. Health guidelines are chemical-specific values that are based on available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice to derive health guidelines is to identify, usually from animal toxicology experiments, a no observed adverse effect level (NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The known toxicological values are doses derived from human and animal studies that are summarized in ATSDR's *Toxicological Profiles (www.atsdr.cdc.gov/toxpro2.html).* The NOAEL is modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (e.g., children, pregnant women, the elderly), extrapolation from animals to humans, and the completeness of the available data. Thus, exposure doses at or below the established health guideline are not expected to cause adverse health effects because these values are much lower (and more human health protective) than doses, which do not cause adverse health effects in laboratory animal studies.

For non-cancer health effects, the following health guidelines were used in this health consultation:

A **minimal risk level (MRL)** is an estimate of the daily human exposure to a chemical that is likely to be without a significant risk of harmful effects over a specified period of time. MRLs are developed for ingestion and inhalation exposure, and for lengths of exposures; acute (less than 14 days), intermediate (between 15-364 days), and chronic (365 days or greater). ATSDR has not developed MRLs for dermal exposure (absorption through skin).

A **Reference Dose (RfD)** is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It is derived from a calculated dose, with uncertainty factors generally applied to reflect limitations of the data used.

If the estimated exposure dose to an individual is less than the health guideline value, the exposure is unlikely to result in non-cancer health effects. If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the health consultation. A direct comparison of site-specific exposure and doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur.

It is important to consider that the methodology used to develop health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer risk evaluation is necessary for potentially cancer-causing contaminants detected at this site.

Cancer Risks

Exposure to a cancer-causing chemical, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated risk for developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific doses by EPA's chemical-specific cancer slope factors (CSFs) available at *www.epa.gov/iris*. This calculation estimates a theoretical excess cancer risk expressed as a proportion of the population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million. An increased lifetime cancer risk is not a specified estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime in his or her lifetime following exposure to a particular contaminant under specific exposure scenarios. For children, the theoretical excess cancer risk is not calculated for a lifetime of exposure, but from a fraction of lifetime; based on known or suspected length of exposure, or years of childhood.

Because of conservative models used to derive CSFs, using this approach provides a theoretical estimate of risk; the true or actual risk is unknown and could be as low as zero. Numerical risk estimates are generated using mathematical models applied to epidemiologic or experimental data for carcinogenic effects. The mathematical models extrapolate from higher experimental doses to lower experimental doses. Often, the experimental data represent exposures to chemicals at concentrations orders of magnitude higher than concentrations found in the environment. In addition, these models often assume that there are no thresholds to carcinogenic effects--a single molecule of a carcinogen is assumed to be able to cause cancer. The doses associated with these estimated hypothetical risks might be orders of magnitude lower that doses reported in toxicology literature to cause carcinogenic effects. As such, a low cancer risk estimate of 1×10^{-6} and below may indicate that the toxicology literature supports a finding that no excess cancer risk is likely. A cancer risk estimate greater than 1×10^{-6}, however, indicates that a careful review of toxicology literature before making conclusions about cancer risks is in order.

***Pica* Dose Calculations**

Assessing an exposure dose for a child with *pica* to determine cancer risk estimates includes accounting for an increased soil ingestion rate during the period that the child is expressing *pica* behavior, as well as the default soil ingestion rate for children over the estimated period of exposure. To account for the difference in ingestion rates over an estimated exposure period, the increased exposure dose estimate for a child during the period which *pica* behavior is expressed is divided by the total estimated period of exposure (e.g. years), and then added to the estimated exposure dose for a child without *pica* where default ingestion rates have been used over the estimated period of exposure. Therefore, the estimated exposure dose of a child who once exhibited *pica* characteristics will always be slightly higher than estimated exposure doses of a child without *pica* over the same exposure period. For example, if the total exposure period is 10 years, and a child expresses *pica* behavior for 1 year during that exposure period, the estimated exposure dose for the child over the year of increased ingestion is divided by 10 years, and then added to the estimated exposure dose of a child over that 10-year period. This allows for an estimated exposure dose, which averages out the child's increased ingestion rate during the period that the child expressed *pica* behavior and additional periods of exposure during which that child did not express *pica* behavior. Cancer risk can then be calculated by multiplying the estimated dose by the appropriate cancer slope factor. The total estimated cancer risk for a child with *pica* can then be determined by adding the estimated cancer risk of a child without *pica* to the estimated cancer risk to that of a child with *pica*.

APPENDIX D: TABLES

TABLE D-1. GOODYEAR ELEMENTARY SCHOOL
Comparison Of Soil Sample Results To Applicable Comparison Values For Ingestion

Chemical Compound	Maximum Soil Concentration (ppm)	Comparison Values* (ppm)			Sample Location (Grid)
		EMEG[1]		CREG	
		Pica Child	Child		
total chlordane	0.795	1.00	30	2.00	GY-16
cxychlordane	0.014	---	---	---	GY-16
toxaphene	<0.010	0.60	50	2.00	GY-16
total polychlorinated biphenyls (PCBs)	0.025	---	---	0.40	GY-36,37
heptachlor	0.008	---	---	0.20	GY-16
heptachlor epoxide	0.049	---	---	0.08	GY-16
cis-nonachlor	0.008	---	---	---	GY-16
trans-nonachlor	0.152	---	---	---	GY-16
2-methyl-naphthalene	0.010	---	---	---	GY-20,27
1-methly-naphthalene	0.005	---	4000	---	GY-20,27
biphenyl	0.001	---	---	---	GY-24
acenapthene	0.007	1000	---	---	GY-20,27
fluorine	0.075	---	---	---	GY-10
fluoranthene	4.400	---	---	---	GY-10
1-methlyphenanthrene	0.024	---	---	---	GY-16
anthracene	0.013	20,000	---	---	GY-18,19
phenanthrene	0.072	---	---	---	GY-18,19
pyrene	3.600	---	---	---	GY-10
benzo(a)anthracene	3.200	---	---	---	GY-10
chrysene	1.800	---	---	---	GY-10
benzo(b)fluoranthene	1.800	---	---	---	GY-10
benzo(k)fluoranthene	0.065	---	---	---	GY-24
benzo(e)pyrene	1.400	---	---	---	GY-10
benzo(a)pyrene	**2.100**	**---**	**---**	**0.10**	GY-10
benzo(a)pyrene	**0.096**	**---**	**---**	**0.10**	GY-18,19
indenol(1,2,3,c,d,)pyrene	1.100	---	---	---	GY-10
dibenzo(a,h)anthracene	0.063	---	---	---	GY-18,19
benzo(g,h,i)perylene	2.100	---	---	---	GY-10
total polycyclic aromatic hydrocarbons (PAHs)	**21.700**	---	---	**0.10[2]**	GY-10

ppm: parts per million
EMEG: Environmental Media Evaluation Guide
CREG: Cancer Risk Evaluation Guide ($1x10^{-6}$ excess cancer risk)
[1] Based on intermediate oral exposure
---: no CV has been established
Bold type: exceeds a CV
[2] Includes all isomeric forms. CV based on benzo(a)pyrene.
* Source: ATSDR Soil Comparison Values (1/10/05)

TABLE D-2. BURROUGHS-MOLLETTE ELEMENTARY SCHOOL
Comparison Of Soil Sample Results To Applicable Comparison Values For Ingestion

Chemical Compound	Maximum Soil Concentration (ppm)	Comparison Values* (ppm)			Sample Location (Grid)
		EMEG[1]		CREG	
		Pica Child	Child		
total chlordane[2]	0.005	1.00	30	2.00	BM-20
oxychlordane	<0.001	---	---	---	---
toxaphene	0.180	0.60	50	2.00	BM-20
total polychlorinated biphenyls (PCBs)	0.034	---	---	0.40	BM-26
heptachlor	Not detected	---	---	0.20	---
heptachlor epoxide	Not detected	---	---	0.08	---
cis-nonachlor	0.004	---	---	---	BM-20
trans-nonachlor	0.002	---	---	---	BM-20
2-methyl-naphthalene	Not detected	---	---	---	---
1-methly-naphthalene	Not detected	---	4000	---	---
biphenyl	Not detected	---	---	---	---
acenapthene	Not detected	1000	---	---	---
fluorine	Not detected	---	---	---	---
fluoranthene	0.044	---	---	---	BM-13
1-methlyphenanthrene	0.004	---	---	---	BM-13
anthracene	Not detected	20,000	---	---	---
phenanthrene	Not detected	---	---	---	---
pyrene	0.096	---	---	---	BM-13
benzo(a)anthracene	0.067	---	---	---	BM-13
chrysene	0.047	---	---	---	BM-13
benzo(b)fluoranthene	0.051	---	---	---	BM-2
benzo(k)fluoranthene	0.120	---	---	---	BM-13
benzo(e)pyrene	0.110	---	---	---	BM-13
benzo(a)pyrene	**0.120**	**---**	**---**	**0.10**	BM-13
indenol(1,2,3,c,d,)pyrene	0.016	---	---	---	BM-13
dibenzo(a,h)anthracene	Not detected	---	---	---	---
benzo(g,h,i)perylene	0.002	---	---	---	BM-20
total polycyclic aromatic hydrocarbons (PAHs)	**0.640**	---	---	**0.10**[2]	BM13

ppm: parts per million
EMEG: Environmental Media Evaluation Guide
CREG: Cancer Risk Evaluation Guide (1×10^{-6} excess cancer risk)
[1] Based on intermediate oral exposure
---: no CV has been established
Bold type: exceeds a CV
[2] Includes all isomeric forms. CV based on benzo(a)pyrene.
* Source: ATSDR Soil Comparison Values (1/10/05)

TABLE D-3. RISLEY MIDDLE SCHOOL

Comparison Of Soil Sample Results To Applicable Comparison Values For Ingestion

Chemical Compound	Maximum Soil Concentration (ppm)	Comparison values* (ppm)			Sample Location (Grid)
		EMEG[1]		CREG	
		Pica Child	Child		
total chlordane[2]	0.009	1.00	30	2.00	RIS-35
oxychlordane	<0.001	---	---	---	RIS-35
toxaphene	0.030	0.60	50	2.00	RIS-07
total polychlorinated biphenyls (PCBs)	0.018	---	---	0.04	RIS-02
heptachlor	<0.001	---	---	0.20	RIS-35
Heptachlor epoxide	<0.001	---	---	0.08	RIS-35
cis-nonachlor	0.002	---	---	---	RIS-35
trans-nonachlor	0.001	---	---	---	RIS-35
2-methyl-naphthalene	Not detected	---	---	---	---
1-methly-naphthalene	Not detected	---	4000	---	---
biphenyl	Not detected	---	---	---	---
acenapthene	Not detected	1000	---	---	---
fluorine	0.001	---	---	---	RIS-06
fluoranthene	1.480	---	---	---	RIS-35
1-methlyphenanthrene	0.032	---	---	---	RIS-35
anthracene	0.093	20,000	---	---	RIS-35
phenanthrene	0.830	---	---	---	RIS-35
pyrene	1.031	---	---	---	RIS-35
benzo(a)anthracene	0.720	---	---	---	RIS-35
Chrysene	0.580	---	---	---	RIS-35
benzo(b)fluoranthene	0.740	---	---	---	RIS-35
benzo(k)fluoranthene	0.008	---	---	---	RIS-07
benzo(e)pyrene	0.440	---	---	---	RIS-35
benzo(a)pyrene	**0.570**	**---**	**---**	**0.10**	RIS-35
indenol(1,2,3,c,d,)pyrene	0.019	---	---	---	RIS-35
dibenzo(a,h)anthracene	0.030	---	---	---	RIS-02
benzo(g,h,i)perylene	0.600	---	---	---	RIS-35
total polycyclic aromatic hydrocarbons (PAHs)	**7.300**	---	---	**0.10[2]**	RIS-35

ppm: parts per million
EMEG: Environmental Media Evaluation Guide
CREG: Cancer Risk Evaluation Guide ($1x10^{-6}$ excess cancer risk)
[1] Based on intermediate oral exposure
---: no CV has been established
Bold type: exceeds a CV
[2] Includes all isomeric forms. CV based on benzo(a)pyrene.
* Source: ATSDR Soil Comparison Values (1/10/05)

TABLE D-4. EDO-MILLER PARK/LANIER FIELD

Comparison Of Soil Sample Results To Applicable Comparison Values For Ingestion

Chemical Compound	Maximum Soil Concentration (ppm)	Comparison values* (ppm)			Sample Location (Grid)
		EMEG[1]		CREG	
		Pica Child	Child		
total chlordane[2]	0.054	1.00	30	2.00	EMF 7-14
oxychlordane	0.001	---	---	---	EMF 7-14
toxaphene	0.380	0.60	50	2.00	EMF 7-14
total polychlorinated biphenyls (PCBs)	0.064	---	---	0.40	EMF 1-1a-6a
heptachlor	Not detected	---	---	0.20	
Heptachlor epoxide	Not detected	---	---	0.08	
cis-nonachlor	0.005	---	---	---	EMF 1-6-6a
trans-nonachlor	0.008	---	---	---	EMF 1-1a-6a
2-methyl-naphthalene	Not detected	---	---	---	
1-methly-naphthalene	Not detected	---	4000	---	
biphenyl	Not detected	---	---	---	
acenapthene	Not detected	1000	---	---	
fluorine	Not detected	---	---	---	
fluoranthene	0.059	---	---	---	EMF 1-1a-6a
1-methlyphenanthrene	0.002	---	---	---	EMF 28-29
anthracene	0.002	20,000	---	---	EMF 1-1a-6a
phenanthrene	Not detected	---	---	---	
pyrene	0.052	---	---	---	EMF 1-1a-6a
benzo(a)anthracene	0.022	---	---	---	EMF 1-1a-6a
chrysene	0.017	---	---	---	EMF 30-37-37a
benzo(b)fluoranthene	0.051	---	---	---	EMF 30-37-37a
benzo(k)fluoranthene	Not detected	---	---	--	
benzo(e)pyrene	0.009	---	---	---	EMF 1-1a-6a
benzo(a)pyrene	0.001	---	---	0.10	EMF 2a-3a-4a
indenol(1,2,3,c,d,)pyrene	0.007	---	---	---	EMF 1-1a-6a
dibenzo(a,h)anthracene	Not detected	---	---	---	
benzo(g,h,i)perylene	0.003	---	---	---	EMF 1-1a-6a
total polynuclear aromatic hydrocarbons (PAHs)	**0.210**	**---**	**---**	**0.10[2]**	EMF 1-1a-6a

ppm: parts per million
EMEG: Environmental Media Evaluation Guide
CREG: Cancer Risk Evaluation Guide ($1x10^{-6}$ excess cancer risk)
[1] Based on intermediate oral exposure
---: no CV has been established
Bold type: exceeds a CV
[2] Includes all isomeric forms. CV based on benzo(a)pyrene.
* Source: ATSDR, Soil Comparison Values (1/10/05)