Rick Scott
Governor

FLORIDA DEPARTMENT OF HEALTH

John H. Armstrong, MD
State Surgeon General

August 23, 2012

Albert C. Gray, M.P.H.
Environmental Health
Hernando County Health Department
7551 Forest Oaks Boulevard
Spring Hill, FL 34606

RE: Evaluation of Soil Tests at the Harar Avenue Residential Property and Adjacent County Ditch on the South Side of Smith Street

Dear Mr. Gray:

Florida Department of Health (DOH) previously recommended testing the soil for petroleum hydrocarbons from a residential property on Harar Avenue and an adjacent ditch in Brooksville. Recently, Florida Department of Environmental Protection (DEP) did this testing.

Florida DOH evaluates the public health risk of hazardous waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). This is a state certified report. Florida DOH prepared this report following the same procedures and quality control as ATSDR approved reports.

This letter addresses surface and subsurface soil samples collected in November 2011 on the Harar Avenue residential property and in the adjacent county ditch on the south side of Smith Street ("the property and ditch"). Florida DOH included in this evaluation one 2006 soil sample collected from the property and ditch.

Florida DOH concludes that incidental ingestion (swallowing) of surface or subsurface soil at the property and ditch is not likely to harm people's health now or in the future. Because the level of soil contamination prior to 2006 is unknown, Florida DOH cannot assess the health threat from past exposures.

Background and Statement of Issues

Harar Avenue Residential Property

In 2010, a resident of Harar Avenue in Brooksville, Hernando County (Figures 1 and 2), expressed concerns about possible health effects associated with arsenic in the soil on

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his property. A nearby hazardous waste site, the former S & B Go, Inc. facility (DEP Facility ID No. 278508778) was thought to be the source of the arsenic [DOH 2011a; DOH 2011b]. As part of a site assessment for the former S & B Go facility, Florida DEP's contractor collected soil samples in August and December 2010 at the Harar Avenue property and at the adjacent county ditch. Soil samples were analyzed for arsenic, chromium, copper, and iron [ES 2010a; ES 2010b]. Florida DOH examined the results in a health consultation report and determined that the incidental ingestion of soil is not likely to harm people's health [DOH 2011a].

In March 2011, Florida DEP's contractor collected more soil samples at the property and ditch and analyzed for arsenic [ES 2011a]. Florida DOH evaluated the results in a second health consultation report and concluded that the incidental ingestion of arsenic in the soil is not likely to harm people's health [DOH 2011b]. After both assessments, Florida DOH recommended Florida DEP test the soil at the property and ditch for petroleum hydrocarbons [DOH 2011a; DOH 2011b].

In November 2011, Florida DEP's contractor collected 10 surface soil (6 inches below land surface) and 10 subsurface soil (2 feet below land surface) samples at the property and ditch (sample numbers B-89 through B-98; Figure 2). The contractor analyzed for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), including petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs). Additionally, the contractor analyzed the samples for arsenic, chromium, cadmium, lead, and polychlorinated biphenyls (PCBs) [ES 2011b].

This letter estimates possible current and future health effects associated with the chemicals found in the soil at the property and ditch. It evaluates the November 2011 surface and subsurface soil samples (Figure 2). In addition, it examines concentrations of VOCs and SVOCs measured in one subsurface soil (1 foot below land surface) sample at the property and ditch that was collected in August 2006 (sample number SB-4; Figure 2). Florida DEP's contractor collected this sample as part of a site assessment for another facility that is close by, the former Springstead Oil Company (DEP Facility ID No. 278508847) [ES 2007a].

<u>S & B Go, Inc.</u>

The former S & B Go, Inc. facility is directly across the street to the north of the Harar Avenue property and ditch (Figure 2). The site was an active bulk petroleum fueling facility operating since approximately 1927 [ES 2006]. S & B Go, Inc. appeared in record as the company name in 1984. The company reported being inactive in 1993 [DOS 1993]. While in operation, S & B Go had eight aboveground storage tanks (ASTs) holding gasoline, diesel fuel, and kerosene. Additionally, it had two underground storage tanks (USTs) holding waste oil and spilled materials [DER 1990; DER 1992a; DER 1992b]. By 2006, the facility had removed all 10 tanks. Only remnants of three buildings and the AST cradles remained on the site [ES 2006].

In 1990, Florida Department of Environmental Regulation (DER) found petroleum contamination at the S & B Go facility [DER 1990]. In 2003, Florida DEP (previously known as Florida DER) removed two ASTs and the two USTs as well as cleaned and locked four ASTs. Petroleum-contaminated soil and groundwater were found in the area of one of the USTs [Jones-Ayres 2003]. In April 2005, Florida DEP removed approximately 1,473 tons of contaminated soils from the facility and backfilled the excavated area with clean fill material [Handex 2005]. From 2005 to 2009, petroleum-contaminated soil and groundwater continued to be a concern [ES 2006; ES 2007b; ES 2009]. As a result, in September 2009, the Florida DEP removed an additional 318 tons of contaminated soil [ES 2009]. However, in December 2009, petroleum hydrocarbons were still detected in some previously installed monitoring wells [ES 2010c].

Site Visit

On March 9, 2012, Florida DOH visited the Harar Avenue neighborhood and former S & B Go facility. A distinctive slope from the S & B Go site, into Smith Street, and to the ditch and property was not evident. However, Google Earth images indicate a slight decrease in elevation when moving south of the S & B Go [Google Inc. 2012]. Thus, stormwater may run off from the S & B Go site towards the ditch and property. Stormwater could transport contaminants to the ditch and property. Because the weather was clear during the site visit, Florida DOH was not able to observe stormwater runoff. Staff observed remnants of structures and extensive overgrown vegetation at the S & B Go site.

Discussion

Pathway Analysis

Florida DOH determines exposure to environmental contamination by identifying exposure pathways. An exposure pathway consists of five elements:

1. a source of contaminants, like a hazardous waste site,
2. an environmental medium like air, water or soil that can hold or move the contamination,
3. a point where people come in contact with a contaminated medium, like soil in a residential yard or drinking water,
4. an exposure route like ingesting contaminated soil that was left on hands or food items or drinking contaminated water from a well, and
5. a population who could be exposed to the contaminants.

Florida DOH eliminates an exposure pathway if at least one of the five items described above is missing and is very unlikely to be present in the future. Exposure pathways not eliminated are either completed or potential pathways. For completed pathways, all five components exist and exposure to a contaminant has occurred, is occurring, or will occur. A potential pathway exists when some, but not all, of the five elements are present and the potential exists that the missing element(s) have been present, are present, or will be present in the future [ATSDR 2005]. Identification of a completed or potential exposure pathway does not necessarily mean it will result in illness.

Completed Exposure Pathways

Florida DOH identified incidental ingestion (swallowing of very small amounts of soil) as a route of exposure to contaminants at the property and ditch (Table 1). Incidental ingestion may occur by inadvertently swallowing soil stuck on hands or food items or through the mouthing of objects. Children in particular mouth or ingest non-food items [ATSDR 2005]. The possible source for soil contamination is S & B Go, Inc. Stormwater may have carried contaminants into the ditch and to the property. Soil is the environmental media, and points of exposure are the Harar Avenue residential property and adjacent ditch. Residents at the property are the exposed population.

Potential Exposure Pathways

Florida DOH assessed current and future exposures to contaminants in the surface soil. If subsurface soil is brought to the surface in the future, residents at the property and ditch could be exposed to contaminants in this soil. Thus, Florida DOH also evaluated future exposures to subsurface soil.

Eliminated Exposure Pathways

Ingestion of contaminants through groundwater is not an exposure route for this site. Homes in the area are connected to a municipal water supply, which obtains source water from a distant location [DOH 2011a; DOH 2011b].

The risk from skin absorption of contaminants from this site is an eliminated pathway. Compared to ingestion (eating/drinking), the risk from dermal exposure (skin absorption) to chemicals in soil is usually insignificant.

Incidental ingestion (swallowing of very small amounts of soil) from past exposure is an eliminated pathway. No data prior to 2006 are available for the property and ditch, and, thus, Florida DOH is unable to make an assessment about past concentrations and exposures.

Environmental Data

Florida DOH used data from the Florida DEP for this health consultation. A Florida DEP contractor conducted all of the sampling, and the sampling appears to be in accordance with the Florida DEP Standard Operating Procedures (http://www.dep.state.fl.us/water/sas/sop/sops.htm). Laboratories certified by the Department of Health Environmental Laboratory Certification Program (http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm) conducted the analyses of the soil samples. Analytical performance of the laboratories is in accordance with the National Environmental Laboratory Accreditation Conference (NELAC) Standards. Florida DOH assumes these data are valid and representative of the environmental conditions at the site. The completeness and reliability of the referenced environmental data determine the validity of the analyses and conclusions drawn for this health consultation.

Identifying Contaminants of Concern

If the concentration of a contaminant in the soil meets or exceeds an environmental comparison value, Florida DOH will consider the sample for further analysis. The Department will not analyze the sample further if a soil contaminant does not meet or exceed its appropriate comparison value, and will assume that the sample poses no further health risk at that concentration [ATSDR 2005]. Florida DOH used standard comparison values to select the contaminants of concern from the chemicals measured (see Appendix A).

Florida DOH compared the maximum concentration of each chemical measured in surface and subsurface soil to the appropriate ATSDR comparison value. If an ATSDR comparison value was not available, Florida DOH evaluated the concentration using the Florida DEP Soil Cleanup Target Levels (SCTLs).

Non-carcinogenic Contaminants of Concern

After reviewing the concentration of each compound in the soil samples with regards to the appropriate comparison values, Florida DOH determined that chromium needs further evaluation for non-cancer illnesses (Tables 2 and 3). The highest concentrations of lead in the surface and subsurface soils are below the comparison value (Tables 2 and 3). However, because of recent changes to federal lead guidelines, Florida DOH evaluated the health risk for lead [CDC 2012].

Carcinogenic Contaminants of Concern

For carcinogens, Florida DOH evaluates the theoretical cancer risk for adults regardless of the contaminant concentration. Florida DOH identified arsenic, chromium, cadmium, lead, and PAHs as contaminants of concern for further evaluation of potential cancer effects.

Special Considerations

The laboratory did not detect benzidine in any samples, but the detection limits were above the comparison value in all samples [ES 2011b]. Because benzidine is not associated with petroleum, the actual concentrations in the soil at the property and ditch are not likely above the comparison value. Benzidine is a synthetic chemical used in the production of dyes for paper, cloth, and leather. It has not been made for sale in the United States since the mid-1970s. Small amounts of this chemical may be manufactured or imported for research in scientific laboratories or other specialized uses [ATSDR 2001].

Although the laboratory detection limits for some of the SVOCs in one surface soil sample, B-94, were higher than the ATSDR cancer comparison values, the laboratory did not detect them in any other samples [ES 2011b]. Therefore, it is unlikely the actual SVOC concentrations are above the comparison values in this one sample.

Polycyclic aromatic hydrocarbons (PAHs) occur as complex mixtures in the environment rather than as single compounds. In assessing non-cancer effects, Florida DOH evaluates individual PAHs according to appropriate comparison values.

In consideration of cancer risks from exposure to a PAH mixture, Florida DOH estimates the potency of each carcinogenic PAH based on its relative potency to benzo[a]pyrene. Benzo[a]pyrene is the PAH about which most information is available, and it is known be one of the most highly carcinogenic compounds in the group. A toxicity equivalency factor (TEF) has been assigned to each PAH according to its relative potency. This report shows the 15 carcinogenic PAHs commonly found at National Priorities List (NPL) hazardous waste sites and their TEFs in Appendix B [Nisbet and LaGoy 1992; ATSDR 1995]. Florida DOH multiplies the concentration of each chemical by its appropriate TEF. For concentrations at the detection limits and qualified as being not detected, Florida DOH uses half of the detection limit when at least one other PAH is actually measured in the sample [CEHT 2005; EPA 1991]. Florida DOH then adds the products to obtain a total toxic equivalent (TEQ), and evaluates against a benzo[a]pyrene comparison value.

The maximum soil concentrations for all of the petroleum hydrocarbons were below comparison values and thus unlikely to cause any non-cancer illness.

Public Health Implications

Florida DOH provides site-specific public health recommendations based on toxicological literature, evaluation of potential exposure pathways, levels of environmental contaminants, duration of exposure, and characteristics of the exposed population. Whether a person will be harmed depends on the type and amount of contaminant, how he/she is exposed, how long he/she is exposed, how much contaminant is absorbed, his/her health status, his/her genetics, and individual lifestyles.

Florida DOH conservatively assumes that people are exposed daily to the maximum concentration of each chemical measured. Florida DOH also makes the health protective assumption that 100% of the ingested chemical is absorbed into the body. The percent actually absorbed into the body, however, is likely less than 100%.

Florida DOH evaluates exposures by estimating daily doses for children and adults. The standard assumptions used and the calculations for this assessment are in Appendix C. Florida DOH compares the calculated exposure doses to ATSDR Minimal Risk Levels (MRLs) to assess non-cancer health risks. An MRL is expressed in terms of milligrams of chemical per kilogram of body weight per day (mg/kg/day) for oral exposures. The ATSDR derives MRLs from the most relevant documented no-observed-adverse-effects level (NOAEL) or lowest-observed-adverse-effects level (LOAEL) and an uncertainty factor. These MRLs serve as a screening tool to help identify whether Florida DOH should further evaluate a chemical. Exposure to levels below an MRL is unlikely to contribute to any non-cancer illness. Exposures to levels above an MRL do not necessarily mean that adverse health effects will definitely occur, only that further evaluation is necessary [ATSDR 2005].

Lead is an exception to this process. Because of the scientific information available for lead, Florida DOH does not estimate a dose by traditional methods. Instead, they evaluate lead by using a biological model that predicts a blood lead concentration that would result from exposure to environmental lead contamination. Florida DOH estimates the blood lead concentration for one of the most sensitive populations: young children. Florida DOH compares the modeled concentration to a health value established by the Centers for Disease Control and Prevention (CDC). The Department uses the Integrated Exposure Uptake Biokinetic (IEUBK) model developed by the United States Environmental Protection Agency (EPA) to provide estimated blood lead levels for children from 6 months to 7 years old. This model does not, however, provide estimates for children older than 7 years old or adults [EPA 1994a, 1994b].

Florida DOH also estimates a theoretical excess cancer risk for adults with chronic exposure to a contaminant. The Department quantifies the increased theoretical risk by multiplying the estimated exposure dose by the appropriate EPA-established cancer slope factor (CSF). Florida DOH adjusts the highest estimated average daily dose to a dose that would yield an equivalent exposure if exposure continued for the entire lifetime. Florida DOH assumes lifetime exposure occurs over a 70-year period. They use at minimum 35 years to reflect a significant portion of a lifetime. Studies of animals exposed over their entire lifetimes are the basis for calculating most CSFs. Usually, little is known about the cancer risk in animals from less than lifetime exposures. Therefore, Florida DOH also uses lifetime exposure to estimate the cancer risk in people. Estimating the cancer risk for children, or from less than 35 years exposure, may introduce significant uncertainty.

Florida DOH estimates the most conservative, health protective increased cancer risk. The actual increased cancer risk is likely lower. Because of large uncertainties in the way scientists estimate cancer risks, the actual increased risk of cancer may be as low as zero.

Florida DOH examined all five contaminants of concern with regard to cancerous health effects to adult residents at the property. To put the cancer risk into perspective, the Department uses the following descriptors for the different numeric cancer risks:

1 in 10 (10-1)	"very high" increased risk
1 in 100 (10-2)	"high" increased risk
1 in 1,000 (10-3)	"moderate" increased risk
1 in 10,000 (10-4)	"low" increased risk
1 in 100,000 (10-5)	"very low" increased risk
1 in 1,000,000 (10-6)	"extremely low" increased risk

If there is no CSF or potency factor, Florida DOH cannot quantify the risk.

It is important to note that the concentrations of arsenic, cadmium, lead, and PAHs found at the property and ditch did not exceed the non-cancer comparison values (Tables 2 and 3). Florida DOH only estimated the exposures for arsenic, cadmium, and benzo[a]pyrene toxic equivalents as a necessary step in cancer risk calculations (Appendix C). Florida DOH also estimated the blood lead levels and compared them to the newly defined CDC reference value.

Surface Soil (6 inches below land surface)

Florida DOH examined the highest detected concentrations in surface soil to determine current and future health effects. Because Florida DOH does not have soil data prior to 2006, they are unable to evaluate past exposure.

Arsenic

Arsenic is a metal found throughout the Earth's crust. It occurs naturally in soils at concentrations ranging from about 1 to 40 milligrams arsenic per kilogram soil (mg/kg) with an average of 3 to 4 mg/kg [ATSDR 2007a]. In 445 surface soil samples taken throughout the state of Florida, concentrations ranged from 0.01 to 50.6 mg/kg [Chen et al. 1999, 2002].

Wind-blown dust may release arsenic to air, water, and land. Arsenic may enter water from runoff and leaching. While arsenic can come from natural sources, such as from soils and volcanoes, releases from man-made sources are more prevalent. Such man-made sources include wood treating, pesticide application, coal combustion, waste incineration, and metal mining and smelting. Arsenic may be in the inorganic form, or it may be present in an organic form combined with carbon and hydrogen. Inorganic arsenic is more toxic than organic arsenic [ATSDR 2007a]. To be protective of human health, Florida DOH assumed that the arsenic measured in the soils at the property and ditch was in the more toxic, inorganic form.

The highest arsenic concentration in surface soil from the property and ditch, 2.2 mg/kg, was below the ATSDR non-cancer comparison value of 20 mg/kg (Table 2). Thus, it is unlikely this 2.2 mg/kg concentration of arsenic would contribute to non-cancer illness.

Arsenic is known to be a human carcinogen. The estimated dose for adults exposed to the highest concentration (2.2 mg/kg) through incidental ingestion is 0.0000031 mg/kg/day (Table 4). To determine a theoretical cancer risk, Florida DOH multiplied this estimated dose by the EPA's oral CSF of 1.5 per (mg/kg)/day. This CSF is based on a human study in which people developed skin cancer upon exposure to inorganic arsenic [EPA 2012a]. Florida DOH determined the theoretical increased cancer risk for exposure to arsenic at the highest levels found at the property and ditch is five additional cancer cases in a population of one million persons. The increased risk is considered "extremely low".

According to the American Cancer Society (ACS), American men have slightly less than a 1 in 2 lifetime risk of developing cancer, while women have a lifetime risk of a little more than 1 in 3 [ACS 2012]. Thus, putting the above calculated theoretical increased cancer risk into context, 500,000 out of 1,000,000 men are naturally anticipated to be diagnosed with cancer. For women, 333,333 out of 1,000,000 women are expected to be diagnosed with some form of cancer in their lifetime. Adding the theoretical increased cancer risk from lifetime exposure to the arsenic concentrations measured at the property and ditch, the cancer incidence would increase to 500,00**5** cases in 1,000,000 men or 333,33**8** cases in 1,000,000 women.

Cadmium

Cadmium is a metal found in the Earth's crust; generally part of zinc, lead, and copper ores. The concentration averages between 0.1 to 0.5 mg cadmium/kg soil [ATSDR 2008a]. In 439 surface soil samples taken throughout the state of Florida, cadmium concentrations ranged from 0.004 to 2.80 mg/kg [Chen et al. 1999].

Natural sources for cadmium include forest fires, sea salt aerosols, and volcanoes. The primary man-made sources of cadmium are burning of fossil fuels, waste incineration and disposal, production and application of fertilizers, and metal mining and refining. This element is present in only one oxidation state (+2), and its behavior in soil depends upon various conditions such as pH and availability of organic matter [ATSDR 2008a].

The highest concentration of cadmium measured in the surface soil at the property and ditch was 1.1 mg/kg (Table 2). This concentration is below the ATSDR non-cancer screening value of 5 mg/kg. Thus, the cadmium in the surface soil is not likely to contribute to non-cancer health effects.

Because there is no oral CSF for cadmium, it is not possible to quantify the risk of cancer. There are not any positive studies of ingested cadmium suitable for quantifying cancer effects [EPA 2012b]. Both human and animal studies provide insufficient evidence for determining whether cadmium is a carcinogen through oral exposure [ATSDR 2008a].

Chromium

Chromium is another metal that is naturally in the Earth's crust. Total chromium concentrations throughout the United States range from 1 to 2,000 mg chromium/kg soil, with levels averaging 37 mg/kg [ATSDR 2008b]. Chromium concentrations in 444 surface soil samples taken throughout the state of Florida ranged from 0.02 to 447 mg/kg [Chen et al. 1999].

Both natural and man-made sources release chromium into the environment, with the highest amounts coming from industry. Tannery facilities, metal processing, stainless steel welding, and ferrochrome and chrome pigment products are some of the major contributors. Chromium can exist in several different forms. It commonly occurs as chromium(0), chromium(III), and chromium(VI). Steel production uses chromium(0). Chromium(III) is an important nutrient that aids the body with using sugar, protein, and fat. Certain foods—like fruits, vegetables, nuts, and meats—naturally contain low levels of chromium(III). Wood preserving, dyes and pigments, leather tanning, and chrome plating utilize both chromium(VI) and chromium(III). The most toxic form of chromium is chromium(VI) [ATSDR 2008b]. To be protective of human health, Florida DOH assumes that the chromium found in the soils at the property and ditch was the more toxic chromium(VI) or hexavalent chromium.

The maximum amount of chromium measured in the surface soil from the property and ditch was 62 mg/kg. This concentration exceeded the ATSDR comparison value of 50 mg/kg (Table 2). As a result, Florida DOH calculated the maximum doses for children and adults to assess non-cancer effects. The estimated incidental ingestion doses are 0.00078 mg/kg/day and 0.000089 mg/kg/day for children and adults, respectively (Table 4). Both estimated doses are less than the chronic oral MRL of 0.001 mg/kg/day for chromium(VI). This MRL was determined based on a chronic-duration exposure of rats and mice to sodium dichromate dihydrate in drinking water in a 2-year toxicology and carcinogenicity study [ATSDR 2008b]. Thus, the highest level of chromium detected in the surface soil is not likely to cause non-cancer health effects in residents at the property.

The cancer risk from chromium(VI) could not be determined because there is no oral CSF. The oral carcinogenicity for chromium(VI) cannot be determined and no data in the current literature indicates that chromium(VI) is cancerous by oral exposure [EPA 2012c]. Studies of associations with environmental exposures to chromium via the oral pathway and cancer outcomes in humans are limited to ecological studies. These studies investigate possible associations between rates of selected diseases (e.g., cancer deaths) within a geographic population and some measure of average exposure to chromium (e.g., drinking water chromium concentrations). Actual exposures to individuals are not determined, and uncertainty regarding associations between outcomes and exposures can occur. Ultimately, the findings from the ecological studies are mixed and do not strongly support associations between cancer and oral exposures to chromium [ATSDR 2008b].

<u>Lead</u>

Lead is a metal that occurs naturally in the Earth's crust at levels ranging from 15 to 20 mg lead/kg soil. However, it is generally present with two or more other elements in lead compounds rather than in a metallic form. There is approximately 71,000,000 tons of lead throughout the world, with more than one-third of this amount located in North America [ATSDR 2007b]. Concentrations of lead in 439 surface soil samples taken throughout the state of Florida ranged from 0.18 to 290 mg/kg [Chen et al. 1999].

Human activity has contributed significantly to increases in lead over the past three centuries. Much of this was a result of the use of leaded gasoline. By 1978, the United States banned the use of leaded paints; however, leaded paint is still present in older homes. Additionally, the United States banned the use of lead as a gasoline additive in 1995. Mining and manufacturing can contribute to lead concentrations in the environment. Today the largest use for lead is in vehicle batteries [ATSDR 2007b].

Florida DOH evaluated lead in terms of blood lead levels and the newly defined CDC reference value. The maximum concentration of lead was 75 mg/kg in the surface soil at the property and ditch (Table 2). Using this concentration and the standard default values, the IEUBK model predicts blood lead levels between 1.2 to 1.9 micrograms per deciliter (ug/dL) for children aged 0.5 to 7 years old. The highest estimated blood lead level is 1.9 ug/dL for children aged 1 to 2 years old. This level is below the newly defined reference value of 5 ug/dL [CDC 2012]. Thus, the highest level of lead measured in the surface soil is not likely to cause non-cancer health effects in residents at the property.

Lead does not have an oral CSF. Although lead is a probable human carcinogen based on animal studies, available human evidence is inadequate to demonstrate human carcinogenicity. Quantifying the cancer risk from lead involves many uncertainties and using current standard risk assessment procedures may not truly describe the potential risk [EPA 2012d].

PAHs

Polycyclic aromatic hydrocarbons (PAHs) are chemicals that form during the incomplete burning of oil, gas, coal, wood, garbage, or other organic substances. More than 100 different PAHs exist, generally occurring as complex mixtures of two or more compounds. However, individual PAHs may be produced for use in research. Medicines may contain certain PAHs. Dyes, plastics, and pesticides may also have PAHs used in their manufacturing processes. Natural releases of PAHs into the environment may occur through volcanoes and forest fires. Man-made sources of PAHs include residential wood burning, agricultural burning, municipal and industrial waste incineration, vehicle exhaust, coal, coal tar, fertilizer application, and hazardous waste sites (e.g., former manufactured-gas factory sites and wood-preserving facilities) [ATSDR 1995].

Fifteen PAH compounds are evaluated in this health consultation (Appendix B). These are considered to be of the greatest concern because they are potentially the most harmful, have been found in some of the highest concentrations at hazardous waste sites, and have the highest likelihood of humans being exposed to them [ATSDR 1995].

Individual PAH concentrations in the surface soil were compared to available non-cancer comparison values and were found not likely to contribute to non-cancer adverse health effects.

The highest level of PAHs in terms of toxic equivalents of benzo[a]pyrene was 0.19 mg/kg in the surface soil at the property and ditch (Table 2). Estimated doses are 0.0000024 mg/kg/day and 0.00000027 mg/kg/day for children and adults, respectively (Table 4). Certain PAHs have been documented to cause cancer in rats and mice after oral exposure. The route of exposure influences the incidence of cancer in animal studies; stomach cancer follows ingestion, lung cancer follows inhalation, and skin cancer follows dermal contact [ATSDR 1995]. To evaluate a theoretical cancer risk from incidental ingestion, the EPA determined a CSF of 7.3 per (mg/kg)/day based on a study of squamous cell papillomas and carcinomas in mice [EPA 2012e]. The calculated theoretical increased cancer risk for incidental ingestion of PAH-contaminated soils at the levels measured at the property and ditch is two additional cancer cases in a population of one million persons. The predicted increased risk is considered "extremely low".

The calculated theoretical increased cancer risk to PAHs can also be examined in the lifetime risk terms ACS provided [ACS 2012]. Again, 500,000 out of 1,000,000 men and 333,333 out of 1,000,000 women are anticipated to be diagnosed with some form of cancer in their lifetimes. Adding the theoretical increased cancer risk from lifetime exposure to the maximum PAH concentration measured at the property and ditch, the cancer incidence would increase to 500,00**2** in 1,000,000 men or 333,33**5** in 1,000,000 women.

Subsurface Soil (1 and 2 feet below land surface)

People are typically exposed to only the top few inches of soil (i.e. surface soil). Exposure to subsurface soil would only occur if future activities brought subsurface soil to the surface. Florida DOH looked at potential effects from exposure to contaminant concentrations in the subsurface soil if this occurs in the future.

Arsenic

The highest concentration of arsenic in subsurface soil, 0.46 mg/kg, is less than the ATSDR non-cancer comparison value of 20 mg/kg (Table 3). Thus, arsenic is not likely to cause non-cancerous health effects.

Because the highest arsenic concentration is close to the ATSDR cancer comparison value of 0.5 mg/kg, Florida DOH evaluated potential carcinogenic effects from arsenic in the subsurface soil. The estimated dose for adults exposed to this concentration through incidental ingestion is 0.00000066 mg/kg/day (Table 5). Florida DOH multiplied this dose by the EPA's oral CSF of 1.5 per (mg/kg)/day to calculate the theoretical increased cancer risk [EPA 2012a]. Florida DOH determined the theoretical increased cancer risk for exposure to arsenic at the levels found at the property and ditch is one additional cancer case in a population of one million persons. Based on the lifetime risks estimated by ACS, the cancer incidence would increase from 500,000 to 500,00**1** in 1,000,000 men or from 333,333 to 333,33**4** in 1,000,000 women. The predicted increased risk is considered "extremely low".

Cadmium

The highest concentration of cadmium measured in subsurface soil, 0.89 mg/kg, is less than the ATSDR comparison value of 5 mg/kg (Table 3). Therefore, cadmium in subsurface soil is not likely to contribute to non-cancer adverse health effects.

As previously stated, there is too much uncertainty to determine if oral exposure to cadmium can cause cancer [ATSDR 2008a; EPA 2012b].

Chromium

The highest level of chromium detected in subsurface soil was 73 mg/kg. Florida DOH estimated the doses as 0.00091 mg/kg/day and 0.00010 mg/kg/day for children and adults, respectively (Table 5). Both doses are below the chronic oral MRL of 0.001 mg/kg/day for chromium(VI). Because the child's dose is only slightly below the comparison value, Florida DOH examined the studies in the ATSDR Toxicological Profile for Chromium. The child's dose is more than 230 times less than the no observed adverse effect level (NOAEL) of 0.21 mg chromium(VI)/kg/day determined in studies with male rats that were exposed for a year to chromium(VI) in drinking water. [ATSDR 2008b]. Thus, the highest level of chromium detected in the subsurface soil is unlikely to cause any non-cancer health effects in residents at the property.

The cancer risk from incidental ingestion of chromium cannot be evaluated because no ingestion CSF is available. Cancer effects from oral exposure to chromium(VI) have not been clearly determined [ATSDR 2008b; EPA 2012c].

Lead

The highest level of lead detected in the subsurface soil was 36 mg/kg (Table 3). Florida DOH used this concentration and standard default values to predict blood lead levels in children 6 months to 7 years old using EPA's IEUBK model. The model predicts blood lead levels between 0.9 to 1.4 ug/dL for children aged 0.5 to 7 years old. The highest estimated blood lead level is 1.4 ug/dL for children aged 1 to 2 years old. This level is below the CDC reference value of 5 ug/dL [CDC 2012]. Thus, the highest level of lead measured in the subsurface soil is not likely to cause non-cancer health effects in residents at the property.

As stated previously, the increased cancer risk from incidental ingestion of lead cannot be determined because there is no EPA CSF.

PAHs

The concentrations of PAHs in subsurface soils at the property and ditch were below detection limits (Table 3) and thus unlikely to contribute to non-cancer or cancerous adverse health effects.

Conclusions

Based on the available data, incidental ingestion of surface or subsurface soil at the property and ditch is not likely to harm people's health now or in the future. Because the level of soil contamination prior to 2006 is unknown, Florida DOH cannot assess the health threat from past exposures.

Recommendations

Florida DOH has no additional recommendations regarding the Harar Avenue site.

Public Health Action Plan

Florida DOH has no further plans regarding the Harar Avenue site.

If you have any questions or concerns regarding the information provided in this health consultation, please contact me at 850-245-4444 extension 2080.

Sincerely,

Laura Morse
Health Assessor

LM/lm

cc: Concerned resident
Grant Willis, Florida DEP
Carl Blair, ATSDR

References

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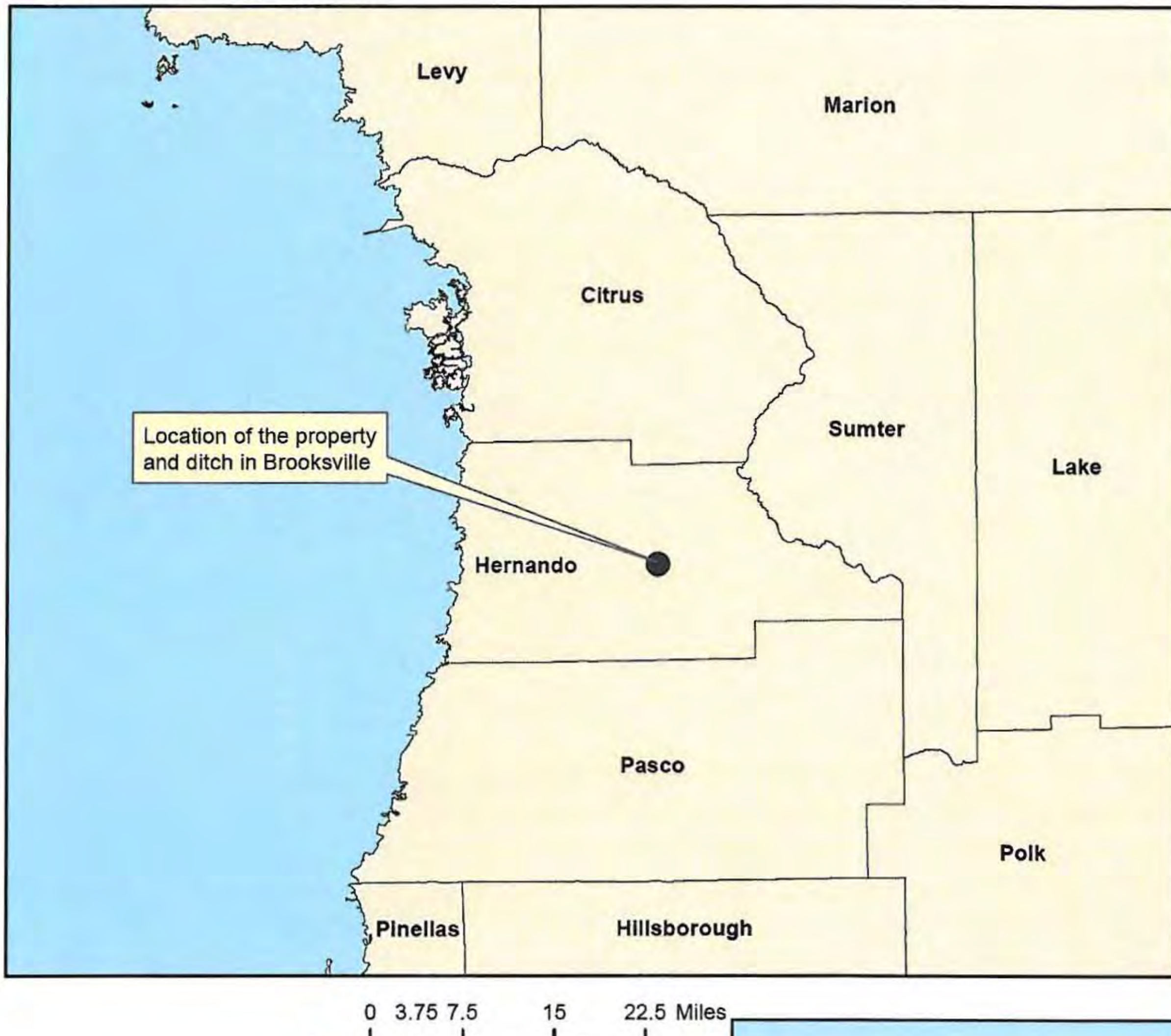
Figure 1. Location of Harar Avenue Residential Property and Adjacent County Ditch on the South Side of Smith Street ("the property and ditch") in Brooksville, Hernando County, Florida



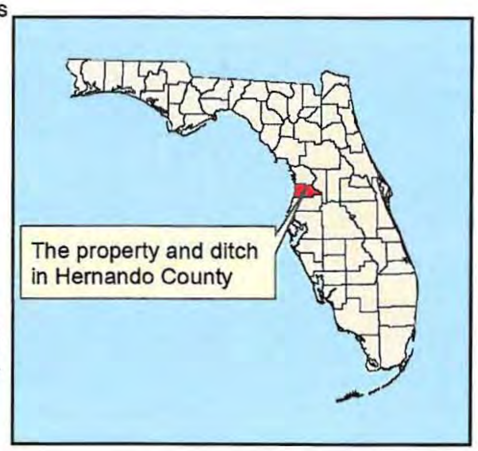


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Figure 2. Locations of Soil Samples Collected at the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street ("The Property and Ditch") [ES 2007a; ES 2011b]

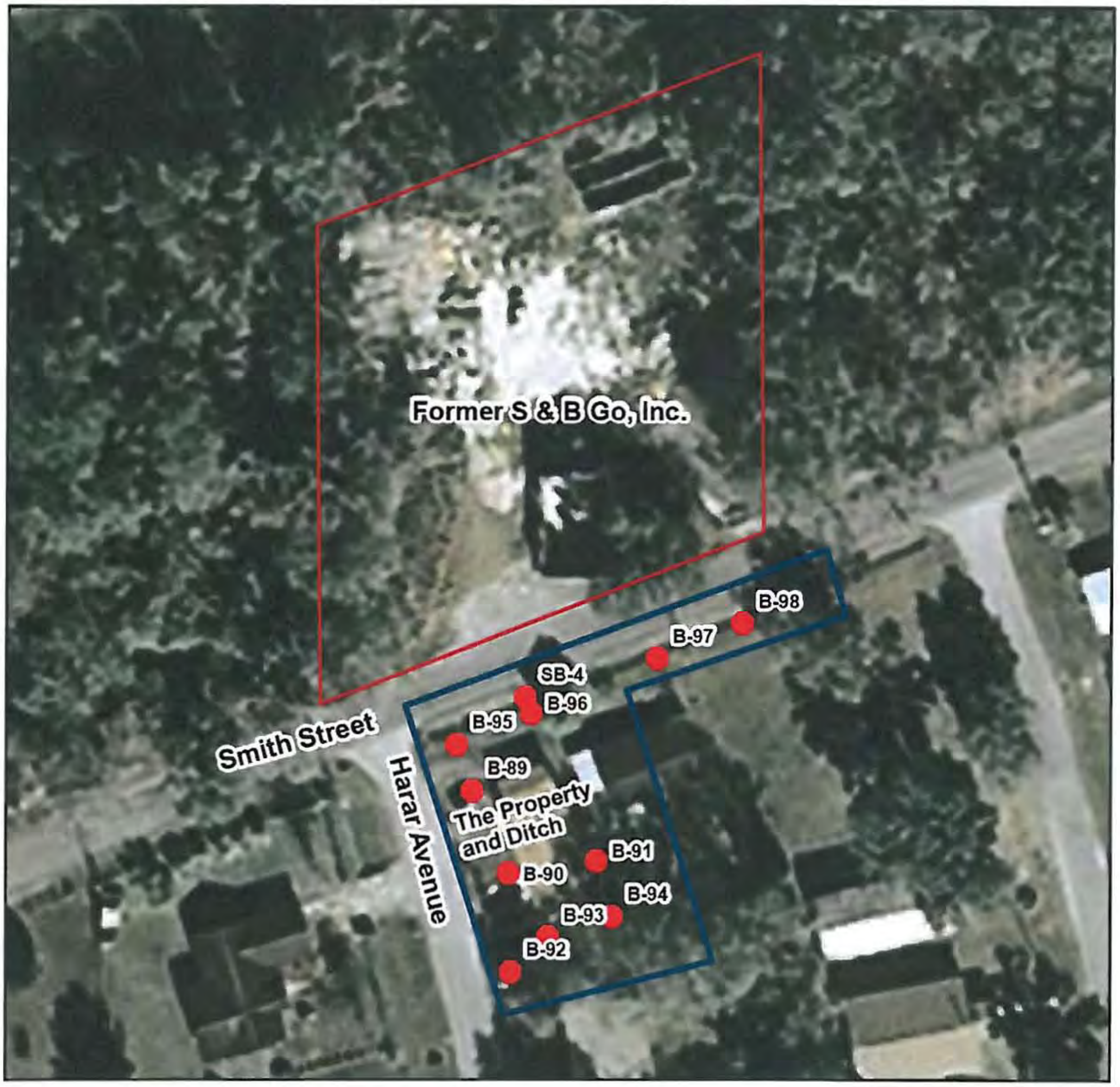

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Table 1: Potential Exposure to Soil on the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street

POTENTIAL PATHWAY NAME	POTENTIAL EXPOSURE PATHWAY ELEMENTS					TIME
	SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	
Incidental ingestion of surface soil	S & B Go, Inc.	Soil	Soil in the yard or ditch next to yard	Incidental ingestion (swallowing)	Residents at the Harar Avenue property	Current Future
Incidental ingestion of subsurface soil	S & B Go, Inc	Soil	Soil in the yard or ditch next to yard	Incidental ingestion (swallowing)	Residents at the Harar Avenue property	Future

Table 2. Maximum Contaminant Concentrations in Surface Soil (6 inches below land surface) on the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street

CONTAMINANTS OF CONCERN	ATSDR OR DEP COMPARISON VALUE (mg/kg) CHILD / ADULT	HIGHEST SOIL CONCENTRATION (mg/kg)	LOCATION OF HIGHEST CONCENTRATION	NUMBER OF SOIL SAMPLES ABOVE ATSDR OR DEP COMPARISON VALUE
Arsenic	20 / 200 Chronic EMEG 0.5 CREG	2.2	B-89	8/10 exceeded the CREG; none exceeded the chronic EMEG
Cadmium	5 / 70 Chronic EMEG	1.1	B-94	0/10
Chromium	50 / 700 Chronic EMEG	62	B-89	1/10
Lead	400 Residential SCTL	75	B-94	0/10
PAH-TEQ	0.1 CREG	0.19	B-97	1/10

ATSDR— Agency for Toxic Substances and Disease Registry
DEP— Florida Department of Environmental Protection
mg/kg— milligrams per kilogram
CREG— Cancer Risk Evaluation Guide, target risk level of 10^{-6} representing a risk of 1 excess cancer cases in a population of 1 million
EMEG— Environmental Media Evaluation Guide, chronic addressing exposures lasting longer than a year
SCTL— Soil Cleanup Target Level, based on exposure from residential land use
PAH-TEQ— total polycyclic aromatic hydrocarbon toxic equivalent (as compared to benzo[a]pyrene)
To be protective of human health, Florida DOH assumed that the arsenic was in the more toxic inorganic form
To be protective of human health, Florida DOH assumed that the chromium was the more toxic chromium(VI)
Comparison values only used to select chemicals for further scrutiny, not to judge the risk of illness
Source: [ES 2011b]

Table 3. Maximum Contaminant Concentrations in Subsurface Soil (1 and 2 feet below land surface) on the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street

CONTAMINANTS OF CONCERN	ATSDR OR DEP COMPARISON VALUE (mg/kg) CHILD/ADULT	HIGHEST SOIL CONCENTRATION (mg/kg)	LOCATION OF HIGHEST CONCENTRATION	NUMBER OF SOIL SAMPLES ABOVE ATSDR OR DEP COMPARISON VALUE
Arsenic	20 / 200 Chronic EMEG 0.5 CREG	0.46	B-91	0/10
Cadmium	5 / 70 Chronic EMEG	0.89	B-92, B-93	0/10
Chromium	50 / 700 Chronic EMEG	73	B-91	5/10
Lead	400 Residential SCTL	36	B-93	0/10
PAH-TEQ	0.1 CREG	BDL	----	0/11

ATSDR— Agency for Toxic Substances and Disease Registry
DEP— Florida Department of Environmental Protection
mg/kg— milligrams per kilogram
CREG—Cancer Risk Evaluation Guide, target risk level of 10^{-6} representing a risk of 1 excess cancer cases in a population of 1 million
EMEG— Environmental Media Evaluation Guide, chronic addressing exposures lasting longer than a year
SCTL— Soil Cleanup Target Level, based on exposure from residential land use
PAH-TEQ— total polycyclic aromatic hydrocarbon toxic equivalent (as compared to benzo[a]pyrene)
BDL— below detection limit
To be protective of human health, Florida DOH assumed that the arsenic was in the more toxic inorganic form
To be protective of human health, Florida DOH assumed that the chromium was the more toxic chromium(VI)
Comparison values only used to select chemicals for further scrutiny, not to judge the risk of illness
Source: [ES 2007a; ES 2011b]

Table 4. Estimated Maximum Dose from Exposure to Surface Soil (6 inches below land surface) on the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street

CONTAMINANTS OF CONCERN (maximum concentration in mg/kg)	CHRONIC ORAL MRL (mg/kg/day)	ESTIMATED MAXIMUM SOIL INGESTION DOSE (mg/kg/day)	
		Child	Adult
Arsenic (2.2)	0.0003	0.000028	0.0000031
Cadmium (1.1)	0.0001	0.000014	0.0000016
Chromium (62)	0.001	0.00078	0.000089
PAH-TEQ (0.19)	None	0.0000024	0.00000027

mg/kg— milligrams per kilogram
mg/kg/day— milligrams of chemical per kilogram of body weight per day
MRL— Minimal Risk Level, an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure
Chronic— Chronic exposure length of more than 365 days
PAH-TEQ— total polycyclic aromatic hydrocarbon toxic equivalent (as compared to benzo[a]pyrene)
To be protective of human health, Florida DOH assumed that the arsenic was in the more toxic inorganic form
To be protective of human health, Florida DOH assumed that the chromium was the more toxic chromium(VI)
Source for contaminants of potential concern: [ES 2011b]

Table 5. Estimated Maximum Dose from Exposure to Subsurface Soil (1 and 2 feet below land surface) on the Harar Avenue Residential Property and in the Adjacent County Ditch on the South Side of Smith Street

CONTAMINANTS OF POTENTIAL CONCERN (maximum concentration in mg/kg)	CHRONIC ORAL MRL (mg/kg/day)	ESTIMATED MAXIMUM SOIL INGESTION DOSE (mg/kg/day)	
		Child	Adult
Arsenic (0.46)	0.0003	0.0000058	0.00000066
Cadmium (0.89)	0.0001	0.000011	0.0000013
Chromium (73)	0.001	0.00091	0.00010
PAHs TEQ (BDL)	None	----	----

mg/kg— milligrams per kilogram
mg/kg/day— milligrams of chemical per kilogram of body weight per day
MRL— Minimal Risk Level, an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure
Chronic— Chronic exposure length of more than 365 days
PAH-TEQ— total polycyclic aromatic hydrocarbon toxic equivalent (as compared to benzo[a]pyrene)
BDL— below detection limit
To be protective of human health, Florida DOH assumed that the arsenic was in the more toxic inorganic form
To be protective of human health, Florida DOH assumed that the chromium was the more toxic chromium(VI)
Source for contaminants of potential concern: [ES 2007a; ES 2011b]

Appendix A

Environmental Comparison Values

Florida Department of Health (DOH) used the following standard comparison values to select the contaminants of concern from the chemicals measured in the surface and subsurface soils at the Harar Avenue residential property and in the adjacent county ditch on the south side of Smith Street:

1. Cancer Risk Evaluation Guides (CREGs). A CREG is the contaminant concentration estimated to result in no more than one excess cancer per one million (10^{-6}) persons exposed during their lifetime (i.e., over a period of 70 years). The Agency for Toxic Substances and Disease Registry (ATSDR) CREGs used for the evaluation of the property and ditch are determined from cancer slope factors (CSFs) established for oral exposures by the United States Environmental Protection Agency (EPA) [ATSDR 2005].
2. Environmental Media Evaluation Guides (EMEGs). An EMEG is an estimated contaminant concentration that is not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. An EMEG is derived from the ATSDR established Minimal Risk Level (MRL) and standard assumptions about exposure, such as an ingestion rate of 200 milligrams (mg) and body weight of 30 kilograms (kg) for children. An MRL is an estimate of daily human exposure to a substance that is likely to be without non-carcinogenic health effects during a specified duration of exposure based on ATSDR evaluations, and is in terms of milligrams of chemical per kilogram of body weight per day (mg/kg/day) for oral exposures. The ATSDR derives soil EMEGs from MRLs that are based on studies in which the chemical was administered in drinking water, food, or by force feeding through a tube into the stomach using oil or water as the medium [ATSDR 2005].
3. Reference Dose Media Evaluation Guides (RMEGs). An RMEG is an estimated concentration for a contaminant to which humans can be exposed and not expect to experience adverse non-carcinogenic health effects. The ATSDR values used for evaluation of the property and ditch were determined based on EPA reference doses (RfDs) for oral exposures and default assumptions accounting for various intake rates between adults and children [ATSDR 2005].
4. Soil Cleanup Target Levels (SCTLs). Additionally, Florida DOH took into consideration SCTLs established by Florida Department of Environmental Protection (DEP). Florida DOH specifically looked at the SCTLs that apply to residential exposure rather than commercial/industrial exposure. Florida DEP develops a SCTL based on humans receiving direct exposure and soil being a source of contamination for ground or surface water. A SCTL is developed using standard assumptions and intended to be broadly applied [CEHT 2005].

Florida DOH compared the maximum concentration of each chemical measured in surface and subsurface soil to the appropriate ATSDR comparison value. If an ATSDR comparison value was not available, Florida DOH evaluated the concentration using the Florida DEP SCTL.

Appendix B

Toxic Equivalency Factors (TEFs) for Polycyclic Aromatic Hydrocarbons (PAHs)

To assess the risk of exposure to a PAH mixture, Florida Department of Health (DOH) estimates the potency of each carcinogenic PAH based on its relative potency to benzo[a]pyrene. Analytical results are multiplied by the following factors and then added together to obtain the total PAH toxic equivalent (TEQ) as compared to benzo[a]pyrene. Florida DOH then evaluates the calculated TEQ against the appropriate benzo[a]pyrene comparison value. According to methods established by the Florida Department of Environmental Protection (DEP) and United States Environmental Protection Agency (EPA), half of the detection level is used for a PAH concentration measured below the detection limit if any PAHs are detected in a sample [CEHT 2005; EPA 1991].

PAH	*Toxicity Equivalency Factor*
Dibenz[a,h]anthracene	5
Benzo[a]pyrene	1
Benzo[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
Fluoranthene	0.001
Fluorene	0.001
Phenanthrene	0.001
Pyrene	0.001

Source: [Nisbet and LaGoy 1992; ATSDR 1995]

Appendix C
Calculations

I). Exposure dose

Incidental soil ingestion

Non-cancer

To estimate exposure from incidental ingestion of contaminated soil, Florida Department of Health (DOH) uses the following standard assumptions:

- children incidentally ingest (swallow) an average of 200 milligrams (mg) of soil per day (about the weight of a postage stamp),
- adults incidentally ingest (swallow) an average of 100 mg of soil per day,
- children weigh an average of 16 kilograms (kg) or about 35 pounds,
- adults weigh an average of 70 kg, or about 155 pounds,
- children and adults incidentally ingest (swallow) contaminated surface soil at the maximum concentration measured for each contaminant
- exposure factor is 1 (reflecting chronic daily exposure of 365 days 24 hours per day)

Abbreviations:

D= exposure dose (mg/kg/day)
C= contaminant concentration (mg/kg)
IR= intake rate of contaminated soil (mg/day)
EF= exposure factor (unitless; in this instance, the EF is 1 to account for daily exposure)
CF= conversion factor (10^{-6} kg/mg)
BW= body weight
mg= milligram
kg= kilogram
d= day

D= (C x IR x EF x CF)/ BW

None of the arsenic, cadmium, lead, or individual polycyclic aromatic hydrocarbon (PAH) levels found on the Harar Avenue residential property and in the adjacent county ditch on the south side of Smith Street ("the property and ditch") exceeded the non-cancer comparison values. Florida DOH estimates the exposure doses for arsenic, cadmium, and total PAH toxic equivalent as compared to benzo[a]pyrene only as a necessary step in completing the later cancer risk calculations for adults exposed to the contaminant over an average lifetime (70 years). Florida DOH calculated the blood lead levels for children and compared them to the newly defined reference value to assess any potential concerns with lead contamination. In addition, a non-cancer comparison value is unavailable for polycyclic aromatic hydrocarbons (PAHs). Florida DOH estimated non-cancer exposure for PAHs and compared the results to studies in ATSDR Toxicological Profiles. Florida DOH calculated cancer risk for PAHs using the predicted non-cancer exposure dose.

Surface Soil (6 inches below land surface)

Arsenic

- assumed that the arsenic was in the more toxic inorganic form
- maximum surface soil concentration = 2.2 mg/kg

D_{adult}= (2.2 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.0000031 mg/kg/day

Cadmium

- maximum surface soil concentration = 1.1 mg/kg

D_{adult}= (1.1 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.0000016 mg/kg/day

Chromium

- assumed that the chromium was the more toxic chromium(VI)
- maximum surface soil concentration = 62 mg/kg

D_{adult}= (62 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.000089 mg/kg/day

D_{child}= (62 mg/kg x 200mg/day x 1 x 10^{-6} kg/mg)/ 16 kg = 0.000014 mg/kg/day

PAHs

- maximum surface soil concentration in terms of benzo[a]pyrene toxic equivalents = 0.19 mg/kg

D_{adult}= (0.19 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.00000027 mg/kg/day

Subsurface Soil (1 and 2 feet below land surface)

Arsenic

- assumed that the arsenic was in the more toxic inorganic form
- maximum surface soil concentration = 0.46 mg/kg

D_{adult}= (0.46 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.00000066 mg/kg/day

Cadmium

- maximum surface soil concentration = 0.89 mg/kg

D_{adult}= (0.89 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.0000013 mg/kg/day

Chromium

- assumed that the chromium was the more toxic chromium(VI)
- maximum surface soil concentration = 73 mg/kg

D_{adult}= (73 mg/kg x 100mg/day x 1 x 10^{-6} kg/mg)/ 70 kg = 0.00010 mg/kg/day

D_{child}= (73 mg/kg x 200mg/day x 1 x 10^{-6} kg/mg)/ 16 kg = 0.00091 mg/kg/day

II). Cancer risk

To estimate the theoretical cancer risk from incidental ingestion of contaminated soil, Florida DOH uses the following standard program assumptions:

- An average lifetime is 70 years

To put the cancer risk into perspective, Florida DOH uses the following descriptors for the different numeric cancer risks:

1 in 10 (10^{-1})	"very high" increased risk
1 in 100 (10^{-2})	"high" increased risk
1 in 1,000 (10^{-3})	"moderate" increased risk
1 in 10,000 (10^{-4})	"low" increased risk
1 in 100,000 (10^{-5})	"very low" increased risk
1 in 1,000,000 (10^{-6})	"extremely low" increased risk

ER= CSF x D

ER= estimated theoretical cancer risk (unit less)
CSF=cancer slope factor from United States Environmental Protection Agency (EPA); units shown as per (mg/kg)/day or $(mg/kg/d)^{-1}$
D= exposure dose (mg/kg/day)

It is important to note that Florida DOH estimates the theoretical excess cancer risk for adults over an average lifetime. Estimating the cancer risk for children, or from less than 35 years exposure, may introduce significant uncertainty. Also, note that Florida DOH cannot estimate the cancer risk if no CSF is available. Thus, Florida DOH could not calculate the cancer risk from incidental ingestion of cadmium, chromium, or lead.

<u>Surface Soil (6 inches below land surface)</u>

Arsenic

- arsenic ingestion cancer slope factor = 1.5 $(mg/kg/d)^{-1}$
- arsenic ingestion dose for surface soil = 0.0000031 mg/kg/d

ER= (1.5 $(mg/kg/d)^{-1}$) x 0.0000031 mg/kg/d) = 0.00000471 or approximately 5 x 10^{-6}

This would be interpreted as an increased risk of 5 additional cancer cases for every 1,000,000 people.

PAHs

- PAHs ingestion cancer slope factor in terms of benzo[a]pyrene = 7.3 $(mg/kg/d)^{-1}$
- PAHs ingestion dose calculated from the total PAH toxic equivalent in terms of benzo[a]pyrene = 0.00000027 mg/kg/d

ER= (7.3 $(mg/kg/d)^{-1}$) x 0.00000027 mg/kg/d) = 0.00000198 or approximately 2×10^{-6}

This would be interpreted as an increased risk of 2 additional cancer cases for every 1,000,000 people.

<u>Subsurface Soil (1 and 2 feet below land surface)</u>

Arsenic

- arsenic ingestion cancer slope factor = 1.5 $(mg/kg/d)^{-1}$
- arsenic ingestion dose for subsurface soil = 0.00000066 mg/kg/d

ER= (1.5 $(mg/kg/d)^{-1}$) x 0.00000066 mg/kg/d) = 0.000000986 or approximately 1×10^{-6}

This would be interpreted as an increased risk of 1 additional cancer case for every 1,000,000 people.