Health Consultation

BERKLEY STREET SOIL CONTAMINATION

WINNEBAGO COUNTY, ILLINOIS

NOVEMBER 16, 2012

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners 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 or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

BERKLEY STREET SOIL CONTAMINATION

WINNEBAGO COUNTY, ILLINOIS

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations

Table of Contents

Summary

Introduction

In 1999, while excavating a water line, the City of Rockford encountered blue colored soil along Berkley Street in Rockford, Illinois. In June 2010, residents contacted the Illinois Environmental Protection Agency (Illinois EPA) with complaints that a blue material was infiltrating foundational cracks and a sump in two homes along Berkley Street. IEPA collected surface soil and subsurface soil samples in June and September of 2010, along with scrapings of the blue material from one of the affected basements. Environmental samples were analyzed for inorganic and organic pollutants. Elevated levels of polycyclic aromatic hydrocarbons (PAHs), arsenic, and cyanide were detected. The United States Environmental Protection Agency (USEPA) was subsequently requested to conduct a site assessment and a removal action by Illinois EPA in November of 2010. After consultation with the Agency for Toxic Substances and Disease Registry (ATSDR)-Region 5 and the Illinois Department of Public Health (IDPH), USEPA conducted sampling to characterize the nature and extent of the contamination. The waste material, by appearance and by chemical fingerprint, is consistent with Prussian Blue (iron cyanide), a waste byproduct from manufactured gas plant (MGP) production. However, the properties could also have been used to dump waste material from a farm implement manufacturer established in the 1950s two blocks south. Based on the determination that site contamination posed a health threat, USEPA initiated a time-critical Removal Action to remediate contamination at these two properties, which was completed in early 2012.

Conclusions ATSDR has reached the following conclusions regarding the Berkley Street soil contamination issue:

Conclusion 1 *In the past, exposures to wastes in residential soils on Berkley Street could harm people's health. This is a past public health hazard.*

Basis for Conclusion Based on levels of PAHs, arsenic, and cyanide detected in soil, the potential for non-cancer adverse health effects associated with past exposures are unlikely in children and adults. However, dermal irritation was possible from skin contact with waste material due to the highly acidic nature of the waste material.

Cumulative lifetime excess cancer risks for PAHs and arsenic were calculated to be 1.2 cases in 1,000 for the exposed population with a conservative assumption of regular direct contact with subsurface contamination. Exposures pose a high increase in lifetime cancer risk compared to the background risk of cancer from all causes.

Subsurface soil has a much greater level of contamination than surface soils. Surface soils are covered with vegetation, and have less potential for contact. However, ATSDR cautions against disturbing soil during construction or using the soil for gardening without installing raised beds.

Contaminant concentrations present in the basement posed a threat to human health, so ATSDR recommended immediate action to mitigate exposures. USEPA completed this work in late 2011 and early 2012.

Conclusion 2 ***Current*** *conditions no longer pose an indoor hazard to residents.*

Basis for Conclusion USEPA has repaired and sealed the foundations of the homes to prevent contamination from entering the basements. Therefore, there is no longer an entry point into the affected homes for contaminated subsurface soil.

Conclusion 3 *ATSDR concludes that the presence of wastes in subsurface soils in residential lots on Berkley Street could harm people's health. This is a* ***future*** *public health hazard.*

Basis for Conclusion Elevated levels of PAHs, arsenic, and cyanide and very low pH are present in soils sampled in the block of the affected homes. This contamination could present an exposure hazard if the lots are developed in the future, or if gardening or landscaping exposes contaminated soil.

Next Step ATSDR recommends requiring a land development restriction to ensure that future land development is protective of residents in the area.

For More Information Questions about this health consultation should be directed to the ATSDR Region 5 office at 312-886-0840.

Statement of Issues

In 1999, while excavating a water line, the City of Rockford encountered blue colored soil along Berkley Street in Rockford, Illinois. In June 2010, residents contacted the Illinois Environmental Protection Agency (Illinois EPA) with complaints that a blue material was infiltrating foundational cracks and a sump in two homes along Berkley Street. IEPA collected surface soil and subsurface soil samples in June and September of 2010, along with a surface scraping from one of the affected basements. Environmental samples were analyzed for inorganic and organic pollutants. Elevated levels of polycyclic aromatic hydrocarbons (PAHs), arsenic, and cyanide were detected. The United States Environmental Protection Agency (USEPA) was subsequently requested to conduct a site assessment and a removal action by Illinois EPA. Extent of contamination sampling and remedial work was completed in January 2012 by USEPA after consultation with the Agency for Toxic Substances and Disease Registry (ATSDR), Region 5 and the Illinois Department of Public Health (IDPH) in late winter/spring of 2011. The waste material, by appearance and by chemical fingerprint, is consistent with Prussian Blue (iron cyanide), a waste byproduct of coke oven operations. However, the properties could also have been used to dump waste material from a farm implement manufacturer established in the 1950s two blocks south.

Background

On January 4, 2011 USEPA met with the ATSDR, Region 5 about the infiltration of a blue liquid from an unknown source into two homes on Berkley Street in Rockford, IL. ATSDR was provided with data collected in May of 2000 and June and September of 2010 by the Illinois EPA. USEPA provided ATSDR results from data collected in April and November 2011 to further characterize the extent of contamination on the block.

The Site is located on the south side of the 2000 block of Berkley Street in Rockford, Illinois. It is bordered to the north by Berkley Street, to the east by Stewart Avenue, to the south by Preston Street, and to the west by Webster Avenue. The Site consists of two residential properties and other parcels that comprise 2.5 acres of land in a mixed residential/industrial area. The two residences are occupied. A young child of approximately seven years old is a frequent visitor to one of the houses. Both residences obtain water from a public water supply line. The other parcels that comprise the Site are empty lots with grass and trees. Industrial facilities are located immediately south of Preston Street on Independence Avenue. The Rock River is located approximately 1.5 miles to the east and Leavings Lake is located approximately 0.8 miles to the southwest.

Potential Contamination Sources

Although the source of the contamination under the homes is unknown, there are several surrounding facilities, including a former steel manufacturer that operated contained coke ovens (IEPA, 2010b). The most likely sources given the chemical fingerprint of the waste are manufactured gas plants, and possibly a company that began operations in the 1850s in Rockford, IL called J.H. Manny & Co., two blocks south of the affected properties (USEPA, 2007b).

Manufactured Gas Plant Facilities

The waste characterized along Berkley Street, by appearance and by chemical fingerprint, is consistent with Prussian Blue (iron cyanide). This material is a waste byproduct from manufactured gas plant (MGP) production. Cooling of natural gas from manufactured gas plants yielded contaminated byproducts including coal tar and purifier waste. Coal tar typically is contaminated with benzene, toluene, ethylbenzene, xylenes (BTEX compounds) and polycyclic aromatic hydrocarbons (PAHs). Purifier waste is typically contaminated with complexed cyanide compounds.

From 1810-1966 manufactured gas plants (MGPs) produced gaseous fuel from coal and oil for heating and illumination. Coal gas was produced through the distillation of bituminous coal in heated, anaerobic vessels called retorts, where approximately 40% of the coal's weight was converted into volatile non-solids or gases. Most of the remaining amount of the coal was converted into solids, primarily coke. From the retort, the gases were drawn off into a hydraulic main where some of the vapors were converted to liquids, which consisted of contaminated water and coal tar, and associated wastes. The remaining vaporous material was coal gas. The final stage of purification included passing the generated gas through an "oxide box" chamber filled with a mixture of ferric oxide and wood chips, often with a layer of lime powder, crushed lime rock, or crushed sea shells. Ferric oxide solids bonded with sulfides and cyanides to form stable complexed waste solids. Eventually, most of the filler lost its sorbtive capacity. The oxide box wastes containing sulfides and cyanides were usually discarded into soils on the site or around the site (Heritage Research Center, 2007; Thiboldeaux and Nehls-Lowe, 2002).

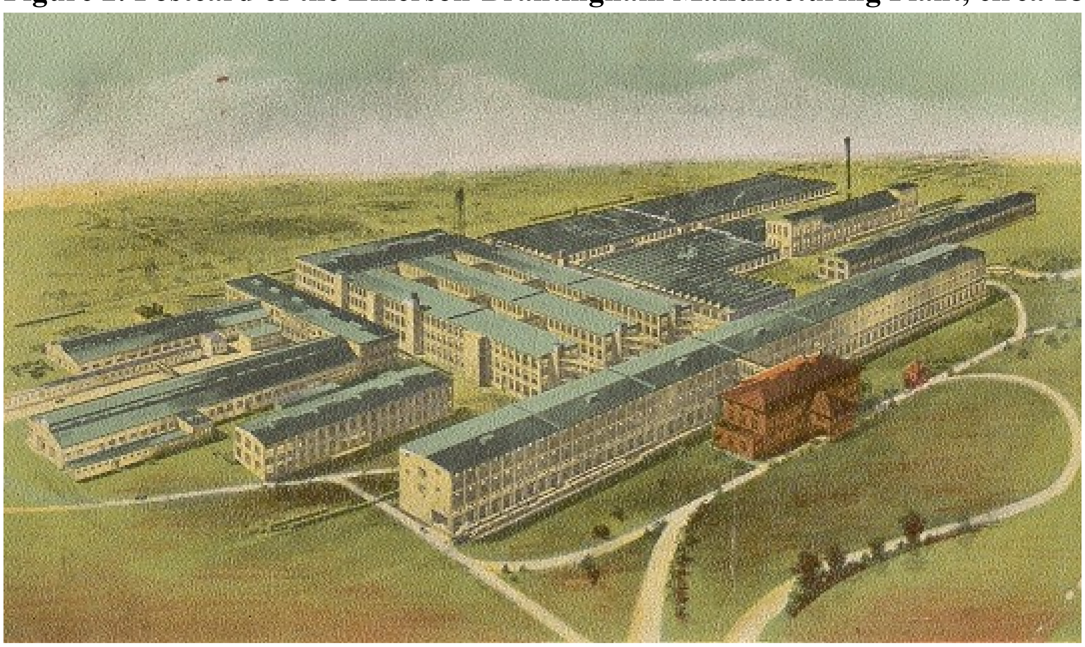
J.I. Case

J.H. Manny & Co. (over the years also known as Talcott, Emerson, and Company; Emerson Manufacturing Company; and Emerson-Brantington Implement Company; sold to J.I. Case and Company in 1928) was established in the 1850s in Rockford Illinois at a site one block south of the affected property on Berkley Street. The company initially manufactured reapers, and over the years had new investors/partners, subsequently changed names, and added products to their manufacturing line. Though they initially manufactured reapers, the company added threshers, steam engines, harvesters, and eventually tractors. At one point, the plant reportedly had 1,700 employees and encompassed a 24 building, 175 acre complex at 500 South Independence Avenue, and was the largest modern agricultural implement machinery facility in the world. It is not known whether or not the affected properties were ever part of the 175 acres, but it is possible. The complex contained a number of different operations, including a boiler house, multiple printing and painting operations, a "dipping room", heat treating, forging, polishing, grinding, and heavy manufacturing, a foundry, and a cyanide heat treating process. Contamination on the properties of interest could have been landfilled there by the farm implement plant or by one of the manufactured gas plants in the area (Emerson-Brantingham, 2012). Figure 1 shows the orientation of the affected properties to the footprint of this property.

Figure 1. Berkley Street Properties and their distance from the former J.I . Case Facility

Source: http://education.nationalgeographic.com/mapping/interactive-map/?ar_a=1

Figure 2. Postcard of the Emerson-Brantingham Manufacturing Plant, circa 1895



Source: http://emersonbrantingham.com

Summary of Previous Investigations

The Berkley Street properties are located in the southwestern part of the city of Rockford, Illinois. The known area of impact includes two property parcels that comprise 2.5 acres of land. Five sampling events have occurred in the area since 1999 (Table 1), in addition to the initial discovery of discolored material.

Table 1. List of historical sampling investigations for the Berkley Street site

Date	Type of Sample	Number of samples	Agency
May 1999	Soil-pH	Not specified	City of Rockford
May 2000	Soil-Metals	12	IEPA
June 2010	Soil (surface); basement wall scraping	4	IEPA
September 2010	Soil borings	6	IEPA
April 2011	Soil borings	8	USEPA
November 2011	Soil borings	37	USEPA

USEPA: *United States Environmental Protection Agency*
IEPA: *Illinois Environmental Protection Agency*

While excavating a water line in 1999, the City of Rockford encountered blue colored soil along Berkley Street. Initial soil sampling indicated a pH of 2.93. In May 2000, IEPA collected 12 soil borings from vacant property northeast of where the tainted soil was observed, and submitted four samples for lab analysis. These samples did not reveal evidence of contamination (IEPA, 2010b).

In June 2010, residents contacted IEPA with complaints that a blue material was infiltrating foundational cracks and a sump in two homes along Berkley Street. IEPA collected three surface soil samples and a scraping of the material inside one of the basements. The samples were analyzed the data for inorganic pollutants, including heavy metals, cyanide, and an abbreviated list of organic compounds, but did not include polycyclic aromatic hydrocarbons (PAHs). Due to elevated metals and pH, the material from the basement was determined to be a dermal and ingestion hazard for the young child known to visit the home daily including the basement. Six additional samples collected from 14 soil borings were collected by IEPA in September 2010 and confirmed contamination in the yards of the two residences sampled in June 2010, prompting IEPA to contact USEPA to request an emergency removal action in November 2010 (IEPA, 2010b).

In April 2011 USEPA conducted a site assessment which included the collection of twelve soil borings from which two surface and seven subsurface soil samples were collected. Also, 48 additional geoprobe samples were collected to assess extent of contamination, from which 37 samples were collected for lab analysis in November 2011. These sampling efforts confirmed IEPA findings of elevated organic and inorganic pollutants and provided justification for a removal action, which took place in the winter of 2011-2012 (USEPA, 2011a).

Demographics

The affected residences are in the 61102 area code of the city of Rockford, Illinois. The neighborhood is a densely populated urban neighborhood of predominantly single family homes. In zip code 61102, there are approximately 20,500 residents where most were reported as predominantly white (38.3%), black (33.9%), and other mixed races (27.8%). Twenty-five percent of the population identified themselves as Hispanic (Census, 2012).

Community Health Concerns

No specific health concerns were reported to IDPH or ATSDR, but one of the residents was concerned about her granddaughter playing with the "blue rocks" in the basement. Mostly, the residents seemed concerned about identifying the material and whether or not it had the potential to cause health effects, but did not report experiencing any health effects related to their exposure.

Environmental Data

ATSDR reviewed data collected by IEPA and USEPA. IEPA collected surface and subsurface soil samples in June and September 2010. The samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs,) and inorganic pollutants. Although approximately 97% of ferric ferrocyanide wastes from MGPs are insoluble in water, the remaining 3% is present as other forms of cyanides and cyanide salts, which may escape into air as hydrogen cyanide (Thiboldeaux and Nehls-Lowe, 2002). No air sampling was conducted in the basement where a surface scraping sample was collected in June 2010, so it is unknown whether or not hydrogen cyanide was present. USEPA collected soil samples in April and November 2011 to characterize the extent of contamination on the properties and surrounding lots, and the removal action was completed in early 2012. General details about each sampling effort are summarized below.

<u>IEPA Sampling</u>

- *June 2010 surface soil sampling*
  Four samples were collected and analyzed for VOCs and metals. Three of these (samples X101, X102, and X103) were surface soil samples and one (X301) was a scraping of the interior wall of the basement where dried blue staining was visible. Samples were not analyzed for semi-volatile organic compounds such as PAHs (IEPA, 2010a).

- *September 2010 subsurface soil sampling*
  Fourteen soil borings were collected around the affected homes (0-12 feet below ground surface (bgs)) from which to assess visual contamination. Six subsurface soil samples were collected at various depths (1-6.5 ft bgs) from borings with the most evidence of blue soil staining for full lab analysis. The samples were analyzed for semi-volatile organic compounds and inorganic pollutants (heavy metals and cyanide). Eight of the borings had a defined layer of blue tinged soil observed from 2 to 8 feet bgs, and five (X101-X105) had an acidic pH (2.1-3.9). Sample X106, intended as a background

sample, was collected some distance from the affected houses on the southeast corner of the block (IEPA, 2010b).

USEPA Sampling

- *April 2011 Sampling*

  Twelve soil borings were collected to determine if there is consistency to the depth of subsurface contamination. From these borings, it appears that the contamination is consistently observed on the lots of the two affected houses between 2 and 7 feet bgs. A temporary well was installed in one of the borings to collect a groundwater sample and determine if there were impacts to groundwater from materials leaching from contaminated soil. In this area, the groundwater table is fairly shallow and groundwater was consistently encountered between 8 and 11 feet bgs during sample collection. From the soil borings, USEPA collected six subsurface soil samples, one duplicate sample, and two surface soil samples and analyzed them for semi-volatile organic compounds and inorganic pollutants (USEPA, 2011a).

- *November 2011 Sampling*

  A geoprobe was used to collect core samples at 48 locations from the properties of the affected homes at various depths of 0-6 feet. The observations of the core showed a clean clay material in the first 2.5 feet and then a stained layer of ash, metallic deposits, dark blue stained soil and coke and coal from 2.5 feet to around 5.5 feet beneath the surface. The samples that were stained or exhibited an elevated metals reading via X-ray Fluorescence (XRF) were sent to the lab and analyzed for metals, cyanide, and SVOCs (USEPA, 2011b). In total 37 samples were sent for analysis.

Contaminants of Potential Concern (COPCs)

Pollutants consistently exceeding health based comparison values in surface and subsurface soils in the affected properties include a number of Polycyclic Aromatic Hydrocarbons (PAHs), arsenic, and cyanide. These COPCs include:

- *PAHs:* Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene,
- *Metals:* Arsenic
- *Cyanide*

Although chromium was detected in all samples, it was not speciated; therefore, the valence state is not known. Trivalent chromium (Cr-III) is relatively harmless and is ubiquitous in soil and air, while hexavalent chromium (Cr-VI) has higher toxicity and is a carcinogen. Cr-VI degrades to Cr-III in the environment. Given the acidic nature of the leachate, most of the chromium is likely to be Cr-III (USEPA, 1994). None of the results exceeded Cr-III comparison values. A summary table of the distribution of these data and their health based comparison values used in this assessment are included in Table 2.

Table 2. Summary of data exceeding health based comparison values

Pollutant	Range of Detection (ppm)	Health based comparison values (CVs)	Number of samples exceeding CVs
PAHs			
Benzo(a)anthracene	ND-52.0	USEPA Residential Soil RSL (ppm): 0.15	43/50
Benzo(a)pyrene	ND-43.0	ATSDR CREG (ppm): 0.1 USEPA Residential Soil RSL (ppm): 0.015	44/50
Benzo(b)fluoranthene	ND-73.0	USEPA Residential Soil RSL (ppm): 0.15	46/50
Benzo(k)fluoranthene	ND-42.0	USEPA Residential Soil RSL (ppm): 1.5	32/50
Dibenz(a,h)anthracene	ND-7.9	USEPA Residential Soil RSL (ppm): 0.015	33/50
Indeno(1,2,3-cd)pyrene	ND-20.0	USEPA Residential Soil RSL (ppm): 0.15	37/50
Metals			
Arsenic	3.3-114.0	ATSDR cEMEG (ppm): 20 (child); 200 (adult) ATSDR CREG (ppm): 0.5; USEPA Residential Soil RSL (ppm): 0.39	51/55
Cadmium	ND-11.6	ATSDR cEMEG (ppm): 5 (child); 70 (adult)	2/47
Cyanide	ND-29,500.0	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) USEPA Residential Soil RSL (ppm): 1600	6/55

ND: *not detected*
USEPA: *United States Environmental Protection Agency*
IEPA: *Illinois Environmental Protection Agency*
Regional Screening Level (RSL): *RSLs are integrated screening levels that incorporate cancer risk from inhalation, ingestion, and dermal exposures yielding a cancer risk of one case of cancer in one million exposed people over a lifetime or a non cancer risk not exceeding a hazard quotient of 1.*
Cancer Risk Evaluation Guide (CREG): *A concentration of a carcinogen in a media (water, soil, or air) at which excess cancer risk is not likely to exceed one case of cancer in one million people exposed over a lifetime.*
Environmental Media Contamination Guide (EMEG): *cEMEGs represent concentrations of substances in water, soil, and air to which humans may be exposed for over a year without experiencing adverse health effects.*
Reference Dose Media Evaluation Guide (RMEG): *RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed to for a lifetime without experiencing adverse health effects.*

ATSDR Evaluation of Environmental Data

ATSDR used health-based guidelines and a review of scientific studies to identify and evaluate compounds of concern in the Health Implications section of this document. In our evaluation, the soil sampling results were compared to ATSDR Cancer Risk Evaluation Guides (CREG), chronic environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and Regional Screening Levels (RSLs). CREGs are concentrations of a carcinogen in a media (water, soil, or air) at which excess cancer risk is not likely to exceed one case of cancer in one million people exposed over a lifetime. EMEGs are calculated from ATSDR minimal risk levels (MRLs) for chronic or intermediate exposures (those occurring longer than 365 days or from between 14-365 days, respectively), as well as acute time frames (14 days of exposure or less). RMEGs are calculated from USEPA's reference doses (RfDs). Like EMEGs, RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed without experiencing adverse health effects. RfDs consider lifetime exposures; therefore, RMEGs apply to chronic exposures. Both MRLs and RfDs are estimates of daily human exposure to a hazardous substance that are unlikely to cause health effects over a specified duration of exposure. MRLs and RfDs are calculated using lowest observed adverse effect levels (LOAELs) and no observed adverse effect levels (NOAELs) identified in the scientific literature. The LOAEL is the lowest exposure in a study that resulted in a measurable health effect. A NOAEL is the highest exposure in a study that ***did not*** result in a measurable health effect. ATSDR also evaluates occupational and epidemiologic studies of human exposures. USEPA Regional Screening Levels (RSLs) are available for multiple exposure pathways and for chemicals with both carcinogenic and noncarcinogenic effects. The RSLs used in this analysis correspond to either a one excess risk of cancer per million exposed people (10^{-6}) risk level for carcinogens or a Hazard Quotient (HQ) of 1 for non-carcinogens (USEPA, 2012).

Polycyclic Aromatic Hydrocarbons (PAHs)

In the four sampling investigations detailed previously, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene exceeded health based screening values. All of these compounds are classified as PAHs.

About PAHs

PAHs are a group of chemicals naturally found in coal, coal tars, oil, wood, tobacco and other organic materials, and they can be released into the environment through the incomplete burning of those materials. PAHs are also formed during some methods of food preparation, such as charbroiling, grilling, roasting, frying, or baking. The primary sources of exposure to PAHs for most of the U.S. population are inhalation of the compounds in tobacco smoke, wood smoke, and ambient air, and consumption of PAHs in foods. While there are several hundred different PAHs, they are usually present in the environment as mixtures, and are generally not used commercially. Most PAHs do not readily dissolve in water and do not readily volatilize. They adsorb (bind) onto soil and sediment. (ATSDR, 1995; ATSDR, 2011). Therefore, the major pathway of exposure to site contamination of PAHs for affected residents on Berkley Street is by ingestion and dermal exposure with contaminated soil.

Health effects of PAH exposure

Health effects experienced from exposure to PAHs depend on the magnitude, duration, and route of exposure as well as the chemical properties of the PAH mixture. Most of our understanding of how PAHs can affect health is based on toxicological studies on animals. It is not clear whether PAHs cause short-term health effects. Other chemicals commonly found with PAHs may be the cause of short-term symptoms noted in research studies such as eye irritation, nausea, vomiting, diarrhea and confusion noted in occupational studies, but skin irritation and sensitization has been well documented in studies of anthracene and benzo(a)pyrene (ATSDR, 1995).

Long-term or chronic health effects are better documented in humans, but there are far more animal studies available for evaluating chronic toxicity. Possible long-term health effects caused by exposure to PAHs may include cancer, decreased immune function, cataracts, and kidney and liver damage. Repeated dermal contact can result in sensitivity to PAHs leading to redness and inflammation upon contact. Animals studies have shown that mice exposed to PAHs in utero may develop birth defects and decreased birth weight. Occupational studies of workers exposed to high levels of PAHs have demonstrated that inhalation or dermal exposure can result in lung and skin cancer. Most studies of health effects from oral exposures to PAHs demonstrated adverse impacts to most biological systems (respiratory, cardiovascular, gastrointestinal, etc.) and cancer but only at very high concentrations for mice and rats dosed orally by gavage (ATSDR, 1995).

PAH exposure on Berkley Street

The single sample collected as a wall scraping in 2010 was not analyzed for PAHs, so it is unknown whether or not the material seeping into the home represented a health hazard from PAH exposure. The highest concentrations of PAHs were identified in subsurface soil around the affected properties, however levels slightly exceeding ATSDR and USEPA comparison values were also detected at the surface. The levels of PAHs detected in soil around Berkley Street are within a range identified to cause sensitization and skin cancer if a person was chronically exposure to similar levels (however, most existing studies were for animals exposed once a day for two or more days a week over months). The removal of visible contamination and repair/sealing of the basement foundations provide a health protective remedy for indoor exposure to PAHs. Given the level of PAHs in subsurface soil, homeowners are advised to create a raised bed garden if they are growing fruits and vegetables for consumption, and to always wear protective clothing when gardening in their yards.

Cancer risk on Berkley Street from soil contamination

Although no studies were located regarding cancer in humans following inhalation exposure to any specific PAHs, epidemiologic studies have shown increased mortality due to lung cancer in humans exposed to coke oven emissions, roofing-tar emissions, and cigarette smoke (ATSDR, 1995) which can contain significant levels of PAHs. There are no studies associating PAHs with cancer from ingestion exposure in humans, but some evidence that PAHs can cause skin cancer. Most studies demonstrating skin cancer effects are animal studies of rats and mice where a highly concentrated single PAH was applied directly to skin for months.

Excess cancer risk can be calculated using measured soil concentrations and a screening level based on 10^{-6} cancer risk (the risk of 1 excess cancer per one million people exposed to the same level of contamination). USEPA's Regional Screening Levels (RSLs) for cancer are the most conservative health-based screening levels for the PAHs measured in this investigation. The generic RSLs are integrated screening levels that incorporate cancer risk from inhalation, ingestion, and dermal exposures. Since all pathways are included in the PAH RSLs, cancer risk can be calculated using site-specific pollutant measurements. USEPA Risk Assessment Guidance suggests that an exposure point concentration (EPC) be used that is believed to be representative of typical site concentrations to evaluate risk. The most commonly used EPC is the 95% upper confidence limit (UCL95), which is the 95^{th} percent confidence limit of the average concentration calculated for each pollutant at the site (USEPA, 2007a).

USEPA developed a software package to calculate the UCL95 called ProUCL®. In this assessment, ProUCL® version 4.0 was used to identify the UCL95 for the various PAHs, from which a total estimated cancer risk can be calculated. The UCL95 as estimated by ProUCL® for the various detected PAHs are listed in Table 3 (USEPA, 2007a).

Table 3. Exposure Point Concentration (EPC) Estimates for Elevated PAHs

Pollutant	Recommended UCL95 (ppm)
Benzo(a)anthracene	14.0
Benzo(a)pyrene	12.4
Benzo(b)fluoranthene	18.9
Benzo(g,h,i)perylene	7.1
Benzo(k)fluoranthene	10.4
Dibenz(a,h)anthracene	2.2
Indeno(1,2,3-cd)pyrene	6.4

UCL95: *the 95th percent confidence limit of the average concentration calculated for each pollutant at the site*

Using the UCL95 and the multi-pathway cancer RSLs, the contaminant-specific cancer rate can be calculated with the following equation:

$$CR_{PAH} = (UCL95 \div RSL\ ) x\ 10^{-6}$$

Where:

CR_{PAH}	=	*Cancer risk for the individual PAH*
UCL95	=	*The 95% upper confidence limit of the mean in ppb*
RSL	=	*The multi-pathway regional screening level for cancer for each individual PAH*
10^{-6}	=	*Mathematical adjustment since the RSL is based on 10^{-6} cancer risk*

Using this equation, individual and cumulative cancer risk based on these assumptions is shown in Table 4.

Table 4. Estimated Individual and Cumulative Cancer Risk for Elevated PAHs (ppm)

Pollutant	UCL95	RSL	Excess Cancer Risk
Benzo(a)anthracene	14.0	0.15	$9.3x10^{-5}$
Benzo(a)pyrene	12.4	0.015	$8.3x10^{-4}$
Benzo(b)fluoranthene	18.9	0.15	$1.3x10^{-4}$
Benzo(k)fluoranthene	7.1	1.50	$6.9x10^{-6}$
Dibenz(a,h)anthracene	10.4	0.015	$1.4x10^{-4}$
Indeno(1,2,3-cd)pyrene	2.2	0.15	$4.3x10^{-5}$
Total excess cancer risk			**$1.2x10^{-3}$**

****Risk from benzo(g,h,i)perylene could not be computed because it has no screening levels***
PAHs: *polycyclic aromatic hydrocarbons*
Regional Screening Level (RSL): *RSLs are integrated screening levels that incorporate cancer risk from inhalation, ingestion, and dermal exposures yielding a cancer risk of one case of cancer in one million exposed people over a lifetime or a non cancer risk not exceeding a hazard quotient of 1.*
UCL95: *the 95th percent confidence limit of the average concentration calculated for each pollutant at the site*

To give the excess cancer risk estimation context, it should be noted that the lifetime risk of being diagnosed with cancer in the United States between 2007 and 2009 was 45 per 100 individuals for males, and 38 per 100 for females; the lifetime risk of being diagnosed with any of common types of cancer can be as high as 16 in 100 (1.6×10^{-2}) people for prostate cancer in men or 12 in 100 (1.2×10^{-2}) people for breast cancer in women (ATSDR, 2011; SEER, 2005). Typically, health guideline CVs developed for carcinogens are based on the risk of one excess cancer case per 1,000,000 (10^{-6}) individuals exposed to the same contaminant level. Cancer risks can be compared to the EPA target cancer risk range of 1×10^{-6} (low-end) to 1×10^{-4} (high-end) or 1 excess cancer case per million exposed individuals to 1 excess cancer cases per 10,000 exposed individuals. The estimated cancer risk for continuous lifetime exposure to the concentrations of PAHs found in surface and subsurface soil on Berkley Street is 1.2×10^{-3}, or 1.2 excess cancer cases per thousand exposed individuals. This cumulative risk from PAHs exceeds the USEPA target risk range of 10^{-4} to 10^{-6} excess cancer risk.

Arsenic

In the four sampling investigations detailed previously, arsenic consistently exceeded cancer-based screening levels and the chronic Environmental Media Evaluation Guide (EMEG) for child exposures. No arsenic measurements exceeded chronic health based comparison values for adults. The highest value of arsenic detected in surface soil was 64.1 ppm in an unpreserved sample. The highest concentration in any sample was 114 ppm at a depth of 4-5 ft bgs. The highest concentration of arsenic measured by USEPA was 25 ppm at any depth. Typical background levels of arsenic in Winnebago County, Illinois range between 3.1-26.9 ppm (USGS, 2002). Data collected by USEPA were within range of data collected by USGS in areas believed to represent background Winnebago County.

About Arsenic

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. Elemental arsenic (sometimes referred to as metallic arsenic) is a steel grey solid material. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic (ATSDR, 2007).

Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. When these ores are heated for industrial purposes, arsenic can be released. Arsenic is also used in wood preservation (but not for residential structures) and has historically been used in pesticides (though using inorganic arsenic is now banned for this purpose). The concentration of arsenic in soil varies widely, generally ranging from about 1 to 40 parts of arsenic to a million parts of soil (ppm) with an average level of 3–4 ppm. However, soils in the vicinity of arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenical pesticides had been applied in the past may contain much higher levels of arsenic (ATSDR, 2007).

Health effects of Arsenic exposure

Studies reporting health effects from arsenic exposure are not of residents exposed to dust and inadvertently swallowing contaminated soil, but to humans and animals swallowing high levels of arsenic. No studies of intermittent incidental ingestion were identified in the scientific literature for comparison to Berkley Street data.

Inorganic arsenic has been recognized as a human poison since ancient times, and very high doses can result in death. Ingestion of large amounts of arsenic in water can cause irritation of the stomach and intestines, with symptoms such as abdominal pain, nausea, vomiting, and diarrhea. Other adverse effects include decreased production of red and white blood cells, which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needles" sensation in the hands and feet (ATSDR, 2007).

Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, and are often associated with changes in the blood vessels of the skin. Skin cancer may also develop. Swallowing arsenic in high concentrations has also been reported to increase the risk of cancer in the liver, bladder, and lungs.

Arsenic exposure on Berkley Street

Arsenic surface soil levels in the impacted area ranged from 3.3 ppm to 114 ppm. All values exceeded the ATSDR cancer risk evaluation guide of 0.5 ppm and the USEPA RSL of 0.39 ppm. Furthermore, nine observations of the 55 total samples analyzed for heavy metals exceeded the chronic EMEG for children (20 ppm), but not for adults (200 ppm).

As with PAHs, a cancer risk can be calculated using the UCL95 and the USEPA multi-pathway cancer RSL of 0.39 ppm. Using ProUCL®, the calculated UCL95 for arsenic is 16.82 ppm, yielding a lifetime excess cancer risk of $4.3x10^{-5}$, or 4.3 possible excess cancers per 100,000 people. The risk from arsenic is within the USEPA target risk range of 10^{-4} to 10^{-6} excess cancer risk, but adds to the overall cancer risk posed by PAH exposure.

Cyanide

Cyanide was detected above the child Reference Dose Media Evaluation Guide (RMEG) in six of 55 samples collected in 2010 and 2011. The maximum detection was 29,500 parts per million (ppm) at a depth of 2-3 feet bgs. Neither the surface soil samples nor the basement wall scraping sample contained cyanide above health based screening levels. Two of the 45 samples collected by USEPA exceeded the child RMEG in subsurface soil at 2,100 ppm (at a depth to 2 ft bgs) and 3,500 ppm (3-4 ft bgs) but not at the surface.

About Cyanide

Cyanides can occur naturally or be man-made. Hydrogen cyanide (HCN), which is a gas, and the simple cyanide salts (sodium cyanide and potassium cyanide) are common examples of cyanide compounds. Certain bacteria, fungi, and algae can produce cyanide, and cyanide is found in a number of foods and plants. In certain plant foods, including almonds, millet sprouts, lima beans, soy, spinach, bamboo shoots, and cassava roots (which are a major source of food in tropical countries), cyanides occur naturally as part of sugars or other naturally-occurring compounds. However, the edible parts of plants that are eaten in the United States contain relatively low amounts of cyanide (ATSDR, 2006).

Many of the cyanides in soil and water come from industrial processes. The major sources of cyanides in water are discharges from some metal mining processes, organic chemical industries, iron and steel plants or manufacturers, and publicly owned wastewater treatment facilities. Other cyanide sources include cigarette and wood smoke, vehicle exhaust, releases from certain chemical industries, burning of municipal waste, and use of cyanide-containing pesticides (ATSDR, 2006). Cyanide can be found in air (generally at concentrations less than 0.2 ppm), drinking water (ranges from 0.001 to 0.011 ppm in the United States), and in soil. In 77 of 124 hazardous waste sites in the United States, the median cyanide concentration in subsoil samples was 0.8 ppm. In the same study, topsoil samples taken from 51 of 91 had median cyanide concentrations of 0.4 ppm. In the soils of former manufactured gas plant sites, the concentrations of cyanide compounds in the United States are generally below 2,000 ppm (ATSDR, 2006).

Health effects of cyanide exposure

The severity of the harmful effects from cyanide exposure depends in part on the form of cyanide, such as hydrogen cyanide gas or cyanide salts. Exposure to high levels of cyanide for a short time causes adverse neurological and cardiopulmonary effects and can result in coma or death. Some of the first indications of cyanide poisoning are rapid, deep breathing and shortness of breath, followed by convulsions, and loss of consciousness. Symptoms are similar, regardless of the route of exposure (ingestion, inhalation, or dermal contact) though cyanide uptake into the body through the skin is slower than these other types of exposure. Dermal contact with hydrogen cyanide or cyanide salts can irritate the skin and produce sores (ATSDR, 2006).

Cyanide exposure on Berkley Street

Intermittent residential exposures to the concentrations of cyanide found in surface soil or in the basement wall scraping are much lower than those that cause serious health effects. As mentioned previously, the maximum detection was 29,500 parts per million (ppm) at a depth of 2-3 feet bgs, indicating that the majority of waste material is present in the subsurface. In surface soils and in the basement, cyanide was detected at concentrations that are not harmful. However, harmful exposures could occur if the parcel were redeveloped, if construction occurred onsite, or if there was excavation of soils for other purposes, like gardening. Residents are advised to wear a protective layer of clothing on parts of their bodies contacting soil while gardening, and to take caution if disturbing the soil for any other purpose (homes additions, etc.).

Although it is unlikely that regular contact will be made with contaminated soil, an exposure dose can be calculated to compare with ATSDR's cyanide MRL. Using the UCL95 calculated by ProUCL® of 8,563 ppm cyanide, the following equation can be used to calculate a dose for a child between 6 and 11 years of age (the age of the child that visits one of the homes) and adults living in the homes:

$$\text{Exposure dose (mg/kg/day)} = \frac{C \times IR \times EF}{BW}$$

Where:
C = Cyanide UCL95 (ppm)
IR = the ingestion rate (200 mg soil/day for the child; 100 mg/day for adults)
EF = exposure factor representing the site-specific scenario; (to be conservative for screening purposes it was assumed that residents are exposed every day for a lifetime, so the EF=1)
BW = Body weight of the child or adult (assumed to be about 70 lbs for the 7-year old child and about 176 lbs for the adults in the homes)

With an assumption for constant exposure to subsurface cyanide levels that yields a very conservative dose estimate, the estimated dose for a 7 year old child (0.05 mg/kg-day) and an adult (0.01 mg/kg-day) do not exceed the ATSDR chronic MRL for cyanide of 0.05 mg/kg-day. Since MRLs are doses not expected to result in adverse health effects, cyanide was not found above health based comparison values in the surface soil or in the basement wall scraping, and exposure assumptions were very conservative (i.e., continuous exposure for a lifetime), it is unlikely that children or adults in the homes could experience adverse health effects from actual exposures to surface soil contamination. Risk would increase substantially if residents were exposed to subsurface levels of cyanide.

Exposure to acidic pH
pH is a measure of how acidic or alkaline a substance is. The pH of human skin free of soaps, lotions, and fragrance averages 4.7 (Lambers, et al., 2006). Dermal exposure to substances that have a pH that is lower than an individual's natural pH can result in skin irritation. Highly acidic soil pH (as low as 2.1) has been reported for Berkley Street soil. Prolonged dermal contact with materials with pH could result in skin irritation.

Child Health Considerations
ATSDR recognizes that in communities faced with contamination of their air, water, soil, or food, the unique vulnerabilities of infants and children demand special emphasis. Children are at greater risk than adults from certain types of exposures to hazardous substances. Their lower body weight and higher intake rate of air, food, and water results in a greater dose of hazardous substance per unit of body weight. Furthermore, the developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. ATSDR is committed to evaluating the health impact of environmental contamination on children, and uses health guidelines in its investigations that are protective of children.

Children could sustain high exposures to site contamination if they had sustained direct skin contact with contaminated subsurface soil. Children living or visiting affected properties on Berkley Street should avoid contaminated subsurface soil and should always wear protective clothing when gardening.

Conclusions

Extensive soil sampling at two homes on a contaminated block of Berkley Street in Rockford, IL indicated the presence of elevated levels of PAHs, arsenic, and cyanide in residential soil. Regular exposure to an upper bound average of each pollutant would result in an increased cancer risk over a lifetime. However, the highest levels of contamination are below ground and thus, not accessible for regular exposure USEPA has repaired the foundations of the two homes and sealed basements to prevent material in the subsurface from seeping into basements. Thus, indoor exposure is no longer likely to occur.

Past Exposure:
In the past, exposures to wastes in residential soils on Berkley Street could harm people's health. This is a past public health hazard because:

- Historical and recent environmental data indicated the presence of harmful levels of arsenic, cyanide and PAHs in subsurface samples near and leaching into the foundations of residential structures; and
- The contaminated material in the basement is acidic and can cause dermal irritation.

Current Exposure:
***Current** conditions no longer pose an indoor hazard to residents. ATSDR concludes that the actions taken by USEPA will prevent migration of hazardous contaminants into residential basements on Berkley Street and that **current** conditions do not pose a health threat because*:

- USEPA has eliminated the potential for subsurface contamination to enter affected homes; and
- Surface soil has not been demonstrated to have levels of contaminants above health based comparison values. Therefore, tracking of soil into the homes is not a significant pathway of exposure.

Future Exposure:
*ATSDR concludes that the presence of wastes in subsurface soils in residential lots on Berkley Street could harm people's health. This is a **future** public health hazard because*:

- Historical and recent environmental data indicate the presence of elevated levels of arsenic, cyanide and PAHs in subsurface samples; and
- Future development or extensive excavation or landscaping of the properties may expose contaminated subsurface soil.

Recommendations

Given our conclusions based on past, current, and future exposure scenarios, ATSDR offers the following recommendations:

1) Ensure any future property use in the area does not result in human exposures to the contaminated waste;
2) Residents should avoid dermal contact with subsurface soil, and should use gloves when gardening;
3) If growing plants for consumption, ATSDR recommends that residents create raised beds to avoid root uptake of subsurface contamination.

Report Preparation

Prepared by
Michelle Colledge, MPH, PhD
Environmental Health Scientist
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations, Central Branch, Region 5

Reviewed by
Rick Gillig, MCP
Branch Chief, Central Branch
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations, Central Branch

Mark Johnson, PhD, DABT
Regional Director
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations, Central Branch, Region 5

References:

ATSDR (Agency for Toxic Substances and Disease Registry). 2011. Health Consultation: Grant Court Housing Complex, Long Branch Manufactured Gas Plant. United States Department of Health and Human Services: Atlanta, Ga.

ATSDR (Agency for Toxic Substances and Disease Registry). 2007. Toxicological Profile for Arsenic. United States Department of Health and Human Services. http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=3

ATSDR (Agency for Toxic Substances and Disease Registry). 2006. Toxicological Profile for Cyanide. United States Department of Health and Human Services. http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=19

ATSDR (Agency for Toxic Substances and Disease Registry). 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. United States Department of Health and Human Services. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=122&tid=25

Emerson-Brantingham. 2012. History of the Emerson-Brantingham Company. http://emerson-brantingham.com. Accessed August 2012.

Heritage Research Center. 2007. Manufactured Gas Plants-a history. http://www.heritageresearch.com/ourlibrary/histories/manufactured_gas.html. Accessed February 2011.

IEPA (Illinois Environmental Protection Agency). 2010a. Raw Data Package: Sampling Inspection Report. Bureau Of Land/Field Operations Section. June 8, 2010.

IEPA (Illinois Environmental Protection Agency). 2010b. Sampling Inspection Report-Berkeley Street Sampling Data Packet. Report # 2010306299. November 29, 2010. Springfield, IL.

IEPA (Illinois Environmental Protection Agency). 2010c. Letter from Bruce Everetts (IEPA) to Mike Ribordy (USEPA) requesting a time-critical removal action. Dated November 29, 2010.

Lambers, H., Piessens, S., Bloem, A. et al. 2006. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. *Int J Cosmet Sci.* 28(5):359-370.

SEER (Surveillance Epidemiology and End Results). 2012. Lifetime Risk (Percent) of Being Diagnosed with Cancer by Site and Race/Ethnicity Both Sexes, 18 SEER Areas, 2007-2009. http://surveillance.cancer.gov/devcan/. Accessed September 4, 2012.

Thiboldeaux, R. and Nehls-Lowe, H. 2002. Issues of cyanide contamination and toxicity associated with manufactured gas plants. Wisconsin Department of Health and Family Services.

Census (United States Census Bureau). 2012. American Fact Finder Demographics, Area Code 61102, Rockford, Illinois. Accessed August 2012. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml

USEPA (United States Environmental Protection Agency). 1994. Natural Attenuation of Hexavalent Chromium in Groundwater and Soils. Office of Research and development. Publication number EPA154015-941505.

USEPA (United States Environmental Protection Agency). 2007a. User's Guide-ProUCL® Version 4.00.02. Publication number EPA/600/R-07/038. http://www.epa.gov/osp/hstl/tsc/ProUCL_v4.00.02_user.pdf. Accessed August 2012.

USEPA (United States Environmental Protection Agency). 2007b. Phase I Site Assessment: Rockford City Yards Areas A and B. Project #46581. April 6, 2007.

USEPA (United States Environmental Protection Agency). 2011a. Site Assessment Report: Berkley Street Properties Site. Document # S05-0001-1104-004. June 3, 2011.

USEPA (United States Environmental Protection Agency). 2011b. Raw Data Package: Time Critical Removal Action Extent of Contamination Sampling. Bureau of Land/Field Operations Section. Provided December 9, 2011.

USEPA (United States Environmental Protection Agency). 2012. Regional Screening Levels: User's Guide (May 2012). http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm. Accessed August 2012.

Appendix

Data

Table 1. Detected results of surface soil sample analysis for inorganics (June 8, 2010)

Analyte	Range of detection (ppm)	Comparison Value
Arsenic	9.4-**64**	CHRONIC EMEG Child: 20 ppm; Adult: 200 ppm CREG*: 0.5 ppm USEPA RSL* 0.39 ppm
Cadmium	2.9-**5.8**	CHRONIC EMEG Child: 5 ppm; Adult: 70 ppm
Cyanide	12-531	ATSDR RMEG Child: 1000; Adult: 10000

ND: *not detected*
USEPA: *United States Environmental Protection Agency*
IEPA: *Illinois Environmental Protection Agency*
RSL: *Regional Screening Level (11/2010);* ***CREG:*** *ATSDR Cancer Risk Evaluation Guide (2010)*
EMEG: *Environmental Media Evaluation Guide (ATSDR, 2010)*
** denotes cancer endpoint representing 1^x10^{-6} cancer risk*
Bolded *values exceed the health-based screening criteria*

Table 2. SVOC Results of sampling from the September 22, 2010 sampling event

Analyte	Results X101 (ppb)	Results X102 (ppb)	Results X103 (ppb)	Results X104 (ppb)	Results X105 (ppb)	Results X106 (ppb)	Comparison Value
Benzo(a)anthracene	**2.7**	0.08	0.12	**0.24**	**3.4**	ND	USEPA RSL*: 0.15 ppm
Benzo(a)pyrene	**1.3**	**0.36**	ND	**0.09**	**2.0**	ND	ATSDR CREG* 0.1 ppm USEPA RSL*: 0.015 ppm
Benzo(b)fluoranthene	**2.6**	**1.5**	**0.2**	**0.28**	**3.5**	ND	USEPA RSL*: 0.15 ppm
Benzo(ghi)perylene	0.8	0.44	ND	0.09	1.2	ND	NONE
Benzo(k)fluoranthene	**2.6**	**1.5**	0.14	0.25	**4.1**	ND	USEPA RSL*: 1.5 ppm
Dibenzo(a,h)anthracene	**0.23**	**0.15**	ND	ND	ND	ND	USEPA RSL*: 0.015 ppm
Indeno(1,2,3-cd)pyrene	**0.87**	**0.55**	0.06	0.1	**1.3**	ND	USEPA RSL*: 0.15 ppm

ND: *not detected*
USEPA: *United States Environmental Protection Agency*
IEPA: *Illinois Environmental Protection Agency*
RSL: *Regional Screening Level (11/2010);* ***CREG:*** *ATSDR Cancer Risk Evaluation Guide (2010)*
EMEG: *Environmental Media Evaluation Guide (ATSDR, 2010)* denotes cancer endpoint representing 1^x10^{-6} cancer risk*
Bolded *values exceed the health-based screening criteria*

Table 3. Results of sampling for inorganics from the September 22, 2010 sampling event

Analyte	Results X101 (ppm)	Results X102 (ppm)	Results X103 (ppm)	Results X104 (ppm)	Results X105 (ppm)	Results X106 (ppm)	Health-based comparison value
Arsenic	**39.5**	**27.3**	13.7	15.3	**114**	10.8	Chronic Child EMEG: 20 USEPA RSL 0.39 ppm
Cadmium	4.33	4.46	3.12	1.98	**11.6**	4.88	CHRONIC EMEG Child: 5 ppm
Cyanide	**29,500**	**21,400**	59.2	**17,100**	**13,500**	16.2	RMEG Child: 1,000 ppm

ND: *not detected*
USEPA: *United States Environmental Protection Agency*
IEPA: *Illinois Environmental Protection Agency*
RSL: *Regional Screening Level (11/2010);* ***CREG:*** *ATSDR Cancer Risk Evaluation Guide (2010)*
EMEG: *Environmental Media Evaluation Guide (ATSDR, 2010)*
Bolded *values exceed the health-based screening criteria*

Table 4. Results of sampling for organics and inorganics from the April 26, 2011 sampling event (ppm)

	0-2 ft	6-7 ft	1-2 ft	3-4 ft	3-4 ft	6-7 ft	surface	surface	
Analyte	**BSP-SB01**	**BSP-SB09**	**BSP-SB06**	**BSP-SB03**	**BSP-SB03**	**BSP-SB12**	**BSP-SS01**	**BSP-SS02**	**Health Based Comparison Values**
Acenaphthene	< 0.041	0.62	< 0.044	0.083	0.29	< 0.04	< 0.04	0.055	ATSDR RMEG (ppm): 3000 (child); 40000 (adult) ATSDR iEMEG pica child (ppm): 1000 USEPA Residential Soil RSL (ppm): 3400
Acenaphthylene	0.083	4.4	0.15	0.45	1.2	< 0.04	0.12	1.5	None
Anthracene	< 0.041	8.1	0.085	1.2	5.3	< 0.04	< 0.04	0.85	ATSDR RMEG (ppm): 20000 (child); 200000 (adult) ATSDR iEMEG pica child (ppm): 20000 USEPA Residential Soil RSL (ppm): 17000
Benz(a)anthracene	**0.25**	**9.9**	**0.84**	**1.5**	**6.5**	< 0.04	**0.43**	**6.9**	USEPA Residential Soil RSL (ppm): 0.15
Benzo(a)pyrene	**0.11**	**12**	**0.68**	**0.99**	**6.3**	< 0.04	**0.16**	**7**	ATSDR CREG (ppm): 0.1 USEPA Residential Soil RSL (ppm): 0.015
Benzo(b)fluoranthene	**0.29**	**7.9**	**0.61**	**0.87**	**4.3**	< 0.04	**0.53**	**7.5**	USEPA Residential Soil RSL (ppm): 0.15
Benzo(g,h,i)perylene	0.12	8.9	0.4	0.41	4.2	< 0.04	0.17	5.8	None
Benzo(k)fluoranthene	0.3	**7.2**	0.85	0.66	**4.1**	< 0.04	0.3	**7.7**	USEPA Residential Soil RSL (ppm): 1.5
Chrysene	0.38	8.8	1.1	1.3	5.9	< 0.04	0.59	8.5	USEPA Residential Soil RSL (ppm): 15
Dibenz(a,h)anthracene	**0.12**	**0.85**	**0.18**	**0.19**	**0.48**	< 0.04	**0.15**	**0.71**	USEPA Residential Soil RSL (ppm): 0.015
Fluoranthene	0.3	26	2.8	3.4	16	< 0.04	0.61	11	ATSDR RMEG (ppm): 2000 (child); 30000 (adult) ATSDR iEMEG pica child (ppm): 800 USEPA Residential Soil RSL (ppm): 2300
Fluorene	< 0.041	2.7	< 0.044	0.88	2.5	< 0.04	< 0.04	0.18	USEPA Residential Soil RSL (ppm): 2300
Indeno(1,2,3-cd)pyrene	**0.21**	**7.2**	**0.42**	**0.42**	**1.2**	< 0.04	**0.25**	**5.3**	USEPA Residential Soil RSL (ppm): 0.15
Naphthalene	0.083	0.75	0.049	0.6	1.6	< 0.04	0.082	0.34	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) ATSDR aEMEG pica child (ppm): 10 USEPA Residential Soil RSL (ppm): 3.6
Phenanthrene	0.11	28	0.61	5.9	22	< 0.04	0.13	2.5	NA
Pyrene	0.32	23	3.3	4.9	20	< 0.04	0.51	9.7	ATSDR RMEG (ppm): 2000 (child); 20000 (adult)
Aluminum	1700	**5500**	**2000**	1100	**2300**	**9600**	**5400**	**5100**	ATSDR cEMEG (ppm): 50000 (child); 700000 (adult) ATSDR iEMEG pica child (ppm): 2000 USEPA Residential Soil RSL (ppm): 77000
Antimony	< 2.4	< 2	< 2.7	< 2.7	< 2.4	< 2.9	< 2.9	< 2.4	ATSDR RMEG (ppm): 20 (child); 300 (adult) USEPA Residential Soil RSL (ppm): 31

Arsenic	**22**	**13**	**17**	**15**	**19**	**25**	**8.4**	**14**	ATSDR cEMEG (ppm): 20 (child); 200 (adult) ATSDR CREG (ppm): 0.5; ATSDR aEMEG pica child: 10 USEPA Residential Soil RSL (ppm): 0.39
Barium	81	150	230	330	200	140	140	87	ATSDR cEMEG (ppm): 10000 (child); 100000 (adult) ATSDR iEMEG pica child (ppm): 400 USEPA Residential Soil RSL (ppm): 15000
Beryllium	< 0.61	0.64	< 0.67	< 0.69	< 0.6	< 0.73	< 0.73	0.6	ATSDR cEMEG (ppm): 100 (child); 1000 (adult) USEPA Residential Soil RSL (ppm): 160
Cadmium	< 0.61	< 0.51	< 0.67	< 0.69	< 0.6	0.97	< 0.73	< 0.59	ATSDR cEMEG (ppm): 5 (child); 70 (adult) ATSDR iEMEG pica child (ppm): 1
Calcium	410	11000	11000	250	480	4600	4300	19000	Essential nutrient
Chromium	**4.3**	**13**	**6.9**	**7.3**	**7.2**	**41**	**12**	**13**	ATSDR cEMEG (ppm): 50 (child); 700 (adult) ATSDR iEMEG pica child: 10 USEPA Residential Soil RSL (ppm): 0.29
Cobalt	< 1.2	3.5	< 1.3	< 1.4	< 1.2	7.6	2.7	2.8	ATSDR iEMEG (ppm): 500 (child); 7000 (adult) ATSDR iEMEG pica child: 20 USEPA Residential Soil RSL (ppm): 23
Copper	< 3	16	16	12	13	**32**	16	**32**	ATSDR iEMEG (ppm): 500 (child); 7000 (adult) ATSDR a+iEMEG pica child: 20 USEPA Residential Soil RSL (ppm): 3100
Cyanide	**2100**	3.9	540	3.8	**3500**	< 0.4	290	710	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) USEPA Residential Soil RSL (ppm): 1600
Iron	15000	16000	31000	23000	23000	6200	14000	22000	USEPA Residential Soil RSL (ppm): 55000
Lead	51	29	120	140	72	13	50	74	USEPA residential soil screening level (ppm): 400
Magnesium	300	6400	960	190	460	1200	1800	11000	Essential nutrient
Manganese	27	250	20	28	29	23	270	390	ATSDR RMEG (ppm): 1000 (child); 20000 (adult) USEPA Residential Soil RSL (ppm): 1800
Mercury	0.098	0.053	0.057	0.025	0.15	< 0.029	0.11	0.3	USEPA Residential Soil RSL (ppm): 10 (elemental mercury)
Nickel	< 1.2	9.3	2	1.8	2.8	11	6.8	7.1	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) USEPA Residential Soil RSL (ppm): 1500 (soluable salts)
Potassium	420	870	1800	1700	2200	850	970	1800	
Selenium	< 1.2	< 1	< 1.3	< 1.4	< 1.2	5	< 1.5	< 1.2	ATSDR cEMEG (ppm): 300 (child); 4000 (adult) USEPA Residential Soil RSL (ppm): 390

Silver	< 1.2	< 1	< 1.3	< 1.4	< 1.2	< 1.5	< 1.5	< 1.2	ATSDR RMEG (ppm): 300 (child); 4000 (adult)
Sodium	75	80	160	380	330	< 88	< 87	240	Essential nutrient
Thallium	< 1.2	< 1	< 1.3	< 1.4	< 1.2	< 1.5	< 1.5	< 1.2	ATSDR RMEG (ppm): 4 (child); 60 (adult) USEPA Residential Soil RSL (ppm): 0.78 (soluable salts)
Vanadium	8.9	**20**	16	8.7	16	**65**	**20**	**25**	ATSDR iEMEG (ppm): 500 (child); 7000 (adult) ATSDR iEMEG pica child: 20 USEPA Residential Soil RSL (ppm): 390
Zinc	8.2	62	9	7.6	14	73	51	46	ATSDR iEMEG (ppm): 20000 (child); 200000 (adult) ATSDR iEMEG pica child: 600 USEPA Residential Soil RSL (ppm): 23000

ND: *not detected*
USEPA: *United States Environmental Protection Agency;* ***IEPA:*** *Illinois Environmental Protection Agency*
RSL: *Regional Screening Level (11/2010);* ***CREG:*** *ATSDR Cancer Risk Evaluation Guide (2010);* ***EMEG:*** *Environmental Media Evaluation Guide (ATSDR, 2010)*
** denotes cancer endpoint representing* $1^{x}10^{-6}$ *cancer risk***; Bolded** *values exceed the health-based screening criteria*

Table 5. Results of sampling for organics and inorganics from the November 1, 2011 sampling event

Pollutant	units	# of samples	min	max	25th percentile	50th percentile	75th percentile	95th percentile	MRLs	# samples above CVs
Acenaphthene	ppm	37	ND	0.96	ND	ND	ND	ND	ATSDR RMEG (ppm): 3000 (child); 40000 (adult) ATSDR iEMEG pica child (ppm): 1000 USEPA Residential Soil RSL (ppm): 3400	0
Acenapthylene	ppm	37	ND	4.30	0.08	0.11	0.57	2.70	None	No CV
Anthracene	ppm	37	ND	10.00	0.08	0.13	0.42	6.68	ATSDR RMEG (ppm): 20000 (child); 200000 (adult) ATSDR iEMEG pica child (ppm): 20000 USEPA Residential Soil RSL (ppm): 17000	0
Arsenic	ppm	**37**	**3.30**	**23.00**	**5.80**	**7.50**	**10.00**	**18.20**	ATSDR cEMEG (ppm): 20 (child); 200 (adult) ATSDR CREG (ppm)*: 0.5; ATSDR aEMEG pica child: 10 USEPA Residential Soil RSL (ppm): 0.39	ALL
Barium	ppm	37	38.00	300.00	97.00	110.00	140.00	192.00	ATSDR cEMEG (ppm): 10000 (child); 100000 (adult) ATSDR iEMEG pica child (ppm): 400 USEPA Residential Soil RSL (ppm): 15000	0
Benzo[a]anthracene	ppm	37	ND	**52.00**	**0.31**	**0.55**	**1.90**	**17.20**	USEPA Residential Soil RSL (ppm): 0.15	33
Benzo[a]pyrene	ppm	37	ND	**43.00**	**0.31**	**0.50**	**1.40**	**17.94**	ATSDR CREG (ppm)*: 0.1 USEPA Residential Soil RSL (ppm): 0.015	33 (33)
Benzo[b]fluoranthene	ppm	37	ND	**73.00**	**0.59**	**1.25**	**2.73**	**18.70**	USEPA Residential Soil RSL (ppm): 0.150	34
Benzo[g,h,i]perylene	ppm	37	ND	21.00	0.21	0.32	1.40	13.40	None	No CV
Benzo[k]fluoranthene	ppm	37	ND	**42.00**	0.18	0.36	1.00	**8.66**	USEPA Residential Soil RSL (ppm): 1.50	26
Cadmium	ppm	37	ND	0.47	ND	ND	ND	ND	ATSDR cEMEG (ppm): 5 (child); 70 (adult) ATSDR iEMEG pica child: 1	0
Chromium	ppm	37	**2.20**	**19.00**	**4.50**	**7.00**	**12.00**	**18.00**	ATSDR cEMEG (ppm): 50 (child); 700 (adult) ATSDR iEMEG pica child: 10 USEPA Residential Soil RSL (ppm): 0.29	ALL (14)
Chrysene	ppm	37	ND	**56.00**	0.33	0.76	2.00	**16.65**	USEPA Residential Soil RSL (ppm): 15.0	3
Cyanide, Total	ppm	37	ND	970.00	2.83	18.50	195.00	490.50	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) USEPA Residential Soil RSL (ppm): 1600	0
Dibenz[a,h]anthracene	ppm	37	ND	**7.90**	**0.10**	**0.16**	**0.36**	**4.18**	USEPA Residential Soil RSL (ppm): 0.015	24
Fluoranthene	ppm	37	ND	73.00	0.35	0.79	2.18	29.90	ATSDR RMEG (ppm): 2000 (child); 30000 (adult) ATSDR iEMEG pica child (ppm): 800 USEPA Residential Soil RSL (ppm): 2300	0
Fluorene	ppm	37	ND	3.10	0.07	0.19	1.01	2.68	USEPA Residential Soil RSL (ppb): 2300	0

Indeno[1,2,3cd]pyrene	ppm	37	ND	**20.00**	**0.20**	**0.31**	**1.18**	**10.34**	USEPA Residential Soil RSL (ppm): 0.15	27
Iron	ppm	37	3200.00	23000.00	7900.00	9500.00	12000.00	15400.00	USEPA Residential Soil RSL (ppm): 55000	0
Lead	ppm	37	3.10	230.00	15.00	24.00	46.00	64.00	USEPA residential soil screening level (ppm): 400	0
Mercury	ppm	37	ND	**2.10**	0.06	0.09	0.16	0.45	USEPA Residential Soil RSL (ppm): 10 (elemental mercury)	0
Naphthalene	ppm	37	ND	**3.60**	0.08	0.19	0.45	3.22	ATSDR RMEG (ppm): 1000 (child); 10000 (adult) ATSDR aEMEG pica child: 10 USEPA Residential Soil RSL (ppm): 3.6	1
pH		37	2.10	8.01	4.22	6.00	7.34	7.88	None	No CV
Phenanthrene	ppm	37	ND	37.00	0.16	0.25	0.69	21.00	None	No CV
Pyrene	ppm	37	ND	69.00	0.01	0.08	0.09	12.45	ATSDR RMEG (ppm): 2000 (child); 20000 (adult)	0
Selenium	ppm	37	ND	9.10					ATSDR cEMEG (ppm): 300 (child); 4000 (adult) USEPA Residential Soil RSL (ppm): 390	0
Silver	ppm	37	ND	0.49					ATSDR RMEG (ppm): 300 (child); 4000 (adult)	0

ND: *not detected*
USEPA: *United States Environmental Protection Agency;* ***IEPA:*** *Illinois Environmental Protection Agency*
RSL: *Regional Screening Level (11/2010);* ***CREG:*** *ATSDR Cancer Risk Evaluation Guide (2010);* ***EMEG:*** *Environmental Media Evaluation Guide (ATSDR, 2010)*
** denotes cancer endpoint representing* $1^{x}10^{-6}$ *cancer risk****; Bolded*** *values exceed the health-based screening criteria*