Assessment of Environmental Sampling Results for Public Health Implications

Simmons-Rand Property
Richlands, Virginia

Public Health Assessment

January 10, 2014

Virginia Department of Health
Division of Environmental Epidemiology
109 Governor Street
Richmond, Virginia 23219

FOREWORD

The Virginia Department of Health's (VDH) Division of Environmental Epidemiology prepared this Public Health Assessment. The purpose of a Public Health Assessment is to identify and prevent health hazards resulting from exposure to harmful contamination in the environment. Health effects associated with specific chemicals are evaluated based on available sampling data and how the community is exposed. VDH determines if exposures have occurred or could potentially occur in the future, describes any potential health effects that could result from exposure, and makes recommendations to protect the health of the community. The following health assessment addresses conditions at the site during the time the report was prepared.

For additional information or questions regarding the content of this health assessment, please contact the Division of Environmental Epidemiology by calling (804) 864-8182 or in writing.

Office of Epidemiology
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LIST OF ABBREVIATIONS

ACCLP	Advisory Committee on Childhood Lead Poisoning Prevention
ATSDR	Agency for Toxic Substances and Disease Registry
B[a]P	benzo[a]pyrene
CDC	Centers for Disease Control and Prevention
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
CV	Comparison Value
DEQ	Department of Environmental Quality
DHHS	Department of Health and Human Services
EMEG	Environmental Media Evaluation Guide
EPA	Environmental Protection Agency
g/kg	Grams per kilogram
IARC	International Agency for Research on Cancer
IEUBK	Integrated Exposure Uptake Biokinetic
IUR	Inhalation Unit Risk
mg/kg	Milligram per kilogram
MM&A	Marshall Miller and Associates
MRL	Minimal Risk Level
PAH	Polycyclic Aromatic Hydrocarbon
ppm	Parts per million
RBC	Risk Based Concentration
RfC	Reference Concentration
RfD	Reference Dose
RMEG	Reference dose Media Evaluation Guide
RSL	Regional Screening Levels
SVOC	Semi Volatile Organic Compound
TCE	Trichloroethylene
TEF	Toxicity Equivalency Factor
µg/L	Microgram per Liter
UST	Underground Storage Tank
VC	Vinyl chloride
VDH	Virginia Department of Health
VOC	Volatile Organic Compound
VRP	Voluntary Remediation Program

SUMMARY

INTRODUCTION	In late 2011, the Cumberland Plateau Health District Director asked the Virginia Department of Health (VDH) to evaluate the levels of contaminants present at the former Simmons-Rand property, evaluate exposure pathways, and determine any public health implications. Simmons-Rand is located at Iron Street in Richlands, Virginia 24641, and covers 3.26 acres. This document includes an evaluation and discussion of the available environmental data provided by the environmental contractor, Arcadis. The property was owned by various businesses from 1930 to 1992. Industrial operations started on this site in 1945 and changed ownership from time to time. Various operations such as battery conditioning, electric motor rewinding, reconditioning, servicing of mine equipment and the production of battery mine scoops were conducted on site from 1955 to 1992. The site is evaluated as four separate tracts of land with the major area of contamination on Tract 2, which is a fenced area with no public access. The soil, sediment and surface water on Tracks 3 and 4 are contaminated with metals, volatile organic compounds, and polycyclic aromatic hydrocarbons. Tracks 3 and 4 are adjacent to residential properties along Jewell Street. During a community meeting in 2012, residents living on Jewell Street expressed concern about the number of individuals diagnosed with cancer living on their street. They are concerned about the drainage system that runs adjacent to their backyard. Residents are also concerned that when the Clinch River floods, it brings contaminants onto their property and into their homes.
Conclusion 1	VDH concludes that contaminants in soil identified on Tracts 1 and 2 are not expected to harm people's health.
Basis For Decision	Tract 1 is covered with an asphalt parking lot. Access to Tract 2 is restricted.
Conclusion 2	VDH concludes that contaminants in the groundwater on site are not expected to harm people's health.
Basis For Decision	Groundwater is not used as potable or non-potable water.
Conclusion 3	VDH concludes that incidental ingestion and dermal contact to soil, on Tracts 3 and 4, poses a public health hazard.
Basis For Decision	Elevated levels of lead were found in the soil on Tracts 3 and 4. The Centers for Disease Control and Prevention has indicated that there is no safe blood lead level. Exposure to soil on Tracts 3 and 4 may result in elevated levels of lead in the blood. The main target for lead toxicity is the nervous system. Children may be more sensitive to the toxic effects of lead.
Conclusion 4	VDH concludes that 0-12 inch soil sampling depths do not adequately

	characterize the public's exposure to soil.
Basis For Decision	The Agency for Toxic Substances and Disease Registry recommends sampling depths up to 3 inches for assessing the public's exposure to contaminants in soil.
Conclusion 5	VDH concludes that additional groundwater monitoring wells are needed to identify if volatile organic compounds are migrating off site and onto residential property on Jewell Street.
Basis For Decision	Volatile organic compounds, which are unrelated to the underground petroleum storage tank(s), have been identified in groundwater below Tract 2 and in the surface water along Tracts 3 and 4 where a drain pipe from below Tract 2 empties. The groundwater flow is characterized as moving towards homes adjacent to Tracts 3 and 4. Volatile organic compounds have been identified in the surface water samples taken from Tracts 3 and 4.
Next Steps	VDH will review additional sampling data once available. VDH will present findings of this assessment to the community and will be available to answer any questions.

PURPOSE

In December 2011, the Cumberland Plateau Health District Director requested the Virginia Department of Health (VDH) to review chemical concentrations in environmental samples collected from the former Simmons-Rand property and determine if soil contamination presents a health hazard to the community. A public health assessment serves to identify concentrations of substances in soil, groundwater, surface water, or biota that may pose a health hazard to people who come in contact with the contaminants. Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), VDH has completed an evaluation of the available environmental data provided by the Virginia Department of Environmental Quality (DEQ) for the Simmons-Rand site.

BACKGROUND

Site description and history

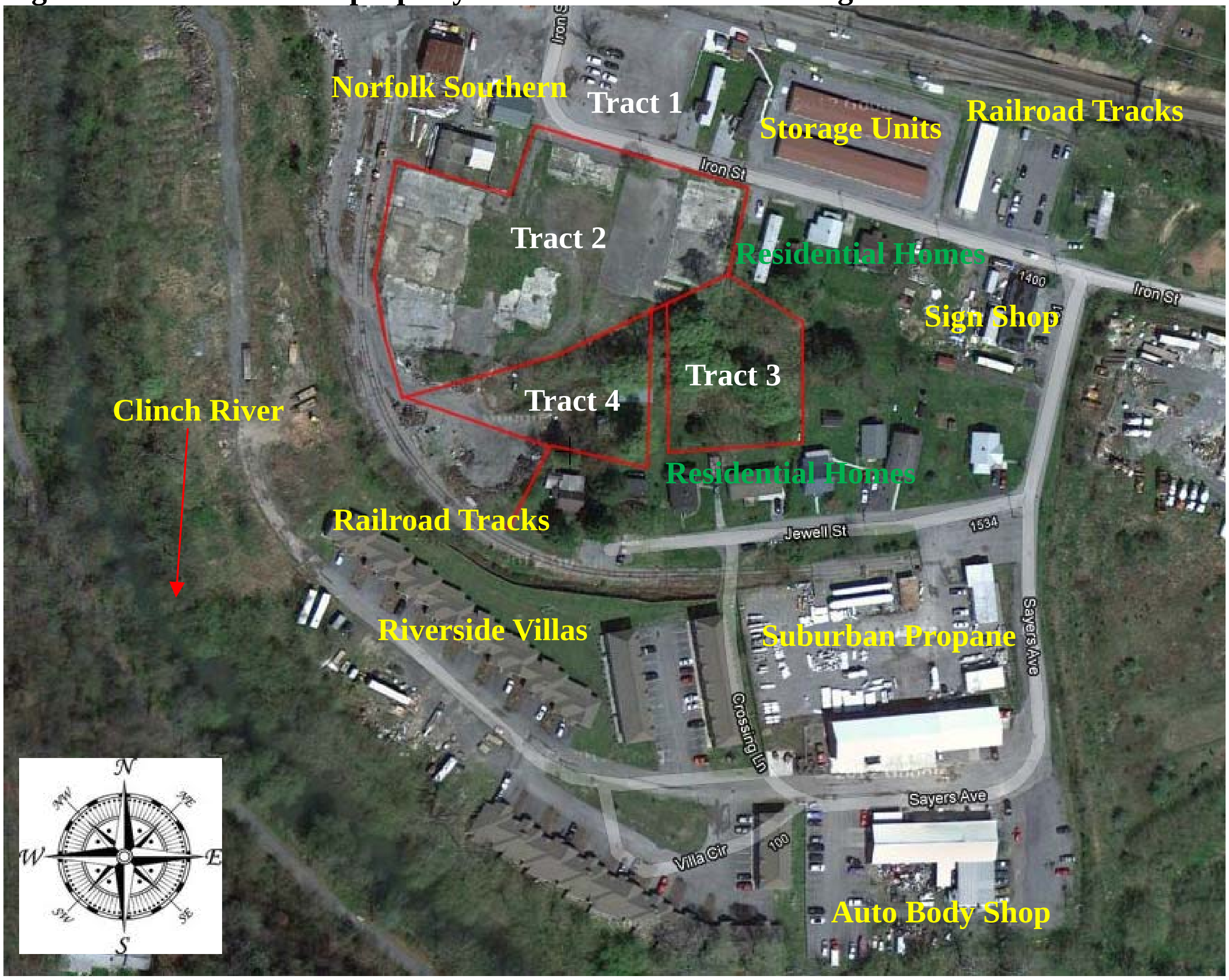
The site, formerly known as Simmons-Rand Property, is located on Iron Street in Richlands, Virginia and covers 3.26 acres (Figure 1). Richlands is in Tazewell County which is in the southwestern part of Virginia. The site is located in a mixed industrial and residential area. Concrete foundations of previous buildings remain in the center of the site and are surrounded by a 6-foot high chain link fence. The northern end of the site is covered with asphalt and the southern end of the site is covered with vegetation and gravel, with a drainage ditch passing through it. There are bolts, creosote lumber, and grease containers on the southern gravel section. Currently there is minimal site activity as only Norfolk Southern Railway is using a section of the site as a lay down yard. Since the 1930's, residential properties have been present near and on the site. Industrial activity did not begin until the mid-1940s (MM&A 1999). The site is currently owned by Ingersoll Rand Company and part of the site is being assessed under DEQ's Voluntary Remediation Program (VRP) (DEQ 2013). Due to the presence of underground storage tanks, the site was assessed by DEQ's Underground Storage Tank (UST) Program. Ingersoll Rand Company hired Arcadis U.S. Inc. to investigate the site and perform a risk assessment to determine the extent of environmental contamination and potential risks to human health posed by the USTs. The DEQ closed the UST investigation on June 14, 2013, based on the reports and recommendations made by Arcadis (Arcadis 2011).

The site is comprised of four adjacent tracts (Tracts 1-4) with Iron Street separating Tract 1 from the other three tracts. The tracts were used for various purposes while Simmons-Rand and other companies were in operation. Further site description and history of each tract is discussed below.

Tract 1 (Lots 18-21)

Historical photographs show that two residential homes and out buildings were present on the tract in 1936. A 1947 photograph shows three residential homes and an icehouse on Tract 1. Lots 18-21 were covered with asphalt and used for employee parking during 1960's to 1980's. This area is still used as a parking lot. Access to Tract 1 is currently unrestricted.

Figure 1: Simmons-Rand property with tracts and surrounding area



Tract 2 (Lots 69-70 and Parcel B)

E.L. Jackson developed Lots 69-70 in the 1930's as a general store. Lots 69 and 70 were sold to Crocket Selfe in 1945. Selfe operated a taxi and school bus facility. There were between 10 and 15 taxicabs and an unknown number of school and public buses kept on the property. In 1955, Selfe sold Lots 69 and 70 to Richlands Lumber Supply. The property changed hands over the next few years and was purchased by S&S Machine Corporation in 1961, which used Selfe garage as a battery mine scoop and uni-hauler fabrication building until the late 1970's. S&S Machine Corporation was acquired by Ingersoll Rand in 1983 and became Simmons-Rand. From the late 1970's to the 1980's, battery conditioning, electric motor rewinding and reconditioning, and mine equipment servicing was performed. Roy and Vivian Fitzer sold Parcel B to Mullins Lumber and Supply, which became Richlands Iron and Steel, and was later sold to S&S Machine in 1961. Early maps (1936) showed that a residential home existed on this tract as well as a "Planer Mill" and lumberyard, office building, and storage building (1947-1950).

Two USTs associated with Selfe's taxicab business and one additional UST reportedly operated by Richlands Lumber are said to exist on site. The locations of these tanks are unknown. It is also reported that metal shavings were used to elevate the surface of Tract 2. Tract 2 has not been active since approximately 1992 and a demolition permit was issued to demolish the buildings in 1994. Currently the concrete foundations of the demolished buildings cover the majority of the tract. A 6-foot high, barbed wire-topped fence circles the tract. The Arcadis assessment found that soil and groundwater in Tract 2 is contaminated with volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs) and metals. Public access to Tract 2 is restricted.

Tract 3

Tract 3 was never extensively developed and was used primarily as a staging yard for mine equipment awaiting repair. Storm water runoff that collects in this area is from both on-site and off-site surface water. A drain pipe that provides drainage from Tract 2 empties onto Tract 3. Also, a drainage ditch that originates off site to the north and runs along the eastern section of Tract 2, continues through Tract 3, and onto Tract 4 (See maps in Appendix B). There are no industrial activities currently being performed on Tract 3 and access is unrestricted. There are residential homes which have backyards adjacent to Tract 3. At present, there are sheds on Tract 3 that may have been constructed by adjacent homeowners. Homeowners on Jewell Street reportedly added soil from off site to raise portions of Tract 3 where storm water collects. Soil, surface water, and sediment samples show that VOCs, SVOCs and metals are present on Tract 3.

Tract 4 (Portions of Lots 88-91)

Tract 4 contained a metal fabrication building and supply house. This tract was developed by the former lumberyard, metal works facility, and S&S Machine. There is a groundwater seep that drains to a drainage ditch on Tract 3. Norfolk Southern uses Tract 4 as a lay down yard for railroad timber, ties, and ballast. Access to Tract 4 is unrestricted. There are residential homes on Jewell Street with backyards adjacent to Tract 4. Sheds are present on Tract 4 and are thought to belong to residents on Jewell Street. Soil, groundwater, surface water and sediment are contaminated with VOCs, SVOCs and metals.

Land Use & Natural Resources

The former Simmons-Rand Property is a mixed industrial, commercial, and residential area (Figure 1). This site is divided into four tracts as described above. Tract 1 is located to the north of Tract 2, 3, 4. Tract 1 is bordered by rail tracks to the north, to the west runs Iron Street which continues to the south of the Tract 1 separating it from the other three tracts. To the east of Tract 1 are two residential homes, contiguous to these homes are storage units. The entrance to Tract 1 is on Iron Street. To the south of the site are homes on Jewell Street. The backyards of some of these homes are adjacent to Tracts 3 and 4. Opposite Jewell Street are large propane tanks. Approximately 350 feet to the east is an area with multiple cement trucks that do not appear to be in working order. All the residential homes in this area are connected to municipal drinking water. The Clinch River is approximately 300 feet from the site and flooding along the river occasionally impacts homes on Jewell Street.

Demographics

VDH examines demographic and land use data to identify sensitive populations, such as young children, the elderly, and women of childbearing age, to determine any potential health risks that may result from exposures. Demographic information also provides details on residential history in a particular area. This information helps VDH evaluate how long residents might have been exposed to contaminants.

As of 2010, the population of Richlands, Virginia was 5,823 according to the U.S. Census Bureau. Regarding sensitive age groups, there are a larger percentage of persons aged 65 and older (16.4%) when compared to the state average of 11.8%. Children under the age of five represent 5.6% of the Richland's population, which is lower than state average (6.8%). Additional demographics for the population within one mile of the site are provided in Appendix B.

Site Geology and Hydrogeology

The site is located in the Valley and Ridge Physiographic Province of Virginia. The site is underlain by Maccrady Shale and Price Formation as shown by 1993 Geologic Map of Virginia. The Maccrady Shale is described as a ducky red, green shale, mudstone and evaporate deposits. The Price formation is comprised of sandstone, conglomeratic sandstone and shale with carbonaceous partings and impure coal beds.

In the vicinity of the site, soil is described as silty clay loam which is well drained and permeable. Subsurface soil consists of sandy, clayey soils overlaying weathered shale bedrock. In 2008, Arcadis reported on the boring logs and well construction diagrams that most of the wells in this area consist of loose, brown, sandy clay grading to gray clay with fine grained sand over weathered grey shale, with thickness of each varying by location.

Topography, natural and manmade drainage, and the proximity to the Clinch River influence the surface hydrology of the site. During the development of the property, the northeastern side of the property was filled, shifting the topography to the southern and southwestern direction towards a drainage located on the southern area of the site. The flow of groundwater is predominantly to the west-southwest towards the Clinch River west of the site (see map in Appendix B). There is a drainage system that flows into the Clinch River 300 feet west of the site. The depth of water on site varied in June 2011 and November 2010 sampling events. The water depth was measured to be 0.75 to 10.95 feet below ground surface in June 2011 and 1.73 to 4.70 feet below the ground surface in November 2010. The river is the only natural water body identified in the area.

Site Visits

VDH became involved with addressing concerns at the former Simmons-Rand property in December 2011. Since that time, the local health department and VDH have worked to gain a better understanding of the community's health concerns related to the historical industrial processes that took place on the property.

On January 23, 2012, the Town of Richlands hosted a sub-committee meeting to review an environmental risk assessment conducted as part of the VRP. About a dozen residents from the community attended the meeting. VDH staff attended the meeting and was available to learn more about community health concerns, explain the public health assessment process, and describe the expected outcomes of the assessment. VDH and the local health department staff toured the site and nearby area with DEQ. After the sub-committee meeting, state and local government officials met with residents that live on Jewell Street and re-visited the site.

The site visit revealed that exposure to soil contaminants on Tracts 1 and 2 is limited because Tract 1 is covered almost entirely with asphalt, and Tract 2 has restricted access and is covered with remnants of concrete foundations and grass. The residents have always been connected to public water.

The site visit also revealed that Tract 3 is overgrown with vegetation and a drainage ditch runs through it. The sheds on Tract 3 are thought to be owned by adjacent homeowners. Homeowners reported that once Simmons-Rand stopped using Tract 3 they leveled it with soil from off site. Tract 4 is largely gravel with a small stream of surface water flowing towards Tract 3. There were containers, electrical boxes, and railroad timber and ties on this tract, and the railroad timber produced an overwhelming odor of creosote.

Community Health Concerns

As part of the public health assessment process it is important to communicate and seek input from community members, local interested parties, and representatives of local government associated with the site. For the former Simmons-Rand property, VDH staff spoke with multiple community members and leaders during a town hall meeting and site visit on January 23, 2012.

On March 1, 2012, VDH staff visited community members and conducted face-to-face interviews with seven people, who represented five of the seven households on Jewell Street adjacent to the site. These residents had a vested interest in the site due to their proximity to the Simmons-Rand Property. Each interview lasted about 20 minutes and residents had the opportunity to express specific concerns related to health and the environment.

All of the residents who were interviewed live on property that is adjacent to the site and most have been living in the community for over 15 years. Their homes are located down gradient from the site, and some have storage sheds located on the former Simmons-Rand property (Tracts 3 and 4). Some of the residents are active participants at the local council meetings and have voiced their concerns about harmful chemical contamination. They have been advocating for remedial activities at the site for over a decade.

In general, the residents desire for the site to be cleaned up, and they want the local and state government to facilitate the process more quickly than the current process. They also expressed an interest in having VDH assess the current site conditions and determine if they are at risk of harmful exposure to contaminants. Specifically, residents are concerned about cancer, poor drainage, and contamination of homes due to flood events. Answers to these questions and concerns are addressed in Appendix A.

Environmental Sampling

VRP site characterization is being conducted to determine the extent of on and off-site contamination. Sampling was done at various locations on site to determine the impact of contaminants (See map in Appendix B). MM&A conducted a Phase I assessment in 1999 and a partial Phase II assessment in 2002. The property owner contracted Arcadis to conduct a risk assessment which was released in 2010. Latest sampling results from Arcadis is the subject of this public health assessment and the site characterization performed by MM&A, which conducted a *partial* Phase II assessment will not be evaluated at this time. Samples collected from Tracts 3 and 4, which are adjacent to homes are discussed further because the public is more likely to come into contact with contaminants on these two tracts.

The soil samples collected on Tracts 3 and 4 appear to be collected from areas based on anticipated contamination from historical knowledge rather than following a sampling grid pattern (see map in Appendix B). Surface soil samples were collected from the top 12 inches of soil. The top three inches of soil is more representative of an exposure by a community member, therefore a sampling depth of 0-3 inches is recommended. The soil sampling performed on Tract 3 was adjacent to the backyards of homes on Jewel Street, whereas, the soil samples collected from Tract 4 were away from the backyards and between the drainage ditch and Tract 2. Sediment and surface water samples were collected from a drainage ditch that traverses Tracts 3 and 4. There is drain pipe that extends from below Tract 2 and empties into the surface water that flows from Tract 3 to Tract 4. Only one groundwater sample was collected from Tract 4. The depth of the groundwater was approximately 11 feet below the ground surface.

In the western side of the site, the groundwater flow is towards the Clinch River (see map in Appendix B). Twenty-six groundwater samples have been collected from eight on-site monitoring wells since 2008. Groundwater samples were collected from Tracts 2 and 4 in June 2011. SVOCs ,VOCs, and metals were identified in groundwater samples. Only one sample was collected from Tract 4. Methyl-tert-butyl ether was determined to be present at 33 µg/L. For additional findings see Appendix G. The groundwater on Tract 3, which is adjacent to homes on Jewell street, was not sampled. Although SVOCs, VOCs, and metals were found in the groundwater below Tract 2, the groundwater is not used as potable water. The concentration of MTBE found in Tract 3 is well below the health based comparison value, 3,000 µg/L, (see the Discussion section for an explanation of comparison values).

Exposure Analysis

Chemical contaminants released into the environment have the potential to cause adverse health effects when people come into contact with them. The VDH public health assessment process starts with evaluating different ways that people may come into contact with environmental contaminants and concurrently determining if the concentration of chemicals in the environment needs further toxicological consideration (See the Discussion section for more details).

After reviewing the samples, visiting the site, and meeting with community members and leaders, only Tracts 3 and 4 were evaluated for public health implications. Tracts 1 and 2 were excluded from exposure analysis because Tract 1 is covered with asphalt eliminating exposure to any contaminants in the soil below; access to Tract 2 is restricted and is covered with several concrete foundations and grass. Tracts 3 and 4 were included in the exposure analysis for the following reasons: several residents have backyards that are adjacent to Tracts 3 and 4; there are sheds potentially used by residents on Tracts 3 and 4, suggesting that residents may come into contact with contaminants on these two tracts; and access to these two tracts is unrestricted. Lastly, the community does not use groundwater for potable use and therefore the drinking water pathway for all tracts was eliminated. VDH will consider evaluating exposure to chemicals in Tracts 1 and 2 should environmental conditions, tract conditions, or tract usage change in the future.

DISCUSSION

The health effects evaluation process involves identifying chemicals present in the environment above acceptable health based standards (chemical evaluation) and determining if the community may come into contact with them (exposure pathway analysis). The evaluation process is described in more detail below.

Chemical Evaluation

VDH determines if the concentration of chemicals in environmental samples is of potential concern by comparing them to health based comparison values (CVs). This screening process is used to rapidly assess large volumes of data and does not identify adverse health outcomes. Comparison values are chemical and media-specific concentrations in air, soil, and drinking water that are used by ATSDR health assessors and others to identify environmental contaminants at sites that require further evaluation. CVs incorporate assumptions of daily exposure to the chemical and, in the case of soil and water, a standard amount that someone may likely take into their body each day. CVs are conservative and non-site specific. CVs are based on health guidelines with uncertainty or safety factors applied to ensure that they are adequately protective of public health. When a contaminant is detected at a concentration less than its respective CVs, exposure is not expected to result in health effects and it is not considered further as part of the public health assessment process. **It should be noted that contaminants detected at concentrations that exceed their respective CVs do not necessarily represent a health threat.** Instead, the results of the CV screening identify those contaminants that warrant a more detailed, site-specific evaluation to determine whether health effects may occur. CVs are not intended to be used as environmental clean-up levels.

CVs can be based on either carcinogenic or non-carcinogenic effects. Cancer-based CVs are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation unit risk (IUR). CVs based on cancerous effects account for a lifetime exposure (80 years) with a calculated excess lifetime cancer risk of 1 extra case per 1 million exposed people. Non-cancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the data comparison for public health protectiveness.

VDH considers access and exposure to Tracts 3 and 4 equal and used the maximum chemical concentration found in either tract when screening against CVs. This health protective approach may be modified if exposure to each tract changes.

VDH identified polycyclic aromatic hydrocarbons (PAHs) and metals in sediment (Table 1) and soil (Table 2) samples collected from Tracts 3 and 4. Metals, VOCs and PAHs were identified in surface water (Table 3).

Table 1: Concentration of contaminants found in sediment and their CV

Contaminant	Detects	Samples	Min	Max	CV	CV Type
Arsenic	4	4	3.4	7.7	0.47	CREG
Benzo[b]fluoranthene	2	2	1.1	1.6	0.15	RSL

(*Source:* Arcadis) CV=comparison value. Min = minimum concentration. Max = maximum concentration. CREG = cancer risk evaluation guide. RSL = EPA regional screening levels. All values in mg/kg.

The metal, arsenic, and the PAH, benzo[b]fluoranthene, were identified above their CV in sediment samples collected from Tracts 3 and 4 (Table 1). These chemicals are evaluated further in the Public Health Implications section.

In soil samples collected from Tracts 3 and 4, VDH identified PAHs and metals that exceeded CVs (Table 2). These chemicals are evaluated further in the Public Health Implications section.

Table 2: Concentration of contaminants found in soil and their CV

Contaminant	Detects	Samples	Min	Max	CV	CV Type
Benzo[a]anthracene	3	5	0.06	0.39	0.15	RSL
Benzo[b]fluoranthene	3	5	0.25	1.1	0.15	RSL
Dibenz(a,h)anthracene	1	3	0.08	0.08	0.015	RSL
Indeno[1,2,3-cd]pyrene	2	3	0.06	0.26	0.15	RSL
Antimony	3	5	1.0	41	20 Child	RMEG
Total Chromium	5	5	7.1	88	50 Child	C-EMEG
Arsenic	5	5	3.3	9.9	0.47	CREG
Lead	5	5	9.6	4000	400	RSL

(*Source:* Arcadis) CV=comparison value. Min = minimum concentration. Max = maximum concentration. CREG = cancer risk evaluation guide. RSL = regional screening levels. RMEG = reference dose media evaluation guide. EMEG = environmental media evaluation guide. All values in mg/kg.

VDH identified halogenated hydrocarbons, PAHs, and metals in surface water samples from Tracts 3 and 4 that were above their CV (Table 3). They are evaluated further in the Public Health Implication section.

Table 3: Concentration of contaminants found in surface water and their CV

Contaminant	Detects	Samples	Min	Max	CV	CV Type
cis-1,2-Dichloroethene	2	7	24	170	20 / 70	RMEG
Trichloroethene	2	7	4	10	0.76	CREG
Vinyl chloride	2	7	2.9	23	0.025	CREG
Benzo[a]anthracene	1	3	0.0	0.23	0.029	RSL
Benzo[b]fluoranthene	1	3	0.0	0.25	0.029	RSL
Arsenic	1	2	0.0	5.3	0.023	CREG
Iron	4	4	1300	26000	11000	RSL
Lead	2	4	7.1	34	15	MCL
Manganese	4	4	360	970	500 Child	RMEG

(*Source:* Arcadis) CV=comparison value. Min = minimum concentration. Max = maximum concentration. CREG = cancer risk evaluation guide. RSL = regional screening levels. RMEG = reference dose media evaluation guide. EMEG = environmental media evaluation guide. All values in µg/L.

Exposure Pathway Analysis

An individual's health can only be affected by a chemical present in the environment if they are exposed to it. There are different ways that individuals are exposed to chemicals such as: through ingestion (e.g., swallowing contaminated soil or water); inhalation (breathing contaminated air); and dermal (absorption of a chemical through the skin). VDH considers five elements when determining if an exposure may have occurred in the past, is occurring at the present, or may occur in the future (Table 4).

Table 4: Five elements of an exposure pathway

Exposure element	Explanation	Site related
Source of contaminant	sources may include drums, landfills, and many others which may release contaminants into various media	Simmons-Rand property
Environmental transport	once released to the environment, contaminants move through and across different media	surface water, sediment, and soil
Point of exposure	where people come into contact with the contaminant	contact with soil, sediment, and surface water
Route of exposure	how people come into contact with the contaminant (e.g., inhalation, ingestion, dermal contact)	dermal exposure of soil, sediment, and surface water; ingestion of soil
Potentially exposed population	populations that may come or may have come into contact with the contaminants	residents on Jewel Street and trespassers who enter Simmons-Rand property

A *completed* exposure pathway exists if all five elements are present or there is a strong likelihood that people have in the past or are presently coming into contact with contaminants on site. An *eliminated* exposure pathway is one where at least one of the five elements or site characteristics make past, current, and future exposures extremely unlikely. A *potential exposure pathway* exists if information on one of the five elements is missing or is insufficient, but could have occurred in the past, may be occurring, or could occur in the future. Because of the location of Tracts 3 and 4 in relation to the homes on Jewell Street, VDH erred on the side of caution and assumed that residents would be exposed to contaminants on those tracts as equally as someone would be exposed to their own backyards. Therefore, four *completed,* two *eliminated,* and one *potential* pathways were identified. *Completed, potential,* and *eliminated* exposure pathways identified at Simmons-Rand are described below.

<u>*Completed exposure pathways*</u>

Dermal contact of soil – Access to Tracts 3 and 4 is unrestricted. There appear to be sheds owned by residents on Jewell Street with backyards adjacent to the tracts. Residents using these sheds may be exposed to contaminants in the soil. Children living in these residences may be exposed when playing on soil behind these homes.

Dermal contact of sediment – Access to Tracts 3 and 4 is unrestricted. Children living in these residences may be exposed to sediment if they play on sediment behind their homes.

Dermal contact of surface water – Access to Tracts 3 and 4 is unrestricted. Children living in these residences may be exposed to surface water if they play in surface waters behind these homes.

Soil ingestion – Access to Tracts 3 and 4 is unrestricted. Incidental ingestion of soil is possible for children playing on soil behind these homes.

<u>*Eliminated Pathways*</u>

Consumption of surface water **–** The depth of the water in the drainage ditch fluctuates and there is no indication that it is ever deep enough for an extended period of time such that anyone could swim in it and incidentally ingest water. During a site visit, the color of the water was brown, it had an oil sheen appearance, and algal growth was visible. VDH does not have any reason to believe that a trespasser would use this water, especially when the Clinch River is within less than a minute walking distance.

Consumption of groundwater **–** The groundwater is not used as potable or non-potable water. The homes adjacent to the site are connected to a public water system.

<u>*Potential Pathway*</u>

Vapor intrusion **–** The groundwater is identified as shallow and flows in the direction of some of the homes on Jewell Street (see Appendix B). It is possible that VOCs identified onsite could move with the groundwater and volatilize into the home exposing residents to VOCs. Additional groundwater sampling would be needed to eliminate this pathway.

Public Health Implications

A *complete* exposure pathway does not mean that a public health hazard exists. *Complete* and *potential* exposure pathways require further evaluation to determine whether exposures are capable of causing adverse health effects. Adverse health effects from exposure to a chemical in the environment are influenced by: the route of exposure (e.g., inhalation, ingestion, or skin contact); the amount of chemical (or dose); how long the person is exposed to the chemical (duration); how often exposure occurs (frequency); and how the chemical affects the body (toxicity).

Using exposure assumption values along with chemical toxicological information, VDH determines the daily dose in milligrams/kilograms (mg/kg) of a chemical that a person receives at a site. This can be compared with MRLs which are daily doses that are known not to adversely affect individuals. If a dose is determined to be unacceptable, VDH may make recommendations to prevent or reduce exposure. Exposure assumption values such as body weight, age, ingestion rates, or how much air a person breathes are used to determine the daily dose (mg/kg-day) of a chemical. VDH may use actual site-specific exposure assumptions when provided by the community, local health department, or the exposed population. VDH may use values that overestimate the risk to be health protective. Equations and exposure assumptions used calculating exposure doses for chemicals of concern are in Appendix D. Each chemical's public health implications as they pertain to the site follows, and additional chemical specific information can be found in Appendix F.

Arsenic

The total daily dose of arsenic from exposure to soil, sediment, and surface water at Simmons-Rand calculated for children (4.6×10^{-5} mg/kg-day), adolescents (1.3×10^{-5} mg/kg-day), and adults (3.5×10^{-6} mg/kg-day) each was less than the chronic oral MRL, 3.0×10^{-4} mg/kg-day. Therefore, we do not expect harmful non-cancer health effects. Excess cancer risk was calculated to determine additional cancers expected from exposure to arsenic for a lifetime (80 years). The additional cancer risk from arsenic exposure (1 in 100,000) is small when compared to the United State background cancer rate which is one in three.

Antimony

The chronic oral RfD for antimony is 4.0×10^{-4} mg/kg-day. The total daily dose of antimony from exposure to soil at Simmons-Rand for children (1.3×10^{-4} mg/kg-day), adolescent (1.3×10^{-5} mg/kg-day), and adult (4.2×10^{-6} mg/kg-day) each was less than the RfD. Therefore, we do not expect harmful non-cancer health effects.

Chromium

The MRL for oral exposure to chromium (VI) is 0.0009 mg/kg-day. This is higher than the average daily dose calculated for oral exposure to chromium in soil at Simmons-Rand for each age group: child (3.0×10^{-4} mg/kg-day), adolescent (2.9×10^{-5} mg/kg-day), and adult (9.1×10^{-6} mg/kg-day). Therefore, we do not expect harmful non-cancer health effects. Chromium exists in multiple forms in the environment and total chromium was reported, therefore, assuming that it was all present in the soil as chromium (VI) is conservative and may overestimate the risk. A cancer risk was not calculated for chromium exposure because an oral slope factor is not available.

Iron

The Food and Drug Administration's reference daily intake for iron is 18 mg. The exposure to iron in soil, sediment, and water at Simmons-Rand would not be expected to contribute enough to the overall daily intake of iron. The daily dose of iron from exposure to soil, sediment, and water at Simmons-Rand for each age group is: child (7.3×10^{-4} mg/kg-day); adolescent (5.8×10^{-4} mg/kg-day); and adult (4.4×10^{-4} mg/kg-day). Therefore, we do not expect harmful non-cancer health effects.

Lead

The Centers for Disease Control and Prevention (CDC) considers any level of lead in the body, especially for children, to be harmful (CDC 2012a; CDC 2012b). Currently, there are no MRLs for lead exposure. On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile blood lead level of children in the United States (ages 1 to 5 years old) as the reference value for designating elevated blood lead levels in children. Based on the latest National Health and Nutrition Examination Survey data, the 97.5 percentile currently is 5 µg/dL (CDC 2012a). On June 7, 2012, the CDC released a statement indicating concurrence with the recommendations of the ACCLPP (CDC 2012b). CDC plans to use the reference value as defined to identify high-risk childhood populations and geographic areas most in need of primary prevention. *Yet still, there may be an underestimation of risk for lead because there is no proven safe level of lead in the blood.*

Soil samples were analyzed for lead; the highest concentration of lead in soil reported was 4,000 mg/kg. Given that the average lead concentration in soil was not available, the highest concentration was used in the Integrated Exposure Uptake Biokinetic (IEUBK) model to determine the estimated blood lead levels in children living near the site (see Appendix E). Using the highest lead concentration in the model may overestimate the risk to lead exposure. The calculated blood lead level using 4,000 mg/kg as the concentration of lead in the soil was 6 times higher than the reference level of 5 µg/dL. Exposure to lead in soil on Tracts 3 and 4 may result in non-cancer adverse health effects in children. To further characterize this exposure, additional sampling is required at the site.

Manganese

There is no MRL for manganese; however, EPA has set a chronic oral RfD equal to 0.05 mg/kg-day. The daily intake of manganese calculated from exposure to soil, sediment, and surface water at Simmons-Rand for each age group: child (2.7×10^{-5} mg/kg-day), adolescent (2.2×10^{-5} mg/kg-day), and adult (1.7×10^{-5} mg/kg-day) is less than the RfD. Therefore, we do not expect harmful non-cancer health effects.

Polycyclic aromatic hydrocarbons (PAHs)

There are no defined MRLs for PAHs. The daily dose of PAHs from exposure to soil, sediment, and surface water at Simmons-Rand is: children (3.6×10^{-6} mg/kg-day), adolescents (1.4×10^{-6}

mg/kg-day), and adult (5.9 x 10^{-7} mg/kg-day). The total additional cancer risk summed for all ages from exposure to PAHs over a lifetime is 6 in 1,000,000. This increase of cancer above background cancer rates (one in three) in the United States is small. Additional information on PAHs and how cancer risk was calculated can be found in Appendix F.

<u>*Volatile Organic Compounds (VOCs)*</u>

Cis- 1,2-dichloroethene

The total daily *cis*-1,2-dichloroethene exposure from surface water at Simmons-Rand calculated for children (2.4x10^{-6} mg/kg-day), adolescents (1.9x10^{-6} mg/kg-day), and adults (1.5x10^{-6} mg/kg-day) each was less than the ATSDR's intermediate oral MRL (0.3 mg/kg/day) and EPA's chronic oral RfD (0.002 mg/kg/day). Therefore, we do not expect harmful non-cancer health effects.

Trichloroethylene (TCE)

The total daily trichloroethylene (TCE) dose from exposure to surface water at Simmons-Rand calculated for children (3.4x10^{-6} mg/kg-day), adolescents (2.7x10^{-6} mg/kg-day), and adults (2.0 x10^{-6} mg/kg-day) each was less than the ATSDR's chronic oral MRL (0.0005 mg/kg/day) and EPA's chronic oral RfD (0.0005 mg/kg/day). Therefore, we do not expect harmful non-cancer health effects. Excess cancer risk was calculated to determine additional cancers expected from exposure to trichloroethylene for a lifetime. The additional cancer risk from TCE exposure (1 in 1,000,000) is small when compared to the United State's background cancer rate, which is one in three.

Vinyl chloride (VC)

The total daily dose of vinyl chloride (VC) from exposure to surface water at Simmons-Rand calculated for children (3.6x10^{-6} mg/kg-day), adolescents (2.9 x10^{-6} mg/kg-day), and adults (2.2 x10^{-6} mg/kg-day) each was less than the ATSDR's chronic oral MRL (0.003 mg/kg/day) and EPA's chronic oral RfD (0.003 mg/kg/day). Therefore, we do not expect harmful non-cancer health effects. Excess cancer risk was calculated to determine additional cancers expected from exposure to vinyl chloride for a lifetime. The additional cancer risk from VC exposure (3 in 1,000,000) is small when compared to the United State's background cancer rate, which is one in three.

CHILD HEALTH CONSIDERATIONS

VDH recognizes that children are at a greater risk of developing illness from exposure to hazardous chemicals given their smaller stature and growing body. Children are likely to breathe more air and consume more food and water per body weight than are adults. Also, children's bodies are developing and are susceptible to damage if toxic exposures are high enough during critical growth stages. For that reason, VDH considers children as one of the most sensitive populations evaluated in this Public Health Assessment, and always takes into account children when evaluating exposures to contaminants. The health-based comparison values for benzene, TCE, VC and arsenic include child-specific CVs. Children daily doses were also calculated and evaluated in this assessment. In addition, the IEUBK model was used to evaluate a child's exposure to lead.

CONCLUSIONS

VDH concludes that contaminants in soil identified on Tracts 1 and 2 are not expected to harm people's health.

VDH concludes that contaminants in the groundwater are not expected to harm people's health.

VDH concludes that the incidental ingestion and dermal contact to soil, on Tracts 3 and 4, poses a public health hazard.

VDH concludes that 0-12 inch soil sampling depths do not adequately characterize the public's exposure to soil.

VDH concludes that additional groundwater monitoring wells are needed to identify if volatile organic compounds are migrating off site and onto residential property on Jewell Street.

RECOMMENDATIONS

Residents with backyards adjacent to Simmons-Rand should refrain from going on to Tracts 3 and 4.

VDH recommends that lead contaminated soil be further characterized and remediated as needed. Additional soil sampling at 0-3 inches below the surface should be conducted to better characterize the extent of contamination on and off site, including adjacent residential property.

VDH recommends additional groundwater monitoring wells on Tracts 3 and 4 to determine if volatile organic compounds in the groundwater are migrating toward homes on Jewell Street.

PUBLIC HEALTH ACTION PLAN

Completed Actions

On January 23, 2012, VDH and the local health department toured the site with DEQ.

On January 23, 2012, VDH attended a sub-committee meeting hosted by the Town of Richlands, to review the environmental risk assessment that was conducted. The meeting was attended by about a dozen local residents, town officials, and the local health department. After the meeting VDH, the local health department and DEQ visited the site with residents and heard their concerns.

On March 1, 2012, VDH conducted in-depth interviews of local community members to gain a better understanding of any concerns related to the site.

Planned Actions

The Virginia Department of Health recognizes that there are no safe levels of lead and that exposure can result in adverse health outcomes. As a result, VDH will work in a collaborative effort with local health departments to implement the following preventative measures in order to reduce lead poisoning and build stronger and healthier communities: 1) developing health education activities associated with lead exposure, prevention and treatment; 2) promoting training programs on lead poisoning prevention such as the CDC's "Healthy Homes and Lead Poisoning Prevention Training," which is a training for health and housing state and local grantees, sanitarians, outreach staff, community development corporations, community based organizations, those interested in healthy housing design and maintenance, or any practitioner interested in building and maintaining healthy homes; and 3) engaging in research to further expand childhood lead poisoning prevention initiatives. VDH recognizes that The *Code of Virginia, sections 32.1-46.1* requires all children determined to be at risk to be screened for elevated blood lead levels at the age of one year (12 months), two years (24 months), and between the ages 36-72 months if not previously tested. Accordingly, VDH will recommend blood testing for lead as a general precaution, especially among children under age 6 or those residing in known areas of lead contamination, making them more susceptible to lead exposure than the general population.

VDH will present findings of the Public Health Assessment to the community and will be available to answer any questions.

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This report was supported by funds from a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

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APPENDIX A: Questions and Answers

Concerns from the community are presented here in the form of questions and answers.

Everyone on my street has cancer. Is it related to the site?

It is difficult to identify a causal relationship between cancer incidence and exposure to substances in the environment. Cancer is a common illness and is caused by a variety of factors; lifestyle factors such as smoking, alcohol use, and poor diet account for the majority of cancer cases. Its occurrence in the population usually increases with age. If environmental exposure caused cancer, the effects would likely result in the occurrence of cases of the same type of cancer.

Several contaminants present at Simmons Rand were assessed for cancer risk. The additional cancer risks calculated from arsenic exposure (1 in 100,000), trichloroethylene (1 in 1,000,000), and vinyl chloride (3 in 1,000,000) are all very small when compared to the United States' background cancer rate, which is one in three.

When the river floods, does it wash harmful chemicals from the site into my house?

When there is a flood, potentially harmful chemicals can be transported by the flood water. As a result, harmful chemicals not only from the site, but from distant areas impacted by the flood could potentially enter your house. Proper clean-up after flooding events should be performed to reduce potential exposure to chemicals transported in the water attached to soil or as dissolved particles. It is recommended that you clean and dry flooded areas within 24-48 hours to prevent mold growth. Also, discard items that were soaked with floodwater and cannot be cleaned. The EPA provides helpful information regarding the proper steps to clean a property after a flood.[1]

Why is it taking so long to have the site remediated?

There are multiple entities involved in assessing this site, including the environmental contractor, both regional and state DEQ personnel, and both local and state health departments. Simmons-Rand is a complex site where extensive environmental sampling is needed to describe the extent of contamination. Once environmental samples are collected, they are sent to qualified laboratories to be analyzed. These data are summarized and provided to those assessing the environmental or health risk. Based on these and other findings (including the historical and future usage of the site), additional sampling is sometimes recommended. . In addition, this process may be complicated if it is determined that the site may pose a risk to the surrounding community. These combined factors make for a lengthy process, but are needed to ensure that recommendations are meaningful and effective, and that remediation helps to reduce any harmful exposure.

[1] http://www.epa.gov/iaq/flood/

Is soil sampling being done adequately?

VDH and ATSDR recommend that soil sampling be collected from the top zero to three inches to better characterize exposure to residents (called "surface soil") because residents are usually only digging or stirring up the first few inches of soil.

Why is there water behind my house when there never used to be?

This may be related to residents adding soil to level the land, but we do not know the definite answer to this question.

Is it safe for children to play in my backyard?

There was no sampling done in residential backyards; therefore, data are not available to evaluate. However, sampling from Tracts 3 and 4 indicate exposure to high concentrations of lead, and children should not play in these areas.

Is it safe to garden in my backyard?

Even if you have consumed vegetables grown in possibly contaminated soil, the health risks are very low; consuming produce for shorter periods (i.e., one season), will not pose a significant risk. Some prudent health measures to use to reduce your chances of exposure to contaminants include:

- using raised beds with clean soil , which is the best vegetable gardening practice;
- wearing gloves, washing hands and clothes, and removing shoes after gardening;
- washing produce before consumption and avoiding areas that may be contaminated.

The best crops to plant in contaminated soil are *fruiting* crops (i.e., tomatoes, peppers, peas, beans and corn) because they accumulate very little contaminants in the parts we consume; however, some exceptions are cucumbers and squash, which can accumulate pesticides.

- *Root* crops known as carrots, beets, onions and potatoes accumulate contaminants from soil; however, peeling the skin before eating can remove some of the contaminants. If you peel these *root* vegetables, and grow and eat less of them, you have a lower likelihood of being exposed to contaminants in the soil.
- *Leafy* greens accumulate dust and soil; therefore, it is advised that these vegetables be washed thoroughly.

What chemicals from the site should I be concerned about?

The evaluation of available data showed some metals, volatile organic compounds, and polycyclic aromatic hydrocarbons were present at various areas of the site. Residents are not thought to be exposed to these chemicals. On the other hand, the concentrations of lead found in the soil on Tracts 3 and 4 are high. Residents, especially children, who are exposed to lead contaminated soil on these tracts, may be at risk for adverse health effects.

Can I limit my exposure to chemicals from the site?

To reduce exposure potential to contaminants, avoid contact with soil and surface water at the site. Young children who exhibit extensive hand-to-mouth activity are more likely than adults to be exposed to contaminants, such as lead in dust and soil. Children should wash their hands with soap and water before eating, naps, and bedtime. Shoes should be removed at the door so that soil and dust are not tracked into the house. Window wells, sills, and floors may be wet washed to remove contaminated soil or dust. Most importantly, children should avoid Tracts 3 and 4.

What are the possible health effects that could have happened from past exposure?

This evaluation focused on the most current sampling results available from the Arcadis report and did not focus on the *partial* report from MM&A. It is difficult to determine the extent to which past exposures might have caused health effects because the environmental data that would be needed to perform this type of assessment are not available or do not exist.

Are my pets at risk from exposure to chemicals from the site?

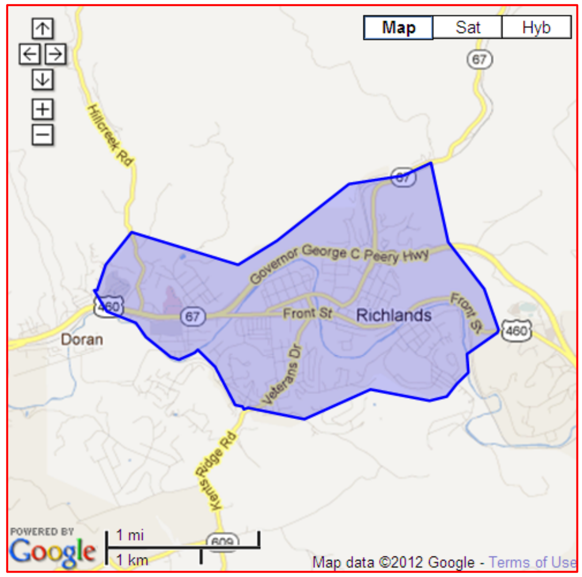
It is advised that you keep pets away from contaminated soil to avoid tracking soil into your home. Cats are susceptible to lead exposure from soil and dust given their cleansing and disposal practices (i.e., licking of the fur, disposing of wastes in soil). Additionally, dogs are just as susceptible to lead exposure from soil because of their cleansing practices, and their soil associated activities (i.e., digging in the yard to bury items). Various studies have indicated that pets may become more poisoned than pet owners in the same leaded environment. Studies have revealed that pets can function as monitors of potential lead exposure, especially to young children in the household. If you are concerned about the health of your pet, please contact your veterinarian.

APPENDIX B: Demographics and maps

Demographic Information

The demographics between the state of Virginia and the town of Richlands, where the former Simmons-Rand property is located varies slightly. The ratio of males to females is about the same. The community in Richlands is predominantly Caucasian (96.8%), with only small percentages of other ethnicities. The age distribution is similar when comparing Richlands to the state averages. The percentage of people under 5 years old is slightly lower than the state average, but the percentage of people over the age of 65 represents a slightly higher percentage compared to the state. Educational attainment is lower in Richlands compared to the state for both high school diploma and bachelor's degree. The unemployment rate in the city and state are the same as of 2011. However, the percentage of families living below the poverty level is much higher in Richlands compared to the state[1,2].

Map of Richlands, Virginia
Demographics taken from shaded area.



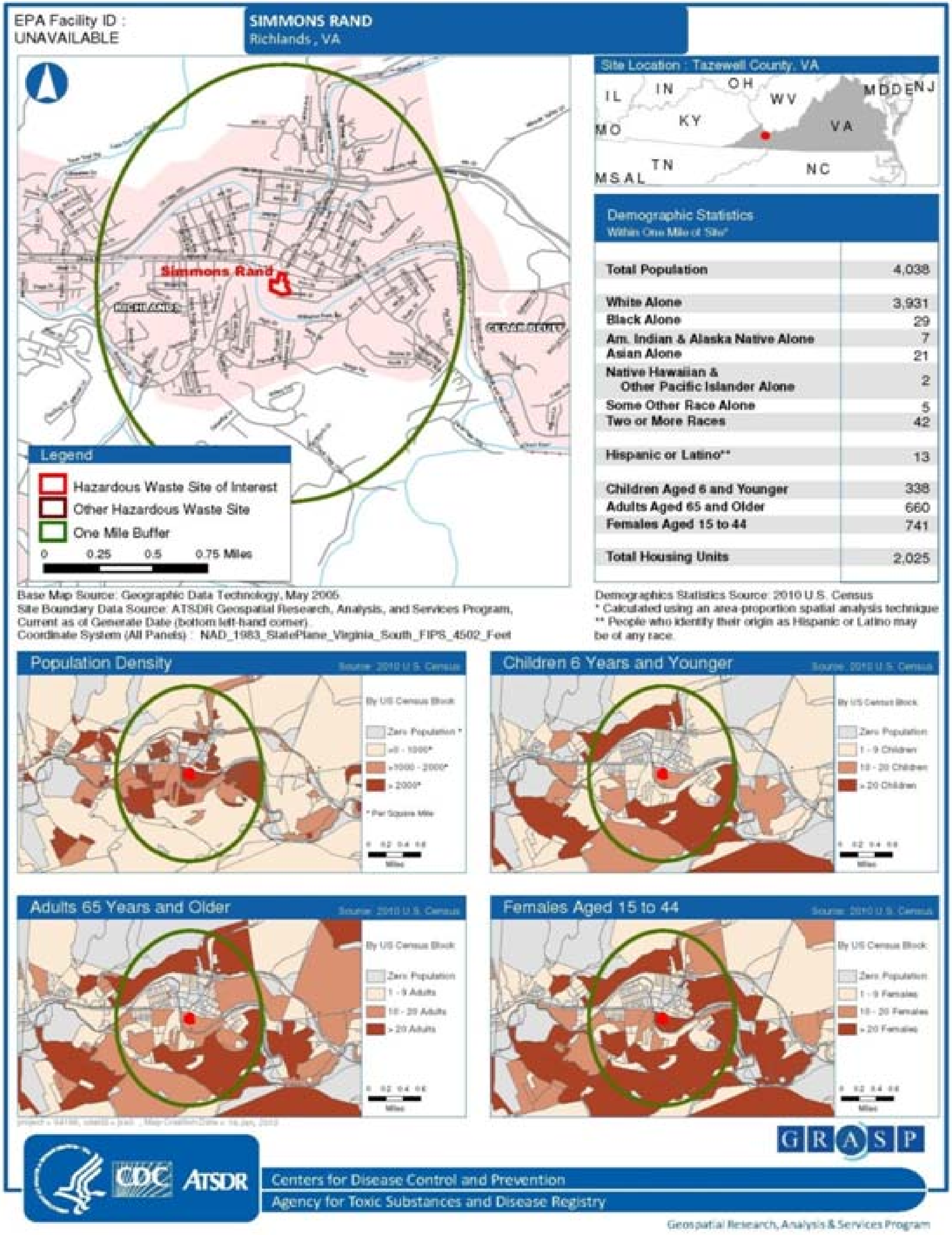
Demographics for Richlands (city) and Virginia (state)

	Richlands	Virginia
Total Population	5,823	8,001,024
Male	47.3%	49.1%
Female	52.7%	50.9%
Race or Ethnicity		
White/Caucasian	96.8%	70.7%
Black/African American	0.7%	19.6%
Age Distribution		
Under 5 years old	5.6%	6.8%
Over 65 years old	16.4%	11.8%
Educational Attainment		
High school diploma or equivalent	70.0%	85.8%
Bachelor's degree or higher	11.5%	33.4%
Economics		
Unemployment Rate 2011	5.8	5.8
Families below poverty level 2010	16.4%	7.2%

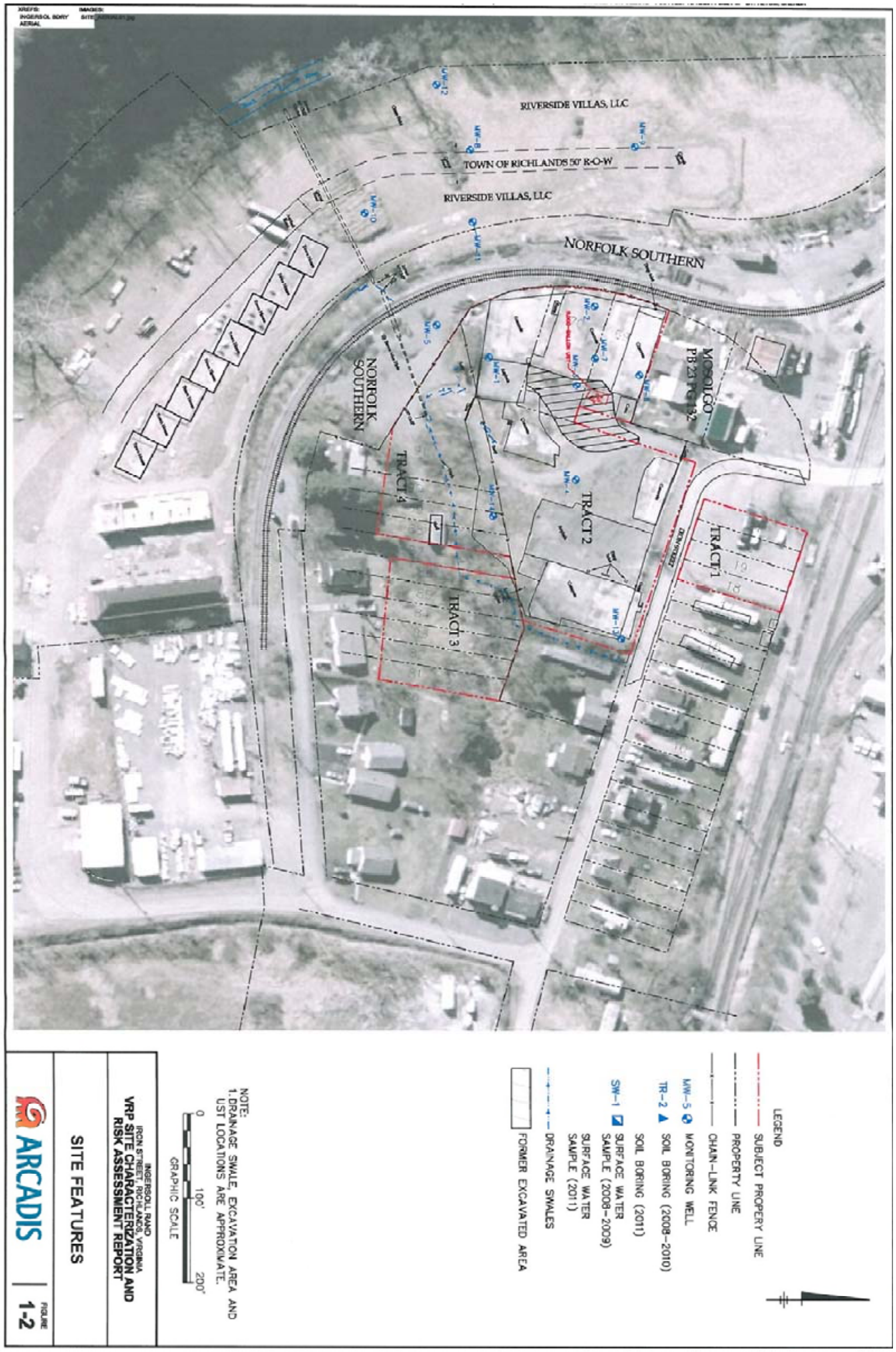
(Source: U.S. Bureau of Labor and Statistics and U.S. Census)

[1] U.S. Census Bureau (2012). Available at: http://quickfacts.census.gov/qfd/states/51/5166928.html
[2] U.S. Bureau of Labor and Statistics (2012). Available at: http://www.bls.gov/ro3/valaus.htm

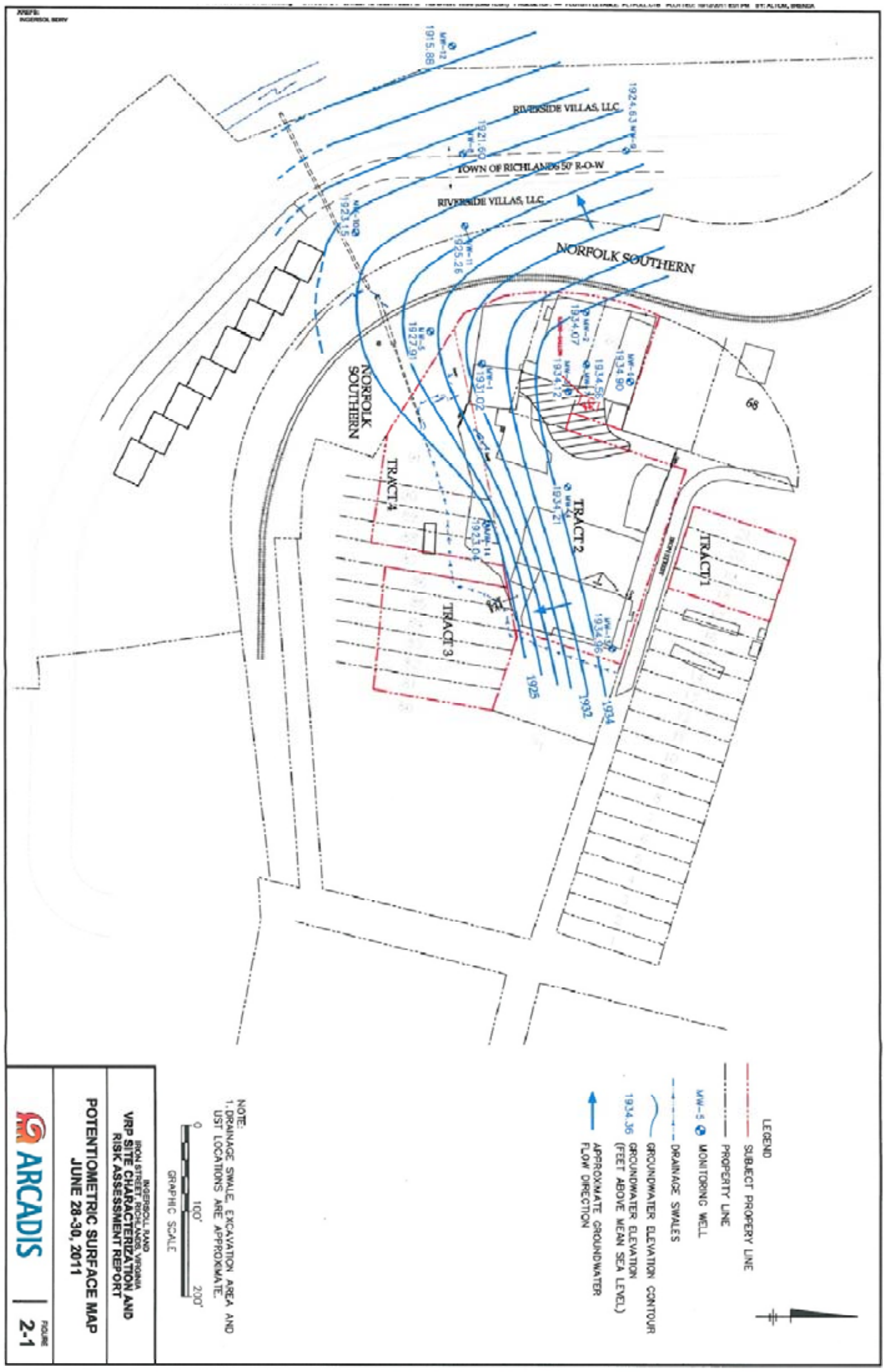
Demographics for population living within one mile of Simmons-Rand



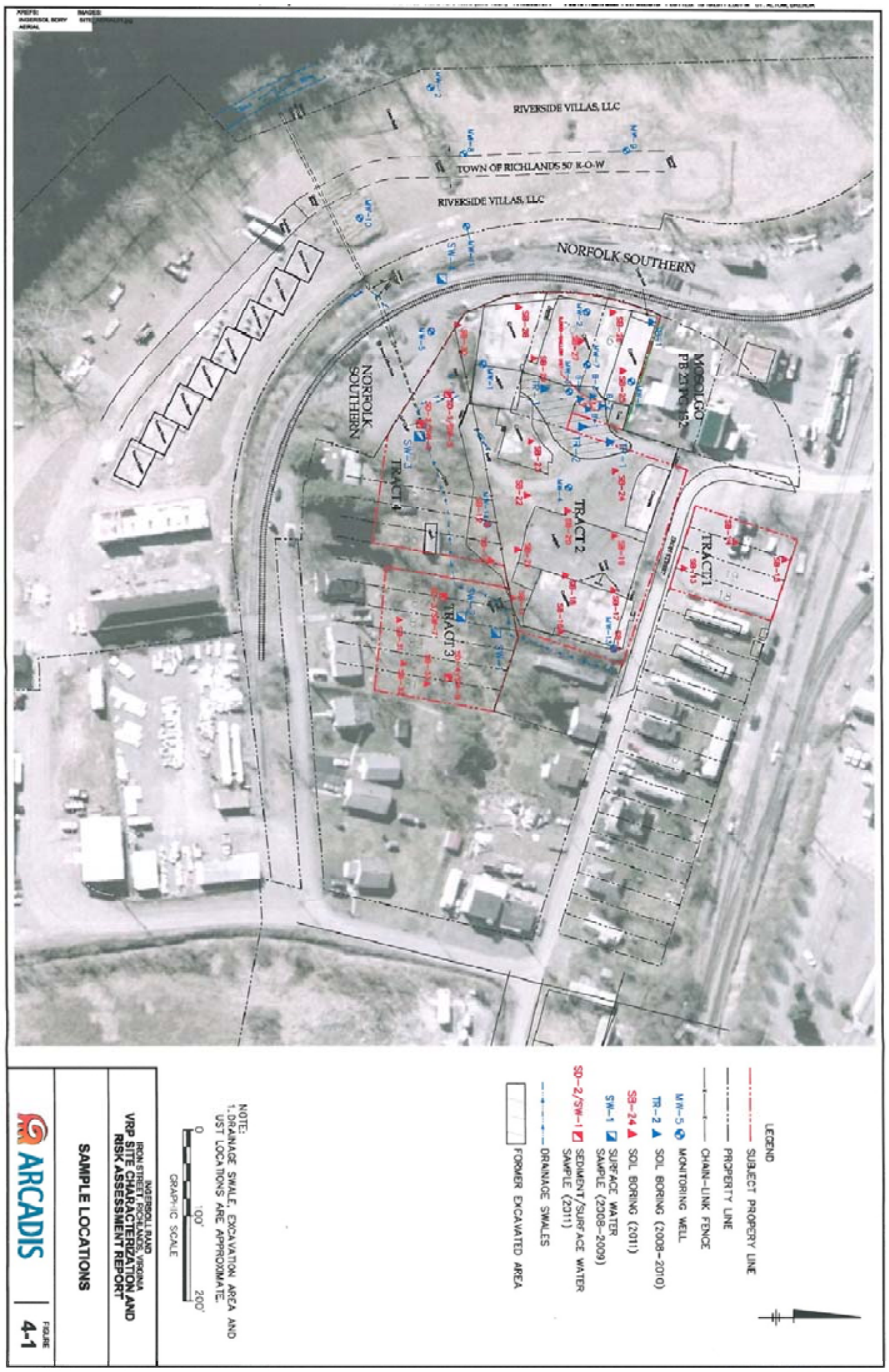
Map of sampling locations



Map of groundwater direction and drainage swale



Map of sampling locations



APPENDIX C: Health guidelines

Description of environmental and health guidelines used for comparison.[1]

ATSDR's Reference Dose Media Evaluation Guides (RMEGs)
"ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluations. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse non-carcinogenic effects."

ATSDR's Environmental Media Evaluation Guides (EMEGs)
"EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR MRLs and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight."

ATSDR's Cancer Risk Evaluation Guides (CREGs)
"CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's cancer slope factors (CSFs) for oral exposures or unit risk values for inhalation exposures. These values are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure."

Regional Screening Levels (RSL)
"EPA Region 3 Risk Based Concentrations (RBCs) are guidelines used to assess the potential for harm from chemicals found at a hazardous waste site. They are developed by combining a substance's toxicologic properties with "standard" scenarios for encountering the substance. EPA's measures of a substance's toxicologic properties are the RfD and CSF. The RfD is the dose of a chemical not expected to result in noncarcinogenic health effects, and the CSF is the cancer risk per unit dose. Exposure scenarios are taken from RAGS or Superfund supplemental guidance. The exposure parameters are generic and are intended to be overly conservative and protective of most populations. EPA uses these standard exposures to determine the exposure dose equivalent of the RfD or target cancer risk level."

Oral Cancer Slope Factor
"A CSF is an estimate of possible increases in cancer cases in a population. A CSF is expressed in dose units [$(mg/kg/day)^{-1}$] to allow for comparison with site-specific calculated oral doses. Because there can be differences in the carcinogenicity of a substance depending on the route of exposure, a CSF for ingestion exposures should not be applied to a different route of exposure, such as inhalation, unless there is adequate justification for this assumption."

[1] Agency for Toxic Substances and Disease Registry (ATSDR) (January 2005). Public Health Assessment Guidance Manual (Update). U.S. Department of Health and Human Services, Atlanta, GA.

Minimal Risk Level

"A MRL is an estimate of daily human exposure to a substance (mg/kg-day) for oral exposures that is likely to be without non-carcinogenic health effects during a specified duration of exposure based on ATSDR toxicological evaluations."

APPENDIX D: Exposure calculations

Equation used to calculate daily dose of chemical from incidental ingestion of soil.

$$D = \frac{C\ x\ IR\ x\ F\ x\ ED\ x\ CF1}{BW\ x\ AT}$$

Equation use to calculate daily dose of chemical from dermal exposure to soil and sediment.

$$D = \frac{C\ x\ A\ x\ AC\ x\ SA\ x\ F\ x\ ED\ x\ CF1}{BW\ x\ AT}$$

Equation used to calculate daily dose of chemical from dermal exposure to surface water.

$$D = \frac{C\ x\ P\ x\ SA\ x\ F\ x\ T\ x\ ED\ x\ CF2}{BW\ x\ AT}$$

Where:

Abbreviation	**Parameter**	**Value & Units**
D	Daily dose	mg/kg-day
C	Concentration	mg/kg (soil and sediment) or µg/L (water)
IR	Ingestion rate	mg/day
A	Total soil adhered each day	mg/day
AC	Absorption coefficient	unitless
SA	Surface area	cm^2
F	Frequency	days/year
ED	Exposure duration	years
T	Exposure Time	hours/day
P	Permeability coefficient	cm/hour
CF1	Conversion factor	1 kg/1,000,000 mg
CF2	Conversion factor	1L/1000 cm^3
BW	Body weight	kg
AT	Averaging time	days (note: = ED x 365 days/year for non-cancer; 80 years x 365 days/year for cancer risk calculation)

VDH calculated daily exposures to chemicals found on site for three age groups: children (1 to 6 years old), adolescents (6 to 16 years old), and adults (16 to 80 years old). Various assumptions used in calculating daily doses are described below.[1,2]

	Child	Adolescent	Adult
Soil (ingestion exposure)			
Body weight	15 kg	44 kg	76 kg
Incidental ingestion rate	200 mg/day	50 mg/day	20 mg/day
Frequency	90 days/year	90 days/year	90 days/year
Exposure duration	5 years	10 years	64 years
Averaging time	1,825 days	3,650 days	23,360 days
Soil and Sediment (dermal exposure)			
Body weight	15 kg	44 kg	76 kg
Soil (50% body surface area)	2,400 cm^2	5,400 cm^2	7,200 cm^2
Frequency	90 days/year	90 days/year	90 days/year
Sediment (surface area-hands and feet)	856 cm^2	1,995 cm^2	2,630 cm^2
Exposure duration	5 years	10 years	64 years
Averaging time	1,825 days	3,650 days	23,360 days
Soil adherence rate	0.2 mg/day	0.16 mg/day	0.16 mg/day
Absorption coefficient	Chemical specific (unitless)		
Surface water (dermal exposure)			
Body weight	15 kg	44 kg	76 kg
Surface area (hands and feet)	856 cm^2	1,995 cm^2	2,630 cm^2
Exposure time	2 hours/day	2 hours/day	2 hours/day
Frequency	90 days/year	90 days/year	90 days/year
Exposure duration	5 years	10 years	64 years
Averaging time	1,825 days	3,650 days	23,360 days
Permeability coefficient	Chemical specific (cm/hour)		

[1] U.S. EPA. Exposure Factors Handbook 2011 Edition (Final). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09/052F, 2011.

[2] U.S. EPA. Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) 2004 (Final). U.S. Environmental Protection Agency, Washington, D.C.

Daily doses of chemicals from exposure to chemicals in soil, sediment, and surface water

Chemical	Child				Adolescent				Adult			
	Soil		Sediment	Surface water	Soil		Sediment	Surface water	Soil		Sediment	Surface water
	Ingestion	Dermal	Dermal	Dermal	Ingestion	Dermal	Dermal	Dermal	Ingestion	Dermal	Dermal	Dermal
PAHs	1.9E-06	5.9E-07	9.7E-07	1.8E-07	1.6E-07	3.6E-07	7.7E-07	1.4E-07	3.7E-08	2.8E-07	1.6E-07	1.1E-07
Antimony	1.3E-04	3.2E-06			1.1E-05	2.0E-06			2.7E-06	1.5E-06		
Arsenic	3.3E-05	2.3E-06	1.1E-05	1.5E-07	2.8E-06	1.4E-06	8.5E-06	1.2E-07	6.4E-07	1.1E-06	1.7E-06	9.0E-08
Chromium	2.9E-04	6.9E-06			2.5E-05	4.2E-06			5.7E-06	3.3E-06		
Iron				7.3E-04				5.8E-04				4.4E-04
Lead	1.3E-02	3.2E-04		9.6E-08	1.1E-03	1.9E-04		7.6E-08	2.6E-04	1.5E-05		5.8E-08
Manganese				2.7E-05				2.2E-05				1.7E-05
***cis*-1,2 Dichloroethylene**				2.4E-06				1.9E-06				1.5E-06
Trichloroethylene				3.4E-06				2.7E-06				2.0E-06
Vinyl Chloride				3.6E-06				2.9E-06				2.2E-06

*All units in mg/kg-day. Shaded boxes = data not available.

Additional cancer risks from exposure to PAHs, arsenic, TCE, and vinyl chloride at Simmons-Rand are below. Additional cancer risk is calculated over a lifetime, therefore 29,200 days (i.e., 80 years x 365 days/year) is used for AT in the above equations to calculate daily dose. This daily dose is then multiplied by the Cancer Slope Factor (CSF) for each chemical to determine the additional cancer risk (see table below).

Additional cancer risk from exposure to PAHs, arsenic, trichloroethylene, and vinyl chloride

	Child Cancer Risk				Adolescent Cancer Risk				Adult Cancer Risk			
	PAH	Arsenic	TCE	Vinyl Chloride	PAH	Arsenic	TCE	Vinyl Chloride	PAH	Arsenic	TCE	Vinyl Chloride
Daily dose	3.6E-06	4.6E-05	3.4E-06	3.6E-06	1.4E-06	1.3E-05	2.7E-06	2.9E-06	5.9E-07	3.5E-06	2.0E-06	2.2E-06
CSF	7.3	1.5	0.046	1.4	7.3	1.5	0.046	1.4	7.3	1.5	0.046	1.4
CR	2 in 1,000,000	4 in 1,000,000	10 in 100,000,000	3 in 10,000,000	1 in 1,000,000	2 in 1,000,000	2 in 100,000,000	5 in 10,000,000	4 in 1,000,000	4 in 1,000,000	7 in 100,000,000	2 in 1,000,000

*PAH=polycyclic aromatic hydrocarbons. TCE=trichloroethylene. mg/kg=milligrams/kilograms. Daily dose expressed as mg/kg-day and is sum of all exposure routes. CSF=cancer slope factor, expressed as $(mg/kg\text{-}day)^{-1}$. CR= Additional cancer risk from soil, sediment, and surface water combined.

APPENDIX E: Child blood lead calculation outcome[1]

VDH assessed the public health implications of lead using the EPA's IEUBK lead model for children. This model is designed to predict the blood lead levels of young children that are exposed to lead.

Soil samples were analyzed for lead; the minimum concentration of lead in these samples was 9.6 mg/kg and the highest concentration was 4000 mg/kg. The highest reported concentration was used in the IEUBK model to determine the estimated blood lead levels in children living near the site. The model used parameters like time outdoors, ventilation rate, lung absorption, outdoor air lead concentration, diet intake, water consumption, soil concentration and house dust. These parameters were used for age groups between 0.5 – 7 years to determine blood lead levels. The values used in each parameter were generated automatically by the model. See table below for parameters and calculated lead blood concentrations for each age group.

Using 4000 mg/kg for the concentration of lead in the soil, the calculated blood lead levels was approximately 6 above the times the CDC's reference level of 5 µg/dL for children 1-4 years old. The other age group's calculated blood lead levels were also above the reference range by approximately 4-fold.

The results of the IEUBK model indicate that children living near Simmons-Rand Property are at a risk of elevated blood lead levels, and this exposure may harm the health of children.

IEUBK model parameters used and calculated blood lead levels

Age	House Dust Lead conc. (µg/g)	Time Outdoors (hrs./day)	Ventilation Rate (m^3/day)	Diet Intake (µg/day)	Water consumption (L/day)	Total Dust and soil ingested (g/day)	Diet Intake (µg/day)	Calculated Blood (µg/dL)*
.5 – 1	2810.000	1.000	2.000	2.260	0.200	0.085	2.260	**24.3**
1-2	2810.000	2.000	3.000	1.960	0.500	0.135	1.960	**28.0**
2-3	2810.000	3.000	5.000	2.130	0.520	0.135	2.130	**26.7**
3-4	2810.000	4.000	5.000	2.040	0.530	0.135	2.040	**26.4**
4-5	2810.000	4.000	5.000	1.950	0.550	0.100	1.950	**23.1**
5-6	2810.000	4.000	7.000	2.050	0.580	0.090	2.050	**20.1**
6-7	2810.000	4.000	7.000	2.220	0.590	0.085	2.220	**18.1**

4000 mg/kg was used for lead soil concentration. 4 µg/L was used for concentration of lead in drinking water. 0.1 µg lead/m^3 was used as concentration of lead in outdoor air. Model provided bioavailability and rates were used.
*All calculated blood lead levels exceed CDC's reference level of 5 µg/dL.

[1] EPA Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows® version, 2010. IEUBK Model

APPENDIX F: Chemical profiles

ARSENIC[1]

Arsenic is a naturally occurring element widely distributed in the earth's crust and can reach unusually high levels in soil and water in some parts of the Unites States. Most people are exposed to arsenic in air, drinking water, and food with the largest exposure coming from ingestion of seafood. The average concentration of arsenic in soil is 7.2 mg/kg. Arsenic concentrations in surface water have been reported as high as 1,700 µg/L. Arsenic compounds such as copper chromated arsenic are used as wood preservatives. Arsenic is immobile in agriculture soils; therefore, it is usually concentrated in the upper soil layer. The ability of arsenic to be transported in water depends on its chemical form.

Ingesting high doses of arsenic may cause nausea, vomiting, diarrhea, heart and blood vessels disease, and brain damage. Long-term health effects from exposure to low concentrations of arsenic include thickening of the skin, warts, pain in the arms and legs, a “pins and needles” sensation. Children who are exposed to high levels of arsenic have symptoms similar to adults. Ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

ANTIMONY[2]

Antimony is a metal that is easily broken and usually combined with lead or zinc to form useful alloys. These alloys are used in lead storage batteries, solder, sheet and pipe metal, bearings, and castings. Antimony cannot be destroyed in the environment. Most antimony will end up in the soil or sediment, where it attaches strongly to particles that contain iron, manganese, or aluminum. Because antimony is strongly bound to soil and sediment, it cannot easily affect individual’s health. Antimony is usually found in soil in concentrations less than 1 mg/kg. Ingesting large doses of antimony can cause vomiting. Other health effects from ingesting antimony are not known. Animals fed antimony chronically developed liver damage and blood changes. Antimony can irritate the skin if it is left on it. DHHS has not classified antimony as to its human carcinogenicity.

CHROMIUM[3]

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is present in the environment in several different forms. The most common forms are chromium(0), chromium(III), and chromium(VI). No taste or odor is associated with chromium compounds. Chromium(III) occurs naturally in the environment and is an essential nutrient. Chromium(VI) and chromium(0) are generally produced by industrial processes. The metal chromium, which is the chromium(0) form, is used for making steel.

[1] ATSDR 2007. Toxicological Profile for Arsenic. U.S. Department of Health and Human Services, Atlanta, GA.

[2] ATSDR 1992. Toxicological Profile for Antimony. U.S. Department of Health and Human Services, Atlanta, GA.

[3] ATSDR 2012. Toxicological Profile for Chromium. U.S. Department of Health and Human Services, Atlanta, GA.

Chromium(VI) and chromium(III) are used for chrome plating, dyes and pigments, leather tanning, and wood preserving.

Chromium concentrations in river water are usually less than 30 µg/L. Soil and surficial materials in the United States had chromium concentrations as high as 2,000 mg/kg. A study of soil in states that included Virginia reported chromium as high as 71 mg/kg. In most soils chromium exists as chromium III which has low solubility and low reactivity resulting in low mobility in the environment.

Chromium III is an essential nutrient required by the body for energy metabolism. Chromium can enter the body through the skin. Less than 10% of chromium ingested is absorbed. The main health problems seen in animals following ingestion of chromium(VI) compounds are to the stomach and small intestine (irritation and ulcer) and the blood (anemia). Chromium(III) compounds are much less toxic and do not appear to cause these problems. Sperm damage and damage to the male reproductive system have also been seen in laboratory animals exposed to chromium(VI). Mixed results have been found in studies of populations living in areas with high levels of chromium(VI) in the drinking water.

In laboratory animals, chromium (VI) compounds have been shown to cause tumors to the stomach, intestinal tract, and lung. DHHS, IARC, and EPA have classified chromium(VI) as a human carcinogen. Chromium (VI) is classified as a known/likely human carcinogen via inhalation exposure and its carcinogenic potential cannot be determined via oral exposure

IRON[1]

Iron is the fourth most abundant element in the earth's crust and is found throughout the environment. Iron compounds may be released through the weathering of rock and soil. Iron concentration measured in surface water range from 61 to 2680 mg/L. Iron is an essential element required by all forms of life. Exposure routes to iron include inhalation, ingestion, and dermal contact. The average iron concentration in soil in the United States is 24 grams/kilogram (g/kg) with the highest concentration equaling 227 g/kg. The mobility of iron in the soil is dependent on its oxidation state.

LEAD[2]

Lead is a heavy metal that occurs naturally in the Earth's crust. It is usually found combined with other elements. It is flexible and can be molded and shaped. Lead is often combined with other metals to form alloys. Lead is used in storage batteries, ammunition, pipes and weights. Most of the lead that enters the body comes from ingestion and is dependent on a number of factors including age and the last time you ate. Children absorb more lead into their blood from ingesting lead than adults. The exposure to lead from skin contact is small. The main target for lead toxicity is the nervous system. Adults exposed to lead in the work environment perform poorly on tests that measure the nervous system function. Lead exposure can cause weakness in the fingers, wrists, and ankles, cause an increase in blood pressure, damage sperm production,

[1] Hazard Substances Data Base. United States National Library of Medicine. Toxicology Data Network. National Institutes of Health, Health and Human Services. Accessed online January 2013 at: Toxicology Data Network.

[2] ATSDR 2007. Toxicological Profile for Lead. U.S. Department of Health and Human Services, Atlanta, GA.

and cause miscarriages. High concentrations of lead can cause brain and kidney damage, and death. DHHS has determined that lead and lead compounds are reasonably anticipated to be human carcinogens based on limited evidence from studies in humans and sufficient evidence from animal studies. Children are more sensitive to the toxic effects of lead. Children that ingest large amounts of lead can develop muscle weakness, anemia, kidney and brain damage. Exposure to low concentrations of lead can affect a child's mental and physical growth. There is no safe level of lead in soil, and preventive measures should be taken to reduce exposure to lead whenever possible. In addition, children under the age of 7 should have their blood tested for lead as a general precaution, especially if they live in or near areas of known lead contamination.[1]

Until recently, the CDC had established a level of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL).[2] Recent scientific research, however, has clearly shown that blood lead levels below this value can cause serious harmful effects in children. Blood lead levels below 10 µg/dL have been shown to cause neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with decreases in intelligent quotient; attention deficit hyperactivity disorder; deficits in reaction time; problems with visual-motor integration and fine motor skills; withdrawn behavior; lack of concentration; issues with sociability; decreased height; and delays in puberty, such as breast and pubic hair development, and delays in menarche.[3]

MANGANESE[4]

Manganese is an essential nutrient necessary for healthy bone and cartilage, wound-healing, and good health. It is naturally occurring and can be found in soil and rocks as oxides, carbonates, silicates and other compounds. It is used in steel production and to increase gasoline octane rating. It is found in foods such as grains, cereal, and in high concentrations in tea. Oral exposure to high concentrations of manganese can cause neurological (nervous system) effects. There is no evidence that manganese causes cancer. The average concentration of manganese found in soil in the United States has been reported as high as 900 mg/kg. The median concentration of manganese in surface water in the United States is 16 µg/L. In water, manganese binds to particles and settles in the sediment. Manganese's mobility in soil is dependent on its chemical state. Only small amounts of manganese can enter the body through the skin.

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[1] CDC 1991. Preventing lead poisoning in young children. US Department of Health and Human Services, PHS, Centers for Disease Control and Prevention, Atlanta, GA. Available at: CDC Publications .

[2] CDC 2005. Preventing Lead Poisoning in Young Children (5th Revision). U.S. Department of Health and Human Services, Atlanta, GA.

[3] CDC 2011. Lead (web page). Accessed online November 22, 2011: http://www.cdc.gov/nceh/lead.

[4] ATSDR 2012b. Toxicological Profile for Manganese. U.S. Department of Health and Human Services, Atlanta, GA.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)[1,2]

PAHs are a group of chemicals that are ubiquitous in the environment. They are organic compounds that have a fused ring structure of two or more benzene rings and can be either manmade or formed during the incomplete combustion of organic material such as tobacco, charbroiled meat, coal, oil, gas, and wood. PAHs are found in creosote, asphalt, coal tars, and petroleum products. Industries where PAHs have been identified in the workplace include mining, electrical, transportation, and metalworking. PAHs do not generally dissolve in water and usually stick to particles in the environment. In water, PAHs attach to particles and settle in the bottom of rivers and lakes. Depending on the number of rings: PAHs can evaporate from water and soil and travel great distances before returning to the earth in rainfall; can move through the soil and contaminate groundwater; can be destroyed by microorganisms in the soil within a month. There are over 100 different PAHs and they are often present in the environment as a mixture. Fifty-four PAHs have been identified at multiple National Priority Listing sites. Of these 54 PAHs, 17 have been evaluated further by ATSDR because of their toxicity, potential for human exposure, frequency of occurrence at NPL sites, and extent of reliable health-based and environmental information.

Little is known about the non-cancer health effects of PAHs in humans. In mice studies, those that were fed high levels of PAHs during pregnancy had difficulty reproducing, and yielded a higher rate of birth defects in their offspring. Other animal studies have shown that PAHs can cause harmful effects to the skin and the immune system. PAHs have been shown in animal and human studies to cause cancer in multiple organs via different routes of exposure. DHHS has determined that some PAHs may reasonably be expected to cause cancer in humans.

ATSDR has developed toxicity equivalency factors (TEFs) based on carcinogenicity for 15 PAHs. When using TEFs, benzo[a]pyrene (B[a]P) is assigned a toxicity factor of one (1). All other PAHs are compared to B[a]P. For example, benz[a]anthracene is 10 times less potent than B[a]P as a carcinogen and is therefore assigned a value of 0.1, while dibenz(a,h)anthracene is five time more potent than B[a]P as a carcinogen and is assigned a value of 5. After multiplying the TEF of each PAH times its concentration in the soil or sediment, they can be summed and expressed as B[a]P equivalents and used for further calculations. See the table below for soil, sediment, and surface water B[a]P concentration equivalents.

[1] ATSDR 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. U.S. Department of Health and Human Services, Atlanta, GA.

[2] Hazard Substances Data Base. United States National Library of Medicine. Toxicology Data Network. National Institutes of Health, Health and Human Services. Accessed online January 2013 at: Toxicology Data Network.

B[a]P equivalent concentration calculation for PAHs found in soil, sediment and surface water

Polycyclic aromatic hydrocarbons	TEF	Soil (mg/kg)		Sediment (mg/kg)		Surface water (µg/L)	
		Max	Max expressed as B[a]P equivalents	Max	Max expressed as B[a]P equivalents	Max	Max expressed as B[a]P equivalents
Benzo[b]fluoranthene	0.1	1.1	0.11	1.6	0.16	0.25	0.025
Benz[a]anthracene	0.1	0.39	0.039	-	-	0.23	0.023
Indeno[1,2,3-cd]pyrene	0.1	0.26	0.026	-	-	-	-
Dibenz(a,h)anthracene	5	0.08	0.4	-	-	-	-
Total B[a]P equivalent concentration		0.575		0.16			0.048

B[a]P = benzo[a]pyrene. Max = maximum concentration. TEF = toxicity equivalency factor. All units mg/kg.

1,2-DICHLOROETHENE[1]

1,2-Dichloroethene, also called 1,2-dichloroethylene, is a mixture of *cis*- and *trans*-1,2-dichloroethene. It is a colorless liquid with a sharp odor that is highly flammable. 1,2-Dichloroethene is a break down product of tetrachloroethylene and trichloroethylene. You can smell very small amounts of 1,2-dichloroethene in air (beginning at a level of about 17 parts per million or ppm). This chemical has been found in air, water, and soil. 1,2-Dichloroethene is released to the environment from chemical factories that make or use this chemical, from landfills and hazardous waste sites containing this chemical. It can evaporate and volatilize from water rapidly.

Breathing high concentrations can cause nausea, drowsiness, and headaches. Exposure to extremely high levels of 1,2-dicholorethene in the air can result in serious health problems. Long-term human health effects after exposure to low concentrations of 1,2-dichloroethene are not known. 1,2-Dichloroethene has not been shown to affect fertility in people or animals. EPA has determined that *cis*-1,2-dichloroethene is not classifiable as to its human carcinogenicity. DHHS and IARC have no cancer classification for this chemical.

TRICHLOROETHYLENE (TCE)[2,3]

TCE is a colorless liquid with a sweet odor and a burning taste. TCE is primarily used as a metal degreaser. TCE can also be found in some household products, including typewriter correction fluid, paint removers, adhesives, and spot removers. ATSDR reports that TCE is the most frequently reported organic contaminant in groundwater. It estimates between 9 and 34 percent of drinking water supply sources have some TCE contamination but that most municipal water supplies are in compliance with the maximum contaminant level of 5 µg/L. The most recent monitoring study found average levels in surface water ranging from 0.0001 to 0.001 ppm (parts per million) or mg/L of water and an average level of 0.007 ppm in groundwater. TCE evaporates from surface

[1] ATSDR 1996. Toxicological Profile for 1,2-Dichloroethene. U.S. Department of Health and Human Services, Atlanta, GA.

[2] ATSDR 1997. Toxicological Profile for Trichloroethylene. U.S. Department of Health and Human Services, Atlanta, GA.

[3] EPA 2000. Accessed online January 2013 at: Technology Transfer Network Air Toxics Web Site: Trichloroethylene.

water and dissolves slightly in water, but can remain in ground water for a long time. It can bind to particles in water and therefore settle to the bottom sediment.

Ingesting large amounts of TCE may cause liver and kidney damage, nausea, and even death. Drinking small amounts for a long period of time may damage the immune system, kidneys, and liver. Skin exposure may result in rashes. Skin contact with TCE for short periods may cause skin rashes. DHHS has determined that TCE is reasonably anticipated to be a human carcinogen. EPA has determined that TCE is a known human carcinogen. IARC has determined that TCE is a probably carcinogenic to humans.

VINYL CHLORIDE (VC)[1,2]

VC is a colorless gas. It has a mild, sweet odor. It is a manufactured substance that does not occur naturally. VC is a breakdown product of TCE and tetrachloroethylene. Most of the VC produced in the United States is used to make polyvinyl chloride (PVC), a material used to manufacture a variety of plastic and vinyl products including pipes, wire and cable coatings, and packaging materials. VC can dissolve in water and it volatilizes rapidly from water surfaces. Average concentrations in ground water are less than 10 ppb or µg/L.

Breathing high levels of VC may cause dizziness and sleepiness. Some people exposed to VC for many years developed liver damage. Others experienced nerve damage and immune reactions. Exposure to high levels may affect blood flow to the hands. Skin exposure may result in numbness, redness, and blisters. Animals exposed to VC for a long time can develop damaged sperm and testes. Effects of drinking high levels of VC are unknown. DHHS, IARC and EPA have determined that VC is a known carcinogen.

[1] ATSDR 2006. Toxicological Profile for Vinyl Chloride. U.S. Department of Health and Human Services, Atlanta, GA.

[2] EPA 2000b. Accessed online January 2013 at: Technology Transfer Network Air Toxics Web Site: Vinyl Chloride.

APPENDIX G: Environmental samples and comparison values

The following tables present environmental sampling results from the four Tracts and are grouped according to Tract and sample type (soil, sediment, groundwater, surface water). The minimum and maximum concentration for each chemical as well as the number of samples and the number of times the chemical was detected are provided.

Comparison values presented follow ATSDR's hierarchy. Only chemicals that exceeded their CV are evaluated in the document.

Hierarchy 1 CVs: include guidelines such as CREGs (water, soil, and air), and chronic EMEGs (water, soil, and air). These values are based on either EPA's CSF, EPA's IUR, or ATSDR's chronic oral or inhalation MRL. In the absence of these values, proceed to Hierarchy 2.

Hierarchy 2 CVs: include intermediate EMEGs (water, soil, air) or RMEGs (water, soil, air). In the case of drinking water, Lifetime Health Advisories (LTHAs) are also used. RMEGs are based on EPA's RfD or RfC and LTHAs are based on EPA's 2012 Edition of the Drinking Water Standards and Health Advisories.

Tract 1: Surface Soil Data 0 to 1 Foot (All concentrations are in mg/kg or parts per million)

Contaminant	Number of detects	Number of samples	Minimum concentration	Maximum concentration	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	3	3	0.03	0.059	**100,000**	**1,000,000**	
SVOCs							
Phenanthrene	1	3	0.14	0.14			
Metals							
Aluminum	3	3	5,100	6,700	**50,000**	**700,000**	
Arsenic	3	3	4	5.5	**15**	**210**	**0.47**
Barium	3	3	160	340	**10,000**	**140,000**	
Beryllium	3	3	0.72	1	**100**	**1,400**	
Cadmium	2	3	0.52	1	**5**	**70**	
Calcium	3	3	4,700	150,000			
Chromium	3	3	7.2	11			
Cobalt	3	3	4	6	**500**	**7,000**	
Copper	3	3	28	73	**500**	**7,000**	
Iron	3	3	5,800	12,000			
Lead	3	3	51	95			
Magnesium	3	3	510	5,900			
Manganese	3	3	26	350	**2,500**	**35,000**	
Mercury	3	3	0.024	0.2			

Nickel	3	3	8.4	11	1,000	14,000	
Potassium	3	3	710	1100			
Selenium	3	3	1.1	1.9	250	3,500	
Sodium	3	3	110	230			
Vanadium	3	3	10	15	500	7,000	
Zinc	3	3	33	180	15,000	210,000	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 2: Surface Soil Data 0 to 1 Foot (All concentrations are in mg/kg)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	9	16	0.015	0.22	100,000	1,000,000	
Benzene	8	16	0.00055	0.76	25	350	13
2-Chlorotoluene	1	16	0.05	0.05	1,000	14,000	
p-Cymene	3	16	0.003	0.078			
1,1-Dichloroethane	2	16	0.041	0.051			
cis-1,2-Dichloroethene	2	16	0.043	0.36	15,000	210,000	
Ethylbenzene	11	16	0.00097	2.2	20,000	280,000	
Isopropylbenzene	8	16	0.00058	0.32			
Methyl ethyl ketone	5	16	0.004	0.022			
Naphthalene	9	16	0.023	0.79	30,000	420,000	
N-Propylbenzene	9	16	0.0011	1.2			
Styrene	2	16	0.0013	0.069	10,000	140,000	
Tetrachloroethene	7	16	0.0021	3.4	300	4,200	330
Toluene	14	16	0.00079	3.6	1,000	14,000	
Trichloroethene	3	16	0.022	0.33	25	350	15
1,2,4-Trimethylbenzene	10	16	0.0023	6.3			
1,3,5-Trimethylbenzene	10	16	0.00087	2.2			
m-Xylene & p-Xylene	12	16	0.0011	6.9	10,000	140,000	
o-Xylene	7	16	0.037	2			
SVOCs							
Acenaphthylene	1	16	0.041	0.041			
Anthracene	2	16	0.055	0.064	500,000	1,000,000	
Benzo[a]anthracene	3	16	0.043	0.25			

Benzo[a]pyrene	2	16	0.04	0.046			**0.096**
Benzo[b]fluoranthene	7	16	0.039	0.56			
Benzo[g,h,i]perylene	2	16	0.099	0.17			
Benzo[k]fluoranthene	3	16	0.054	0.22			
Bis(2-ethylhexyl) phthalate	4	16	0.038	6.4			
Butyl benzyl phthalate	1	16	0.13	0.13	**10,000**	**140,000**	
Carbazole	1	16	0.066	0.066			
Chrysene	5	16	0.051	0.48			
Dibenz(a,h)anthracene	1	16	0.05	0.05			
Di-n-butyl phthalate	2	16	0.041	0.14	**5,000**	**70,000**	
Fluoranthene	5	16	0.057	0.99	**20,000**	**280,000**	
Indeno[1,2,3-cd]pyrene	2	16	0.091	0.15			
1-Methylnaphthalene	8	16	0.046	0.36	**3,500**	**49,000**	
2-Methylnaphthalene	9	16	0.047	0.51	**2,000**	**28,000**	
Phenanthrene	8	16	0.059	0.8			
Pyrene	5	16	0.055	0.7	**1,500**	**21,000**	
Metals							
Aluminum	16	16	3,600	13,000	**50,000**	**700,000**	
Antimony	5	16	1	26	**20**	**280**	
Arsenic	16	16	2.4	30	**15**	**210**	**0.47**
Barium	16	16	19	180	**10,000**	**140,000**	
Beryllium	16	16	0.19	1.7	**100**	**1,400**	
Cadmium	7	16	0.25	1.7	**5**	**70**	
Calcium	16	16	1,300	440,000			
Chromium	16	16	7.8	100			
Cobalt	16	16	2.2	16	**500**	**7,000**	
Copper	16	16	5.1	200	**500**	**7,000**	
Iron	16	16	5700	81,000			
Lead	16	16	8.4	5,500			
Magnesium	16	16	960	7,100			
Manganese	16	16	29	560	**2,500**	**35,000**	
Mercury	16	16	0.013	0.14			
Nickel	16	16	5.1	21	**1,000**	**14,000**	
Potassium	16	16	690	2,700			
Selenium	11	16	0.42	4.6	**250**	**3,500**	
Silver	4	16	0.31	0.8	**250**	**3,500**	

Sodium	12	16	52	420			
Thallium	1	16	0.45	0.45			
Vanadium	16	16	7	35	500	7,000	
Zinc	16	16	15	1,700	15,000	210,000	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 2: Ground Water Data (All concentrations are in µg/L)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Benzene	18	25	0.64	310	5	18	0.64
sec-Butylbenzene	6	25	1.9	15			
tert-Butylbenzene	1	25	0.68	0.68			
p-Cymene	7	25	1.9	20			
1,1-Dichloroethane	1	25	0.85	0.85			
cis-1,2-Dichloroethene	2	25	1.2	8.7	3,000	11,000	
Ethylbenzene	19	25	1.2	1,800	4,000	14,000	
Isopropyl ether	9	25	0.79	17			
Isopropylbenzene	18	25	1.2	83			
Methyl tert-butyl ether	22	25	17	1,600	3,000	11,000	
Naphthalene	13	25	0.2	80	6,000	21,000	
N-Propylbenzene	17	25	0.77	260			
Tetrachloroethene	2	25	53	340	60	210	17
Toluene	10	25	1	450	200	700	
1,2,3-Trimethylbenzene	6	6	12	260			
1,2,4-Trimethylbenzene	15	25	0.83	1,000			
1,3,5-Trimethylbenzene	14	25	1.7	370			
m-Xylene & p-Xylene	8	19	11	750			
o-Xylene	4	19	3.6	71			
Xylenes, Total	6	6	90	4,400	2,000	7,000	
SVOCs							
Acenaphthene	1	13	0.2	0.2	6,000	21,000	
Diethyl phthalate	2	13	0.22	0.25	60,000	210,000	
1-Methylnaphthalene	5	13	0.46	29	700	2,500	
2-Methylnaphthalene	4	13	0.96	46	400	1,400	
Phenanthrene	3	13	0.19	0.28			
Metals							
Aluminum	6	7	66	590	10,000	35,000	

Arsenic	5	7	5.1	30	**3**	**11**	**0.023**
Barium	7	7	57	250	**2,000**	**7,000**	
Calcium	7	7	12,000	110,000			
Chromium	4	7	2	3.2			
Cobalt	1	7	41	41	**100**	**350**	
Copper	1	7	2.7	2.7	**100**	**350**	
Iron	7	7	2,500	25,000			
Magnesium	7	7	7,200	12,000			
Manganese	7	7	250	3,500	**500**	**1,800**	
Mercury	3	7	0.086	0.28			
Nickel	1	7	9.8	9.8	**200**	**700**	
Potassium	7	7	3,200	6,600			
Sodium	7	7	4,500	53,000			
Zinc	5	7	10	310	**3,000**	**11,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 3: Surface Soil Data 0 to 1 Foot (All concentrations are in mg/kg)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	3	3	0.096	0.16	**100,000**	**1,000,000**	
Benzene	1	3	0.0008	0.0008	**25**	**350**	**13**
Methyl ethyl ketone	3	3	0.0059	0.01			
Naphthalene	2	3	0.082	0.093	**30,000**	**420,000**	
Toluene	2	3	0.0011	0.0016	**1,000**	**14,000**	
SVOCs							
Acenaphthylene	1	3	0.054	0.054	**30,000**	**420,000**	
Anthracene	1	3	0.094	0.094	**500,000**	**1,000,000**	
Benzo[a]anthracene	2	3	0.11	0.39			
Benzo[b]fluoranthene	2	3	0.25	1.1			
Benzo[g,h,i]perylene	2	3	0.073	0.27			
Benzo[k]fluoranthene	2	3	0.089	0.39			
Bis(2-ethylhexyl) phthalate	1	3	0.074	0.074			
Carbazole	1	3	0.044	0.044			
Chrysene	2	3	0.2	0.7			
Dibenz(a,h)anthracene	1	3	0.079	0.079			

Fluoranthene	3	3	0.075	0.85	20,000	280,000	
Indeno[1,2,3-cd]pyrene	2	3	0.059	0.26			
1-Methylnaphthalene	2	3	0.095	0.12	3,500	49,000	
2-Methylnaphthalene	2	3	0.13	0.15	2,000	28,000	
Phenanthrene	2	3	0.18	0.24			
Pyrene	3	3	0.078	0.77	1,500	21,000	
Metals							
Aluminum	3	3	6400	6800	50,000	700,000	
Antimony	1	3	1	1	20	280	
Arsenic	3	3	3.3	7.3	15	210	0.47
Barium	3	3	27	130	10,000	140,000	
Beryllium	3	3	0.21	0.92	100	1,400	
Cadmium	2	3	0.22	0.26	5	70	
Calcium	3	3	6000	37000			
Chromium	3	3	7.1	88			
Cobalt	3	3	1.7	7.4	500	7,000	
Copper	3	3	5.1	36	500	7,000	
Iron	3	3	10000	41000			
Lead	3	3	9.6	250			
Magnesium	3	3	550	2400			
Manganese	3	3	70	1100	2,500	35,000	
Mercury	3	3	0.049	0.083			
Nickel	3	3	3.5	14	1,000	14,000	
Potassium	3	3	560	890			
Selenium	2	3	0.63	0.68	250	3,500	
Vanadium	3	3	13	28	500	7,000	
Zinc	3	3	16	59	15,000	210,000	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 3: Surface Water Data (All concentrations are in µg/L)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Chloroethane	1	4	24	24			
1,1-Dichloroethane	1	4	9.9	9.9			
cis-1,2-Dichloroethene	1	4	170	170	3,000	11,000	
Methyl tert-butyl ether	1	4	12	12	3,000	11,000	

Tetrachloroethene	1	4	6.3	6.3	**60**	**210**	**17**
1,1,1-Trichloroethane	1	4	7.3	7.3	**200,000**	**700,000**	
Trichloroethene	1	4	10	10	**5**	**18**	**0.76**
Vinyl chloride	1	4	23	23	**30**	**110**	**0.025**
Metals							
Aluminum	2	2	57	3400	**10,000**	**35,000**	
Arsenic	1	2	5.3	5.3	**3**	**11**	**0.023**
Barium	2	2	110	170	**2,000**	**7,000**	
Calcium	2	2	68,000	77,000			
Chromium	1	2	3.9	3.9			
Copper	1	2	6.4	6.4	**100**	**350**	
Iron	2	2	1,900	15,000			
Lead	1	2	7.1	7.1			
Magnesium	2	2	9,600	11,000			
Manganese	2	2	810	970	**500**	**1,800**	
Mercury	1	2	0.15	0.15			
Nickel	1	2	5.9	5.9	**200**	**700**	
Potassium	2	2	6,300	7,200			
Sodium	2	2	16,000	17,000			
Vanadium	1	2	5.9	5.9	**100**	**350**	
Zinc	1	2	38	38	**3,000**	**11,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 3: Sediment Data (All concentrations are in mg/kg)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	2	2	0.26	0.39	**100,000**	**1,000,000**	
Methyl ethyl ketone	2	2	0.019	0.025			
Toluene	1	2	0.0031	0.0031	**1,000**	**14,000**	
SVOCs							
Bis(2-ethylhexyl) phthalate	1	2	0.08	0.08			
Chrysene	1	2	0.086	0.086			
Fluoranthene	1	2	0.1	0.1	**20,000**	**280,000**	
Phenanthrene	1	2	0.099	0.099			
Pyrene	1	2	0.087	0.087	**1,500**	**21,000**	
Metals							

Aluminum	2	2	5,000	5,200	**50,000**	**700,000**	
Arsenic	2	2	3.4	7.7	**15**	**210**	**0.47**
Barium	2	2	72	85	**10,000**	**140,000**	
Beryllium	2	2	0.38	0.46	**100**	**1,400**	
Cadmium	2	2	0.1	0.17	**5**	**70**	
Calcium	2	2	1,500	1,900			
Chromium	2	2	6.3	8.8			
Cobalt	2	2	4.1	5.6	**500**	**7,000**	
Copper	2	2	8.3	11	**500**	**7,000**	
Iron	2	2	14,000	23,000			
Lead	2	2	14	32			
Magnesium	2	2	680	750			
Manganese	2	2	260	530	**2,500**	**35,000**	
Mercury	1	2	0.038	0.038			
Nickel	2	2	7.5	9.8	**1,000**	**14,000**	
Potassium	2	2	600	620			
Vanadium	2	2	8.8	9.6	**500**	**7,000**	
Zinc	2	2	52	53	**15,000**	**210,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 4: Surface Soil Data 0 to 1 Foot (All concentrations are in mg/kg)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	1	2	0.12	0.12	**100,000**	**1,000,000**	
Benzene	1	2	0.045	0.045	**25**	**350**	**13**
Ethylbenzene	2	2	0.0025	0.051	**20,000**	**280,000**	
Methyl ethyl ketone	1	2	0.0068	0.0068			
Naphthalene	1	2	0.27	0.27	**30,000**	**420,000**	
Tetrachloroethene	2	2	0.0023	0.072	**300**	**4,200**	**330**
Toluene	2	2	0.0027	0.27	**1,000**	**14,000**	
1,2,4-Trimethylbenzene	1	2	0.12	0.12			
1,3,5-Trimethylbenzene	1	2	0.041	0.041			
m-Xylene & p-Xylene	2	2	0.007	0.25	**10,000**	**140,000**	
o-Xylene	2	2	0.002	0.16			
SVOCs							
Benzo[a]anthracene	1	2	0.056	0.056			

Benzo[b]fluoranthene	1	2	0.2	0.2			
Benzo[k]fluoranthene	1	2	0.07	0.07			
Bis(2-ethylhexyl) phthalate	2	2	0.14	1.6			
Butyl benzyl phthalate	1	2	3.7	3.7	**10,000**	**140,000**	
Chrysene	1	2	0.17	0.17			
Fluoranthene	1	2	0.14	0.14	**20,000**	**280,000**	
1-Methylnaphthalene	2	2	0.14	0.22	**3,500**	**49,000**	
2-Methylnaphthalene	2	2	0.18	0.29	**2,000**	**28,000**	
Phenanthrene	2	2	0.15	0.25			
Phenol	1	2	0.67	0.67	**15,000**	**210,000**	
Pyrene	1	2	0.14	0.14	**1,500**	**21,000**	
Metals							
Aluminum	2	2	5,700	7,400	**50,000**	**700,000**	
Antimony	2	2	5.6	41	**20**	**280**	
Arsenic	2	2	4.1	9.9	**15**	**210**	**0.47**
Barium	2	2	66	69	**10,000**	**140,000**	
Beryllium	2	2	0.4	0.69	**100**	**1,400**	
Cadmium	2	2	0.41	0.54	**5**	**70**	
Calcium	2	2	200,000	220,000			
Chromium	2	2	21	27			
Cobalt	2	2	5.6	8.7	**500**	**7,000**	
Copper	2	2	25	35	**500**	**7,000**	
Iron	2	2	15,000	24,000			
Lead	2	2	910	4000			
Magnesium	2	2	8,000	12,000			
Manganese	2	2	200	360	**2,500**	**35,000**	
Mercury	2	2	0.02	0.084			
Nickel	2	2	13	18	**1,000**	**14,000**	
Potassium	2	2	1,100	1,400			
Sodium	2	2	90	97			
Vanadium	2	2	7.2	12	**500**	**7,000**	
Zinc	2	2	46	110	**15,000**	**210,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 4: Ground Water Data (All concentrations are in µg/L)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	

VOCs							
Methyl tert-butyl ether	1	1	33	33	**3,000**	**11,000**	
SVOCs							
Di-n-butyl phthalate	1	1	2.8	2.8	**1,000**	**3,500**	
Metals							
Barium	1	1	170	170	**2,000**	**7,000**	
Calcium	1	1	230,000	230,000			
Iron	1	1	3,600	3,600			
Magnesium	1	1	14,000	14,000			
Manganese	1	1	1,100	1,100	**500**	**1,800**	
Nickel	1	1	7.3	7.3	**200**	**700**	
Potassium	1	1	7,800	7,800			
Sodium	1	1	15,000	15,000			
Zinc	1	1	19	19	**3,000**	**11,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 4: Surface Water Data (All concentrations are in µg/L)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Benzene	1	3	1.2	1.2	**5**	**18**	**0.64**
Chloroethane	1	3	4.4	4.4			
1,1-Dichloroethane	1	3	1.9	1.9			
cis-1,2-Dichloroethene	1	3	24	24	**3,000**	**11,000**	
Methyl tert-butyl ether	3	3	4.2	36	**3,000**	**11,000**	
Tetrachloroethene	1	3	1.5	1.5	**60**	**210**	**17**
Trichloroethene	1	3	4	4	**5**	**18**	**0.76**
Vinyl chloride	1	3	2.9	2.9	**30**	**110**	**0.025**
SVOCs							
Acenaphthene	1	3	0.15	0.15	**6,000**	**21,000**	
Benzo[a]anthracene	1	3	0.23	0.23			
Benzo[b]fluoranthene	1	3	0.25	0.25			
Benzo[k]fluoranthene	1	3	0.21	0.21			
Chrysene	1	3	0.21	0.21			
Fluoranthene	1	3	0.44	0.44	**4,000**	**14,000**	
Phenanthrene	1	3	0.32	0.32			
Pyrene	1	3	0.27	0.27	**300**	**1,100**	
Metals							

Aluminum	2	2	69	660	**10.000**	**35,000**	
Barium	2	2	150	200	**2,000**	**7,000**	
Calcium	2	2	72,000	86,000			
Chromium	1	2	6.4	6.4			
Copper	1	2	5	5	**100**	**350**	
Iron	2	2	1,300	26,000			
Lead	1	2	34	34			
Magnesium	2	2	8,300	9,100			
Manganese	2	2	360	570	**500**	**1,800**	
Potassium	2	2	7,100	7,200			
Sodium	2	2	5,700	9,900			
Vanadium	1	2	2.1	2.1	**100**	**350**	
Zinc	1	2	9	9	**3,000**	**11,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

Tract 4: Sediment Data (All concentrations are in mg/kg)

Contaminant	Number of detects	Number of samples	Minimum conc.	Maximum conc.	Comparison Value		CREG
					Child	Adult	
VOCs							
Acetone	2	2	0.25	1.1	**100,000**	**1,000,000**	
Benzene	1	2	0.0036	0.0036	**25**	**350**	**13**
Chloroethane	1	2	0.006	0.006			
1,1-Dichloroethane	1	2	0.0025	0.0025			
cis-1,2-Dichloroethene	1	2	0.021	0.021	**15,000**	**210,000**	
trans-1,2-Dichloroethene	1	2	0.0038	0.0038	**10,000**	**140,000**	
Methyl ethyl ketone	2	2	0.026	0.06			
Methyl tert-butyl ether	1	2	0.038	0.038	**15,000**	**210,000**	
Naphthalene	1	2	0.16	0.16	**30,000**	**420,000**	
Tetrachloroethene	1	2	0.0038	0.0038	**300**	**4,200**	**330**
Toluene	2	2	0.0016	0.0035	**1,000**	**14,000**	
Trichloroethene	1	2	0.0046	0.0046	**25**	**350**	**15**
Vinyl chloride	1	2	0.041	0.041	**150**	**2,100**	**0.5**
SVOCs							

Acenaphthene	1	2	0.15	0.15	**30,000**	**420,000**	
Anthracene	1	2	0.23	0.23	**500,000**	**1,000,000**	
Benzo[a]anthracene	2	2	0.46	0.86			
Benzo[b]fluoranthene	2	2	1.1	1.6			
Benzo[g,h,i]perylene	1	2	0.2	0.2			
Benzo[k]fluoranthene	2	2	0.44	0.76			
Bis(2-ethylhexyl) phthalate	2	2	0.13	0.49			
Chrysene	2	2	0.9	1.5			
Fluoranthene	2	2	1.4	2	**20,000**	**280,000**	
Fluorene	1	2	0.13	0.13	**20,000**	**280,000**	
Indeno[1,2,3-cd]pyrene	1	2	0.2	0.2			
1-Methylnaphthalene	1	2	0.14	0.14	**3,500**	**49,000**	
2-Methylnaphthalene	1	2	0.2	0.2	**2,000**	**28,000**	
Phenanthrene	2	2	0.68	0.84			
Pyrene	2	2	1.3	2	**1,500**	**21,000**	
Metals							
Aluminum	2	2	1,400	3,700	**50,000**	**700,000**	
Antimony	1	2	0.96	0.96	**20**	**280**	
Arsenic	2	2	4.4	6.6	**15**	**210**	**0.47**
Barium	2	2	78	80	**10,000**	**140,000**	
Beryllium	2	2	0.2	0.34	**100**	**1,400**	
Cadmium	1	2	0.51	0.51	**5**	**70**	
Calcium	2	2	36,000	39,000			
Chromium	2	2	41	60			
Cobalt	2	2	1.7	4.2	**500**	**7,000**	
Copper	2	2	15	47	**500**	**7,000**	
Iron	2	2	24,000	43,000			
Lead	2	2	180	290			
Magnesium	2	2	1,900	2,900			
Manganese	2	2	160	450	**2,500**	**35,000**	
Mercury	2	2	0.024	0.056			
Nickel	2	2	3.8	9.8	**1,000**	**14,000**	

Potassium	2	2	340	710			
Selenium	2	2	0.86	0.86	**250**	**3,500**	
Sodium	1	2	48	48			
Vanadium	2	2	4.6	8.8	**500**	**7,000**	
Zinc	2	2	25	80	**15,000**	**210,000**	

(*Source:* Arcadis) CREG = Cancer Risk Evaluation Guide. **Green** = Chronic Environmental Media Evaluation Guide (Hierarchy 1). **Orange** = Intermediate Environmental Media Evaluation Guide (Hierarchy 2). **Blue** = Reference Dose Media Evaluation Guide (Hierarchy 2).

APPENDIX H: Glossary

Acute
Occurring over a short time.

Acute exposure

Contact with a substance that occurs once or for only a short time (up to 14 days).

Adverse health effect

A change in body function or cell structure that might lead to disease or health problems.

Ambient
Surrounding (for example, *ambient* air).

Background level

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk for getting cancer if exposed to a substance every day for 80 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time.

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year).

Comparison value (CV)

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact

Contact with (touching) the skin [see route of exposure].

Dose
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship

The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media

Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment

The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure investigation

The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway

The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous waste

Potentially harmful substances that have been released or discarded into the environment.

Incidence
The number of new cases of disease in a defined population over a specific time period.

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Minimal risk level (MRL)

An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)

EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

Population

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Public health assessment (PHA)

An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health.

Reference dose (RfD)

An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Route of exposure

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Sample

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size

The number of units chosen from a population or an environment.

Source of contamination

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, industrial site, or drum. A source of contamination is the first part of an exposure pathway.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Surface water

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Volatile organic compounds (VOCs)

Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.