LETTER HEALTH CONSULTATION

Evaluation of the Potential Public Health Implications Associated with the Brownfields Redevelopment of a Former Manufactured Gas Facility (Sections A and B) : An EPA Targeted Brownfield Assessment Site

Sterling, Logan County, Colorado

6/20/2013

Prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). This document has not been reviewed and cleared by ATSDR.

LETTER HEALTH CONSULTATION

TO: Alissa Schultz, Project Manager, HMWMD/CDPHE

FROM: Thomas Simmons, Health Assessor, CCPEHA/DCEED/CDPHE

SUBJECT: Evaluation of the Potential Public Health Implications Associated with the Redevelopment of a former Manufactured Gas Facility (Sections A and B) in Sterling, Logan County, Colorado

CC: Raj Goyal, Principal Investigator, CCPEHA/DCEED/CDPHE

DATE: 6/20/2013

Ms. Schultz,

This letter health consultation is in response to your request for an evaluation of the potential public health implications associated with exposure to site-related contaminants in soil at the former Sterling Manufactured Gas Facility located in Sterling, Logan County, Colorado. In March 2012, Centennial Mental Health Center (CMHC) of Sterling, Colorado, submitted a Targeted Brownfields Assessment (TBA) application to the Colorado Department of Public Health and Environment‘s (CDPHE) Hazardous Materials and Waste Management Division (HMWMD) for their assistance in evaluating any site-related contamination associated with the former gas manufacturing facility (the site) if the site were to be redeveloped in the future. This letter health consultation considers the potential public health implications of contaminated soil based on what is currently known of the proposed future land use at the site. Please note that the evaluation of groundwater data is beyond the scope of this letter health consultation. If requested, the possible public health implications of exposure to contaminants in groundwater can be evaluated in a separate letter health consultation. If changes are made to the proposed plans, the conclusions made in this health consultation may be inaccurate and in need of revision.

Background

The site under consideration is located at 205 South 3rd Avenue, Sterling, Logan County, Colorado. From around 1931-1951, Central States Gas and Electric Company ran a manufactured gas facility at the site for the first 15 years of operation and distributed propane during the remaining 5 years of ownership. From 1951 to 1986, the site was owned and operated by Iowa Electric Light and Power Company, which used the facility to distribute natural gas. The Public Service Company of Colorado owned the property from 1986 to approximately 2005, which also distributed natural gas to the Sterling community. Former onsite features consisted of at least a 33,000 cubic foot steel gasoline above ground storage tank (AST) that was situated on 3 foot concrete piers; four iron

gasoline ASTs, a concrete-lined tar pit/underground storage tank (UST), a tar AST, a 25,000 cubic foot gas holder, a purifier, and numerous other oil and gas ASTs (CDPHE 2012). As per aerial photography, it appears that the majority of the storage tanks had been removed by August 30, 2006 (Google Earth). The last of the onsite buildings were demolished in August 2008, according to the Sterling Public Works Department. The site has remained vacant since that time, consisting only of grass and soil ground-cover (CDPHE 2013). Currently, Land Leasing Company, LLC owns the 1.22 acre parcel under consideration, which is located in a mixed commercial and residential area near downtown Sterling.

In March 2012, Centennial Metal Health Center (CMHC) submitted an application for Targeted Brownfields Assessment assistance to the Colorado Department of Public Health and Environment's Brownfields Program. According to that application, the current owner of the property (Land Leasing Company, LLC) intends to donate a portion of the land to CMHC, which in turn, plans to develop approximately 2/3 of the vacant lot into a paved parking lot that will be used by employees and clients of the CMHC. The remaining area of the parcel will remain undeveloped at this time and be held for future commercial development (CDPHE 2012). Soil and groundwater contamination has been identified onsite through previous investigations conducted in 2008, 2009, and 2011. In general, the gas manufacturing process produced residues, known as coal tars, primarily composed of polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), phenols and inorganic constituents such as ammonia, lead and cyanide. Coal tar deposits can exist in four fractions: solid/semi-solid, light non-aqueous phase liquid (LNAPL), dense non-aqueous phase liquid (DNAPL), and a water soluble fraction (CDPHE 2013).

Historically, the following onsite soil contaminants have been identified by the HMWMD (CDPHE 2012): benzene, ethylbenzene, naphthalene, benzo(a)anthracene, 2-methylpaphthalene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, bis-2- ethylhexyl phthalate, and 4-nitrophenol). Due to the former use of the site as a manufactured gas facility and potentially associated contamination identified in soil, CDPHE indicated that further assessment with respect to the site is warranted prior to redevelopment. CDPHE recommended an additional Limited Site Investigation (LSI) be conducted at the site in order to determine the current extent of contamination due to former onsite uses. The LSI would include soil sampling for chemicals of potential concern (COPC). Results of the LSI would help to determine if remediation and/or a soils management plan is necessary prior to or during redevelopment activities at the site. CDPHE conducted this LSI (i.e., Phase II) in 2012 (CDPHE 2012).

Soil Data

The data utilized in this evaluation consists of subsurface soil sampling collected by CDPHE during the Phase II LSI (CDPHE 2012). Field work for the LSI was conducted during the week of July 30th, 2012. The Sampling and Analysis Plan (SAP) for the LSI initially called for the collection of seven subsurface soil samples and three surficial soil

samples. However, CDPHE did not observe soil staining on the ground surface at the site; therefore, the designated surficial soil samples were not collected.

A total of seven co-located subsurface soil samples were collected from the soil bores produced during installation of the new ground water monitoring wells. In addition, one QA/QC sample was also collected. Soil samples were collected via split-spoon sampling methods by a dual-capability hydraulic push/hollow stem auger drill operated by Drilling Engineers, Inc. according to CDPHE Standard Operating Procedures. Soil samples were analyzed by Pace Analytical Laboratory in Lenexa, Kansas utilizing approved EPA methods. All soil samples were analyzed for volatile organic compounds, semi-volatile organic compounds, and total 8 Resource Conservation and Recovery Act metals. Soil sample results are shown in Table A1. The primary soil contaminants identified in the subsurface sampling include PAHs and metals. Specifically, naphthalene, benzo(a)pyrene, benzo(a)anthracene, benzo (b)fluoranthene, arsenic, and chromium were detected at levels of potential concern. Soil sample results are discussed in more detail in the COPC Selection below.

Selection of Contaminants of Potential Concern

To identify contaminants of potential concern (COPCs), the soil and groundwater data was screened against comparison values established by the ATSDR and EPA. The screening values from both agencies were reviewed and the most conservative value was selected as the Comparison Value (CV). The screening values used to identify COPCs in this evaluation were derived for residential exposure scenarios. ATSDR's comparison values for chronic exposures are based on daily exposure to contaminants over a period longer than 1 year. The EPA's Regional Screening Levels (RSL) for residential exposures are based on 350 days of exposure per year over a period of 30 years (assumes 15 days away from the home per year). Using these CVs for screening is considered conservative and protective of individuals that might come into contact with soil and groundwater contaminants after the redevelopment of the site into a parking lot, and potentially, a future commercial property. Therefore, if the maximum concentration of a particular contaminant is below the CV it is dropped from further evaluation. If the maximum concentration of the contaminant is above the CV; it is generally retained for further analysis as a COPC. However, exceeding the CV does not indicate that a health hazard exists; only that additional evaluation is warranted.

The soil COPC selection is shown in Table A2. Seven contaminants were detected in onsite soils at concentrations exceeding the CVs. This includes the metals arsenic and chromium, as well as, naphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene, which are PAHs.

Metals, including arsenic and chromium, are naturally occurring soil contaminants. The concentrations of arsenic and chromium found at the site are fairly consistent throughout the site and in range of normally occurring background concentrations in soil in Colorado (CDPHE 2013). However, both contaminants were retained for further evaluation as COPCs because they are known human carcinogens (Class A) that exceeded the CVs. Please note that chromium speciation was not conducted during laboratory analysis.

Therefore, the chromium detected in soil at the site was assumed to be the most toxic form of chromium (hexavalent chromium or chromium VI). This is a conservative approach in that the total chromium found at the site most likely contains a significant fraction of the less toxic trivalent chromium. The concentration of arsenic found in onsite soil ranges from 2.7 – 8.5 mg/kg. Chromium concentrations in onsite soil ranged from 4.8 – 11.5 mg/kg. Both metal contaminants were detected in all seven soil samples collected from the site.

On the other hand, PAHs found in onsite soils appear to follow a discernible pattern. They were detected in 2 of the 7 soil samples collected (SB-1 and SB-3). Sampling location SB-1 is located in the northwestern portion of the site at a depth of 4-6 ft. and SB-3 is located in the northeastern portion of the site at a depth of 2-4 ft. (Figure A2). Generally speaking, a smaller number of PAHs were detected in SB-1, but at higher concentrations than found in SB-3. The respective concentration range of naphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene are as follows: 0.815 – 53.8 mg/kg, 1.88 – 5.27 mg/kg, 1.86 – 4.99 mg/kg, Not Detected – 1.02 mg/kg, and Not Detected to 1.0 mg/kg. All PAHs that exceeded the CVs in soil were retained for further evaluation as COPCs.

It should be noted that there are PAHs that were detected in subsurfcace soil, which do not have screening values available. This includes acenaphthylene, phenanthrene, and benzo(g,h,i)perylene.. These PAHs were detected at low concentrations and also follow the same dispersion pattern as the other PAHs that were selected as COPCs. These contaminants are evaluated qualitatively. Exposures to these compounds are not likely to be significant but are noted as a source of uncertainty (i.e., potential underestimation) in the uncertainty analysis.

Exposure Assessment and Conceptual Site Model

The site is currently vacant and access is unrestricted. No significant exposure to any site-related contamination is likely to be occurring at this time because the only known current use of the site is by those conducting environmental investigations and site visits, which is not likely to result in any significant exposure since trained professionals are typically present during these times or the exposure to contaminants is minimal. This health consultation evaluates potential future exposures to soil contaminants. Evaluating potential exposures to contaminants through other media (e.g., groundwater and indoor air) is beyond the scope of this health consultation.

According to the CMHC plans for redevelopment, approximately 2/3 of the site will be developed into a paved parking lot with a detention pond to catch run-off (CDPHE 2013). Exposure to soil contaminants in this area is likely to occur during construction of the parking area. Once the parking lot has been constructed, exposure to soil is likely to be minimal since the paved parking will limit contact with soil and the detention pond will essentially be unused open space. Therefore, a short-term construction worker is a primary exposure scenario of potential concern in the parking lot/detention pond area.

The immediate plans for the remaining area of the site will remain undeveloped and held for future commercial development. In the interim, exposure to soil contaminants in the undeveloped portion is likely to be minimal and similar to the current exposure scenarios that occur at the site (e.g. site visits, environmental investigation, etc.). If this area of the site is redeveloped into commercial property in the future, the primary exposure scenario could potentially include a variety of workers depending on the type of business(es) that purchase the property. Therefore, a scenario that encompasses a variety of potential commercial/industrial worker exposures is of potential concern in this area.

Following the redevelopment effort, future workers will likely be exposed to soil contaminants via three routes of exposure to COPCs: 1) incidental ingestion of surface soil, 2) dermal contact with surface soil, and 3) inhalation of soil particles suspended in air (fugitive dust). Inhalation of dust is typically not considered an important pathway in terms of public health unless there is evidence to suggest a significant mechanical disturbance of the soil as in ATV riding and/or high, sustained winds. At this site, no such evidence exists, so this pathway was not quantitatively evaluated in this health consultation. While there may be some exposure that is unaccounted for from inhalation of fugitive dusts, this pathway is not likely to significantly alter the body burden of doses received from incidental ingestion and dermal exposure. Thus, incidental ingestion and dermal exposure to soil are considered the primary pathways of exposure to soil contaminants at the site. Both pathways were quantitatively evaluated in this health consultation.

A summary of the exposure assessment information is presented below in the Conceptual Site Model.

Conceptual Site Model

Source	Area of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure	Pathway Designation
Soil	205 South 3rd Avenue, Sterling, CO	Subsurface Soil	Future	Construction and Commercial/ Industrial Workers	Incidental Soil Ingestion	Potential
					Dermal Exposure to Soil Contaminants	Potential
					Inhalation of Fugitive Dust	Potential*

NOTE: * Inhalation of fugitive dusts is not considered an important exposure scenario in this evaluation because there is no evidence to suggest any significant mechanical disturbance of soil at the site. Therefore, the concentration of soil contaminants in dust is likely to be low and is not quantitatively evaluated in this health consultation.

Public Health Implications

The potential for non-cancer and cancer health effects is evaluated independently due to differences in methods of health risk estimation. For example, the exposure dose for calculating estimated cancer risk is averaged over the lifetime of the individual whereas the exposure dose for non-cancer health hazards is averaged over the duration of exposure. To evaluate the potential for non-cancer health effects, the estimated exposure dose for each COPC is compared to health-based guidelines developed by the ATSDR and EPA. If the estimated exposure dose is below the health-based guidelines, adverse non-cancer health effects are not likely to occur. If the estimated non-cancer exposure dose is above the health-based guideline, additional evaluation of the potential health effects associated with the exposure is warranted. To evaluate potential cancer risks, the estimated theoretical lifetime risks for cancer are compared with the EPA target cancer risk range of 1×10^{-6} to 1×10^{-4}, or one excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

In this case, non-cancer and cancer doses must be calculated for incidental ingestion and dermal exposure to soil. The non-cancer incidental ingestion dose calculation results and associated hazard quotients are shown in Tables A3 and A4, respectively. The non-cancer dermal dose results and associated hazard quotients are shown in Tables A5 and A6. The estimated cancer doses and associated risks follow the same pattern and are shown in Tables A7-A10. In addition, the estimated doses from each exposure pathway were combined to estimate cumulative non-cancer health hazards and cumulative cancer risks. The resulting cumulative non-cancer health hazards and cancer risks are discussed in more detail below.

Contaminant exposure doses for future construction workers were estimated using the maximum detected concentration and the standard default exposure factors established by the EPA and the ATSDR. This includes incidental ingestion of 330 milligrams of soil per day for 250 days per year over a period of 2 years. For commercial/industrial workers, the estimated doses were derived using 100 mg. of soil per day for 250 days per year over a period of 25 years. As mentioned previously, the estimation of cancer risk is averaged over a lifetime, which is assumed to be 70 years in this evaluation. For dermal dose calculations, the same exposure frequency and duration were used in the dose calculations. The adult construction and commercial/industrial worker was assumed to wear a short-sleeved shirt, long pants, and shoes; therefore, the exposed skin surface is limited to the head, hands, and forearms. The EPA recommended dermal absorption factor for PAHs is 0.13 and for arsenic is 0.03, and skin surface area exposed to contaminated soil for the adult construction and commercial/industrial worker is 3,300 cm^2, which is the average of the 50th percentile for males and females greater than 18 years of age (EPA 2004). In addition, the soil adherence factor of 0.3 mg/ cm^2 (95th percentile value) was used for the construction worker (and the soil adherence factor of 0.2 mg/ cm^2 was used for the commercial/industrial worker (EPA 2004).

In addition, it should be noted that non-cancer health-based guidelines are not available for PAH compounds with the exception of naphthalene. Thus, only carcinogenic risks were estimated for benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene. Many

PAHs are classified as a "probable human carcinogen" by the USEPA. PAHs are generally treated similarly in risk assessments due to their similar structures and toxicities. Per EPA guidance, the cancer risks of individual carcinogenic PAHs were estimated in terms of benzo(a)pyrene toxicity equivalents and adding the cancer risk for all PAHs. Non-cancer toxicity values (or health guidelines) have not been developed by the federal or state agencies for carcinogenic PAHs. This is addressed as a source of uncertainty. Per EPA guidance, a dermal exposure to contaminated soil is only considered significant for arsenic and PAHs in this health consultation (EPA 2004). Therefore, dermal exposure to chromium was not considered in this evaluation.

Construction Workers

As shown in Table 1 below, the estimated non-cancer doses for construction workers from exposure to each COPC at the maximum detected concentration in soil at the site is lower than the associated health-based guideline for these contaminants. Moreover, the combined hazard index (sum of hazard quotient from each COPC) shown in Table 2 from exposure to all COPCs combined is also below the acceptable level of 1. This indicates that cumulative exposure to soil COPCs during construction work is not likely to result in adverse non-cancer health effects at this site. Please note that these findings are based on the conservative assumptions that all chromium is in the hexavalent form and 100% of the metals found in soil are bioavailable.

Table 1. Estimated Non-cancer Exposure Doses from Incidental Ingestion and Dermal Exposure to Soil during Construction Work

COPC	Incidental Ingestion (in mg/kg-day)	Dermal Exposure (in mg/kg-day)	Combined Non-cancer Doses (in mg/kg-day)	Non-cancer Health-based Guideline (in mg/kg-day)
Naphthalene	5.3E-05	4.52E-05	9.8E-05	2.0E-02
Arsenic	8.3E-06	1.65E-06	1.0E-05	3.0E-04
Chromium	1.1E-05	--	1.1E-05	9.0E-04

NOTE: COPC: Contaminant of Potential Concern, 5.3E-05 is equivalent to $5.3 * 10^{-5}$ or 0.000053, mg/kg-day = milligram per kilogram-day

Table 2. Estimated Non-cancer Hazard Quotients from Incidental Ingestion and Dermal Exposure to Soil during Construction Work

COPC	Incidental Ingestion Hazard Quotient	Dermal Exposure Hazard Quotient	Combined Non-cancer Hazard Quotients
Naphthalene	2.6E-03	2.26E-03	4.9E-03
Arsenic	2.8E-02	5.49E-03	3.3E-02
Chromium	1.3E-02	--	1.3E-02
Hazard Index	**4.3E-02**	**7.7E-03**	**5.1E-02**

NOTE: COPC: Contaminant of Potential Concern, 2.6E-03 is equivalent to $2.6 * 10^{-3}$ or 0.0026,

The estimated cancer risks for construction workers are also within the target cancer risk range established by the EPA. As shown in Table 3 below, the estimated cancer risks for construction workers are roughly equal to, or lower than, the low-end of the EPA target cancer risk range. In addition, the cumulative cancer risk from incidental ingestion and dermal exposure to all COPCs is also at the low-end of the target cancer risk range. The estimated cumulative cancer risk for construction workers is 6.6E-06, which means approximately 7 additional cancer cases might occur out of a million people exposed to PAHs, arsenic and chromium in soil at the site. This indicates a very low risk of developing cancer while performing construction work at the site.

Overall, the estimated non-cancer and cancer risks are likely to be overestimated and are associated with a very low risk of developing adverse health effects from exposure to site-related contaminants in soil during construction work.

Table 3. Estimated Cancer Risks associated with Incidental Ingestion and of Dermal Exposure to Soil during Construction Work

COPC	Cancer Risks Associated with Incidental Ingestion	Cancer Risks Associated with Dermal Exposure	Combined Cancer Risks from Incidental Ingestion and Dermal Exposures
Arsenic	3.56E-07	7.06E-08	4.27E-07
Chromium	1.61E-07	--	1.61E-07
Benzo(a)anthracene	1.08E-07	9.23E-08	2.00E-07
Benzo(a)pyrene	1.02E-06	8.74E-07	1.89E-06
Benzo(b)fluoranthene	2.08E-08	1.79E-08	3.87E-08
Indeno(1,2,3-cd)pyrene	6.7E-08	1.8E-08	8.49E-08
Total Cancer Risk	**5.6E-06**	**1.1E-06**	**6.6E-06**

NOTE: COPC: Contaminant of Potential Concern, 6.6E-06 is equivalent to 6.6 * 10^{-6} or 6.6 excess cancer cases per million people exposed, Cancer Risks are calculated by multiplying the estimated cancer dose by the oral slope factor for the contaminant, Total cancer risk is the sum of all individual cancer risks.

Future Commercial/Industrial Workers

As shown in Table 4 below, the estimated non-cancer doses for the future commercial/industrial worker from exposure to all COPCs in soil at the site are lower than the associated health-based guideline for these contaminants. In addition, the hazard index shown in Table 5 from exposure to all COPCs combined is also below the benchmark level of 1. This indicates a very low increased risk of the future commercial/industrial worker developing non-cancer health effects from exposure to COPCs identified in onsite soil.

Table 4. Estimated Non-cancer Exposure Doses from Incidental Ingestion and Dermal Exposure to Soil by the Future Commercial/Industrial Worker

COPC	Incidental Ingestion (in mg/kg-day)	Dermal Exposure (in mg/kg-day)	Combined Non-cancer Doses (in mg/kg-day)	Non-cancer Health-based Guideline (in mg/kg-day)
Naphthalene	2.6E-05	4.52E-05	7.1E-05	2.0E-02
Arsenic	4.2E-06	1.65E-06	5.8E-06	3.0E-04
Chromium	5.6E-06	--	5.6E-06	9.0E-04

NOTE: COPC: Contaminant of Potential Concern, 5.3E-05 is equivalent to 5.3 * 10^{-5} or 0.000053, mg/kg-day = milligram per kilogram-day

Table 5. Estimated Non-cancer Hazard Quotients from Incidental Ingestion and Dermal Exposure to Soil during Future Commercial/Industrial Work

COPC	Incidental Ingestion Hazard Quotient	Dermal Exposure Hazard Quotient	Combined Non-cancer Hazard Quotients
Naphthalene	1.3E-03	2.26E-03	3.6E-03
Arsenic	1.4E-02	5.49E-03	1.9E-02
Chromium	6.3E-03		6.3E-03
Hazard Index	**2.1E-02**	**7.7E-03**	**2.9E-02**

NOTE: COPC: Contaminant of Potential Concern, 1.3E-03 is equivalent to 1.3 * 10^{-3} or 0.0013

The estimated cancer risks for future commercial/industrial workers that are associated with soil exposure to site-related contaminants are shown below in Table 6. The estimated cancer risks are within the target cancer risk range established by the EPA. The highest estimated lifetime cancer risk for the future commercial/industrial worker over a period of 25 years at the maximum detected concentration for an individual chemical is for benzo(a)pyrene, which is equivalent to 1.7 X 10^{-5}, which means out of million people

exposed 17 additional cancer cases might occur. The estimated cancer risks for cumulative exposure to all COPCs in soil is 3.5 X 10^{-5}, which indicates that 35 additional cancer cases could occur out of million future commercial/industrial workers exposed. This level of cancer risk is well within the EPA target cancer risk range, particularly considering the conservative exposure assumption of chromium found onsite as hexavalent chromium and 100% bioavailability of all metals. Thus, the estimated cancer risks for future commercial/industrial workers are likely to be over-estimated in this evaluation.

Overall, the estimated non-cancer and cancer risks for future commercial/industrial workers are likely to be overestimated and are associated with a very low risk of developing adverse health effects from exposure to site-related contaminants in soil. However, since the majority of the cumulative cancer risk for these workers is attributable to benzo(a)pyrene, a contaminant associated with former activities at the site, all reasonable measures should be taken to reduce exposure to benzo(a)pyrene from onsite soils to reduce cancer risks even further.

Table 6. Estimated Cancer Risks associated with Incidental Ingestion and Dermal Exposure to Soil during Future Commercial/Industrial Work

COPC	Cancer Risks Associated with Incidental Ingestion	Cancer Risks Associated with Dermal Exposure	Combined Cancer Risks from Incidental Ingestion and Dermal Exposures
Arsenic	4.5E-06	8.8E-07	5.34E-06
Chromium	2.0E-06	--	2.01E-06
Benzo(a) anthracene	1.3E-06	1.2E-06	2.50E-06
Benzo(a) pyrene	1.3E-05	1.1E-05	2.37E-05
Benzo(b) fluoranthene	2.6E-07	2.2E-07	4.83E-07
Indeno(1,2,3-cd)pyrene	2.6E-07	2.2E-07	4.74E-07
Total Cancer Risks	**2.1E-05**	**1.3E-05**	**3.45E-05**

NOTE: COPC: Contaminant of Potential Concern, 2.1E-05 is equivalent to 2.1 * 10^{-5} or 21 excess cancer cases per million people exposed, Cancer Risks are calculated by multiplying the estimated cancer dose by the oral slope factor for the contaminant, and Total cancer risk is the sum of all individual cancer risks.

Uncertainty/Limitations of the Evaluation

In general, any risk evaluation is likely to over- or underestimate environmental exposures and the associated health risks because of the uncertainty associated with various exposure assumptions and toxicity values. The major assumptions and limitations that are specific to this evaluation and result in uncertainty are as follows.

- A limited, but adequate, amount of soil data currently exists for this site. This limitation is overcome by using the maximum detected concentration as the exposure point concentration, which may result in over- or under-estimation of

risk. The overall cancer and non-cancer risks are likely to be over-estimated based on the following: (a) assumption of 100% bioavailability of metals from soil ingestion (b)and the assumption of 100% hexavalent chromium in soil; (c) use of the most contaminated subsurface soil samples for estimating soil exposures since the surficial samples were not collected, and (d) use of the reasonable maximum exposure (RME) assumptions, especially, the 95th percentile soil adherence factor for the construction worker.

- It should be noted that in this evaluation, oral toxicity values were used to evaluate dermal exposures since dermal toxicity values are not available. This could result in an over or underestimation of risk; however, the resulting uncertainty is presumably low and this method for evaluating dermal risk is standard procedure in risk assessments.

- Offsite ground water contamination was outside the scope of this evaluation since the contaminant plume appears to be confined to the northern most portions of the site and may not be associated with the former Manufactured Gas Plant.

- Screening comparison values for COPC selection were not available for acenaphthylene, phenanthrene, or benzo(g,h,i)perylene. This could result in a slight underestimation of risk in this evaluation.

- As discussed previously, there are no available non-cancer toxicity values for PAHs. However, this appears to be a minor source of uncertainty because the estimated cumulative non-cancer hazards from all contaminants of potential concern are significantly (>10-fold) lower than the acceptable level of one. Exposure to PAHs would likely elevate the non-cancer health hazards estimated in this evaluation. However, it is not likely to significantly alter the conclusions drawn for non-cancer health hazards.

- The overall cancer and non-cancer risks may be over- or under-estimated based on the assumption of additivity due to the potential for antagonistic or synergistic effects of multiple chemical interactions. However, it is not considered a significant source of uncertainty because the cumulative non-cancer hazards (Hazard Indices) are significantly (> 10-fold) lower than the acceptable level of one and the estimated cancer risks are primarily attributable to a single contaminant (benzo(a)pyrene).

Conclusions

Based on a review of the available environmental data and the evaluation of the public health implications associated with future worker exposures of redevelopment and future use of the former Sterling Manufactured Gas Plant, CCPEHA has reached one conclusion.

Exposure to soil contaminants is not likely to harm the health of future construction workers and commercial industrial workers at the former Sterling Manufactured Gas Plant Brownfields site. This conclusion was reached because the estimated non-cancer and cancer risks are below levels of concern. Specifically, the estimated cumulative non-cancer hazard indices from incidental ingestion and dermal exposure to site-related COPCs are below 1 for both types of workers. In addition, the estimated lifetime excess cancer risks resulting from worker exposures to soil are well within the EPA target cancer risk range, which indicates a very low increased risk of developing cancer.
It should be noted that the conclusions are based on the current environmental data collected to date and the purported site use at the time this evaluation was conducted. If additional environmental data becomes available or an alternative land-use/exposure scenario is selected in the future, the findings of this health consultation should be reconsidered.

Recommendations

Based upon a thorough review of the current soil data and the associated public health implications of worker exposures at the former Sterling Manufactured Gas Plant Brownfields site, the following recommendations were made to protect public health:

- With respect to future exposures to soil, no additional action is necessary based on what is currently known about the site because the individual and cumulative cancer and non-cancer risk is at or below CDPHE's risk management goal with the exception of benzo(a)pyrene. To reduce risks associated with benzo(a)pyrene in onsite soil, removal of the contaminant in the area of SB-1 and SB-3 may be appropriate. Removing/excavating the soil in these areas will remove the source of the benzo(a)pyrene impacts to soil and will also remove the potential leachate pathway to groundwater in this area, and would be protective of human health and the environment.

- Based on current knowledge of future land-use at the site, CMHC does not plan to remediate the western portion of the parcel at this time and plans to sell this area in the future in conjunction with Land Leasing Company to a separate and unaffiliated party. Because the VOC and SVOC impacts to soil and groundwater in the northwest portion is at depth (approximately 4-6 feet below ground surface in soils, and in groundwater approximately 8 feet below ground surface), there are currently no exposure pathway issues. However, if future owners of this portion of the site intend to build a commercial property, a Deed Restriction for the property, including a Materials Management Plan for any future potential site development and/or ground disturbance activities, should be required. Additionally, if a structure were to be built in this area, the building may require the installation of a subsurface vapor mitigation system to protect future commercial/industrial workers against potential residual vapors and indoor air.

- Due to the limited amount of environmental data and the potential to encounter site-related contamination during redevelopment of the site, workers participating in the redevelopment of the site should be familiar with the identification and

handling of stained soil and underground storage tanks. In addition, a soils management plan should be established prior to redevelopment activities to ensure the proper handling and/or removal of soil contamination or USTs if encountered during future redevelopment.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by CCPEHA and other governmental agencies at the site. The purpose of the public health action plan is to ensure that this public health consultation both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from breathing, drinking, eating, or touching hazardous substances in the environment. Included is a commitment on the part of CCPEHA to follow up on this plan to be sure that it is implemented.
Public health actions that will be implemented include:

- As necessary, CCPEHA will review any additional data collected from the Sterling Manufactured Gas Site.

- Upon request, CCPEHA will provide input to State and Local environmental officials on sampling plans and analysis.

- Upon request, CCPEHA will provide health education on the findings of this health consultation to stakeholders and the community.

References

Agency for Toxic Substances and Disease Registry (ATSDR 2012). *Soil and Drinking Water Comparison Values from ATSDR Sequoia CV Database*, last update August 2012.

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Report Preparation

This Letter Health Consultation was prepared by the Colorado Department of Public Health and Environment (CDPHE) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methodology existing at the time the letter health consultation was initiated.

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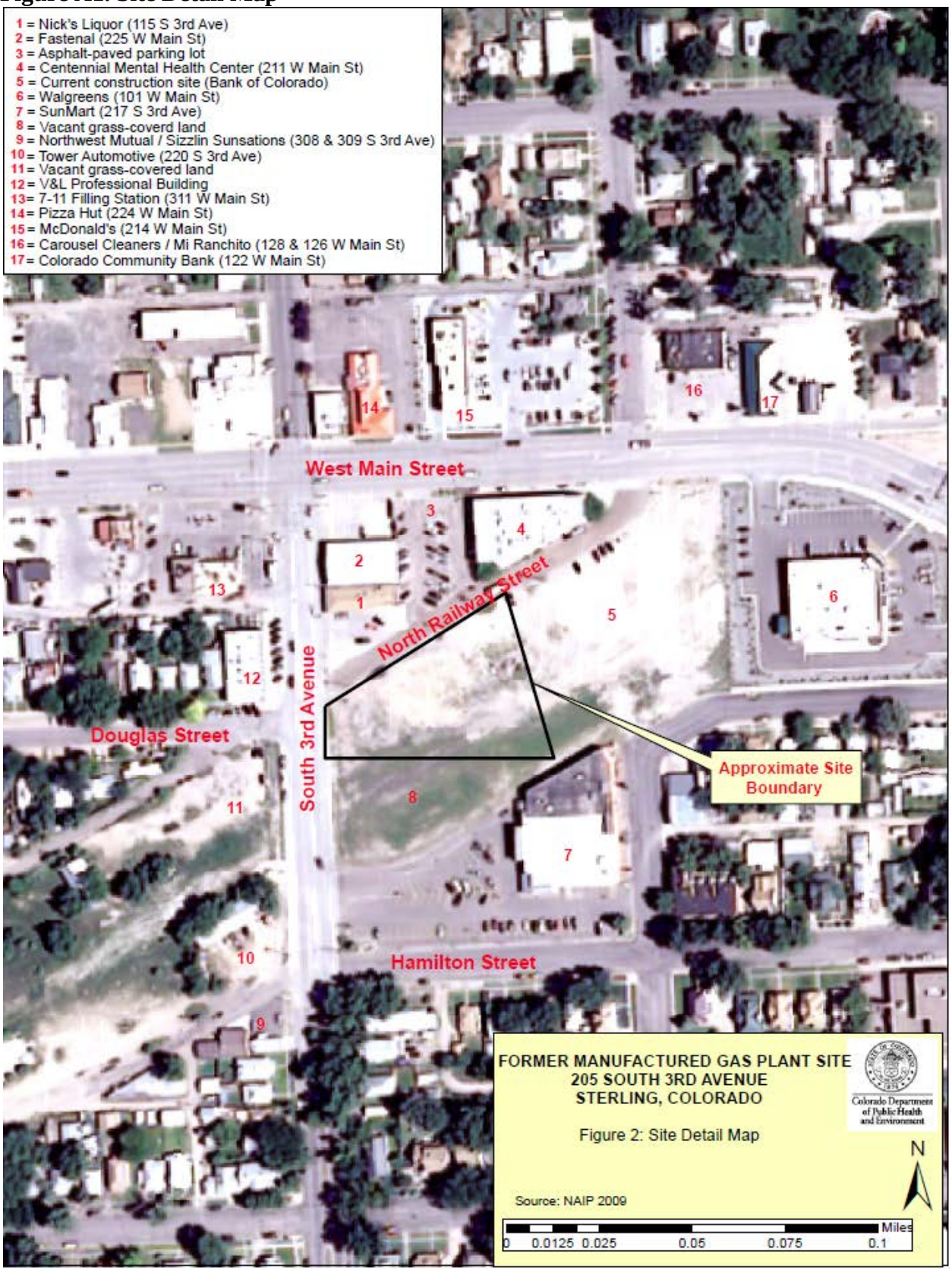
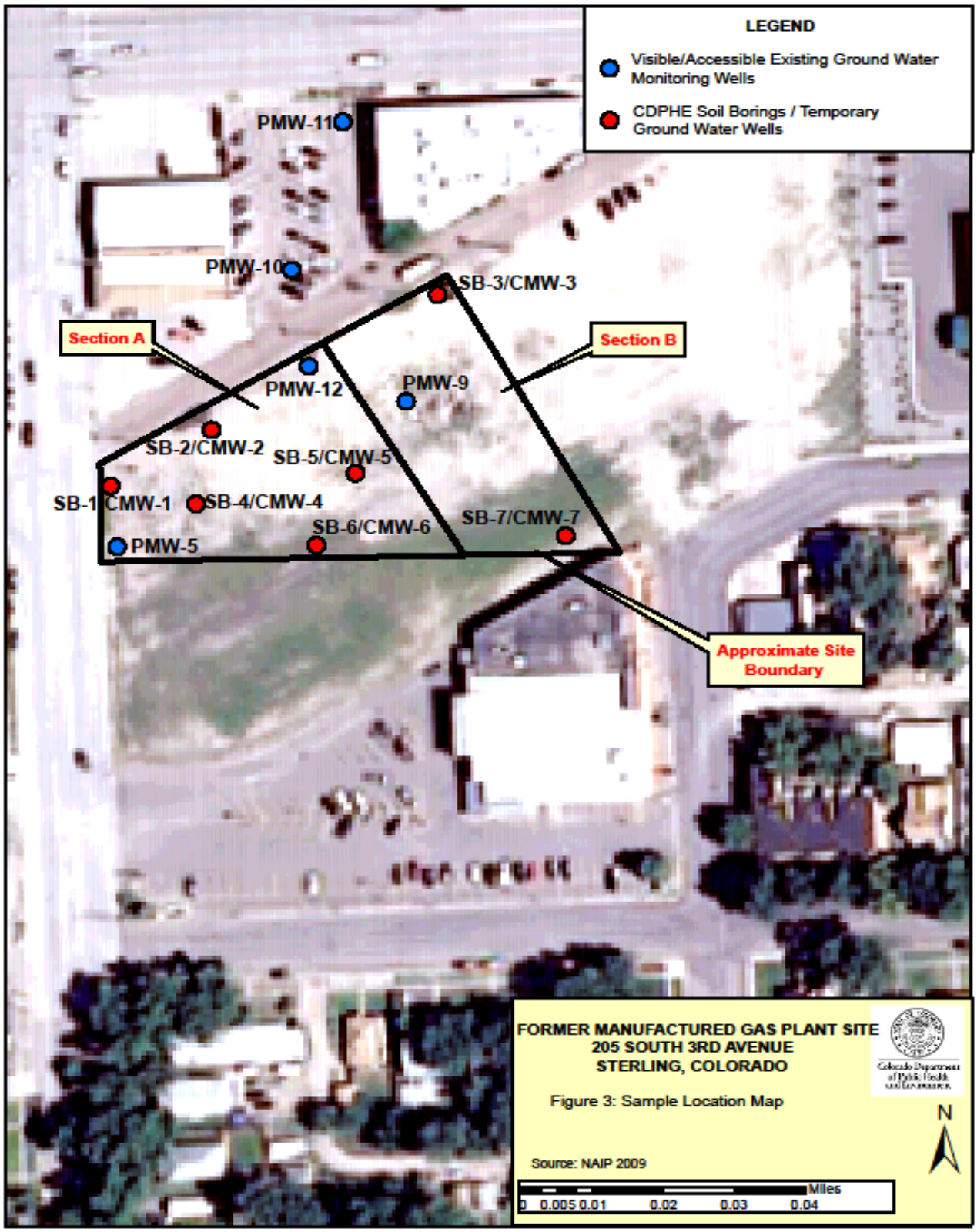
Appendix A. Figures and Tables

Figure A1. Site Detail Map



SOURCE: CDPHE 2012

Figure A2. Sampling Location Map



SOURCE: CDPHE 2012

Table A1. Soil Sampling Results (Samples Collected 7/31/2012 and 8/1/2012)

Analytes	Sample ID (Depth in feet below ground surface) All Sample Results in milligrams per kilogram						
Volatile Organic Compounds	*SB-1 (4-6 ft.)*	*SB-2 (6-8 ft.)*	*SB-3 (2-4 ft.)*	*SB-4 (4-6 ft.)*	*SB-5 (4-6 ft.)*	*SB-6 (4-6 ft.)*	*SB-7 (4-6 ft.)*
Napthalene	53.8	ND	ND	ND	ND	ND	ND
Styrene	0.528	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	2.37	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	1.34	ND	ND	ND	ND	ND	ND
Xylene (Total)	2.23	ND	ND	ND	ND	ND	ND
Other VOCs	ND	ND	ND	ND	ND	ND	ND
Semi-Volatile Volatile Organic Compounds	*SB-1 (4-6 ft.)*	*SB-2 (6-8 ft.)*	*SB-3 (2-4 ft.)*	*SB-4 (4-6 ft.)*	*SB-5 (4-6 ft.)*	*SB-6 (4-6 ft.)*	*SB-7 (4-6 ft.)*
Acenaphthylene	ND	ND	1.28	ND	ND	ND	ND
Anthracene	ND	ND	0.516	ND	ND	ND	ND
Benzo(a)anthracene	5.27	ND	1.88	ND	ND	ND	ND
Benzo(a)pyrene	4.99	ND	1.86	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	1.02	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	1.24	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	1.44	ND	ND	ND	ND
Chrysene	5.04	ND	1.94	ND	ND	ND	ND
Fluoranthene	9.5	ND	1.97	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	1.0	ND	ND	ND	ND
2-Methylnaphthalene	7.57	ND	0.456	ND	ND	ND	ND
Naphthalene	28.5	ND	0.815	ND	ND	ND	ND
Phenanthrene	14.4	ND	1.32	ND	ND	ND	ND
Pyrene	14.0	ND	3.54	ND	ND	ND	ND
Other SVOCs	ND	ND	ND	ND	ND	ND	ND
Total RCRA 8 Metals	*SB-1 (4-6 ft.)*	*SB-2 (6-8 ft.)*	*SB-3 (2-4 ft.)*	*SB-4 (4-6 ft.)*	*SB-5 (4-6 ft.)*	*SB-6 (4-6 ft.)*	*SB-7 (4-6 ft.)*
Arsenic	3.9	2.7	6.3	6.5	6.1	4.7	8.5
Barium	2.7	122	177	228	211	118	112
Cadmium	6.3	ND	ND	ND	ND	ND	ND
Chromium	6.5	4.8	11.5	7.8	8.9	6.7	6.1
Lead	6.1	6.9	14	7.7	7.7	5.9	7.2
Selenium	4.7	ND	ND	ND	ND	ND	ND
Silver	8.5	ND	ND	ND	ND	ND	ND
Mercury	N/a	ND	0.056	ND	ND	ND	ND

NOTE: ND = Not detected, N/a = Not Applicable, ft. = feet

Table A2. Screening for Contaminants of Potential Concern in Soil

Detected Analytes	Maximum Detected Concentration in Soil Site-wide (in mg/kg)	ATSDR Soil Comparison Value (in mg/kg)	Source of ATSDR CV	EPA Regional Screening Level for Soil (in mg/kg)	Selected as COPC
Naphthalene	53.8	1,000	Child RMEG	**3.6c**	X
Styrene	0.528	10,000	Child RMEG	**6,300nc**	
1,2,4-Trimethylbenzene	2.37	NA	N/a	**62nc**	
1,3,5-Trimethylbenzene	1.34	NA	N/a	**780nc**	
Xylene (Total)	2.23	10,000	Child EMEG	**630nc**	
Acenaphthylene	1.28	NA	N/a	NA	
Anthracene	0.516	**15,000**	Child EMEG	17,000nc	
Benzo(a) anthracene	5.27	NA	N/a	**0.15c**	X
Benzo(a) pyrene	4.99	0.096	CREG	**0.015c**	
Benzo(b) fluoranthene	1.02	NA	N/a	**0.15c**	X
Benzo(g,h,i) perylene	1.24	NA	N/a	NA	
Benzo(k) fluoranthene	1.44	NA	N/a	**1.5c**	
Chrysene	1.94	NA	N/a	**15c**	
Fluoranthene	1.97	**2,000**	Child RMEG	2,300nc	
Indeno(1,2,3-cd)pyrene	1	NA	N/a	**0.15c**	X
2-Methyl naphthalene	7.57	NA	N/a	**230nc**	
Phenanthrene	14.4	NA	N/a	NA	
Pyrene	14	**1,500**	Child RMEG	1,700(nc)	
Arsenic	8.5	15	Child EMEG	**0.39(c)**	X
Barium	265	**10,000**	Child EMEG	15,000(nc)	
Cadmium	ND	**5**	Child EMEG	70(nc)	
Chromium	11.5	50	Child EMEG, hexavalent	**0.29(c)**	X
Lead	17.5	NA	N/a	**400(nc)**	
Selenium	ND	**250**	Child RMEG	390(nc)	
Silver	ND	**250**	Child RMEG	390(nc)	
Mercury	**0.056**	NA	N/a	10(nc)	

NOTE: mg/kg = milligram contaminant per kilogram soil, ATSDR = Agency for Toxic Substances and Disease Registry, CV = Comparison Value, EPA = Environmental Protection Agency, RSL = Regional Screening Level, **Bolded Values** were used in the screening process, ND (X) = Not Detected (Reporting Limit/Detection Limit), NA = Not Available, N/a = Not Applicable, EMEG = Environmental Media Evaluation Guide, CREG = Cancer Risk Evaluation Guide, RMEG = Reference dose Media Evaluation Guide, (c)=cancer, (nc)=non-cancer

TableA3. Estimated Non-cancer Exposure Doses associated with Incidental Ingestion of Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers (in mg/kg-day)	Construction Workers (in mg/kg-day)
Naphthalene	5.3E-05	1.7E-04
Arsenic	8.3E-06	2.7E-05
Chromium	1.1E-05	3.7E-05

NOTE: COPC: Contaminant of Potential Concern, 5.3E-05 is equivalent to $5.3 * 10^{-5}$ or 0.000053, mg/kg-day = milligram per kilogram-day

TableA4. Non-cancer Hazard Quotients associated with Incidental Ingestion of Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers	Construction Workers
Naphthalene	2.6E-03	8.7E-03
Arsenic	2.8E-02	9.1E-02
Chromium	1.3E-02	4.1E-02
Hazard Index	**2.6E-03**	**8.7E-03**

NOTE: COPC: Contaminant of Potential Concern, 8.7E-03 is equivalent to $8.7 * 10^{-3}$ or 0.0087, Hazard Quotient (HQ) is the ratio of the estimated dose in relation to the health-based guideline (i.e. Estimated Dose/Health-based Guideline), Hazard Index is the sum of all HQ's.

TableA5. Estimated Non-cancer Exposure Doses associated with Dermal Exposure to Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers (in mg/kg-day)	Construction Workers (in mg/kg-day)
Naphthalene	1.6E-06	1.6E-06
Arsenic	4.5E-05	4.5E-05

NOTE: COPC: Contaminant of Potential Concern, 4.5E-05 is equivalent to $4.5 * 10^{-5}$ or 0.000045, mg/kg-day = milligram per kilogram-day

TableA6. Non-cancer Hazard Quotients associated with Dermal Exposure to Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers	Construction Workers
Naphthalene	5.5E-03	5.5E-03
Arsenic	2.3E-03	2.3E-03
Hazard Index	**7.7E-03**	**7.7E-03**

NOTE: COPC: Contaminant of Potential Concern, 5.5 E-03 is equivalent to $5.5 * 10^{-3}$ or 0.0055, Hazard Quotient (HQ) is the ratio of the estimated dose in relation to the health-based guideline (i.e. Estimated Dose/Health-based Guideline), Hazard Index is the sum of all HQ's.

TableA7. Estimated Cancer Exposure Doses associated with Incidental Ingestion of Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers (in mg/kg-day)	Construction Workers (in mg/kg-day)
Arsenic	3.0E-06	7.8E-07
Chromium	4.0E-06	1.1E-06
Benzo(a)anthracene	1.8E-06	4.9E-07
Benzo(a)pyrene	1.7E-06	4.6E-07
Benzo(b)fluoranthene	3.6E-07	9.4E-08
Indeno(1,2,3-cd)pyrene	3.5E-07	9.2E-08

NOTE: COPC: Contaminant of Potential Concern, 3.0E-06 is equivalent to $3.0 * 10^{-6}$ or 0.0000030, mg/kg-day = milligram per kilogram-day

TableA8. Cancer Risks associated with Incidental Ingestion of Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers	Construction Workers
Arsenic	4.5E-06	1.2E-06
Chromium	2.0E-06	5.3E-07
Benzo(a)anthracene	1.3E-06	3.5E-07
Benzo(a)pyrene	1.3E-05	3.4E-06
Benzo(b)fluoranthene	2.6E-07	6.9E-08
Indeno(1,2,3-cd)pyrene	2.6E-07	6.7E-08
Total Cancer Risk	**2.1E-05**	**5.6E-06**

NOTE: COPC: Contaminant of Potential Concern, 2.1E-05 is equivalent to $2.1 * 10^{-5}$ or 21 excess cancer cases per million people exposed, Cancer Risks are calculated by multiplying the estimated cancer dose by the oral slope factor for the contaminant, Total cancer risk is the sum of all individual cancer risks.

TableA9. Estimated Cancer Exposure Doses associated with Dermal Exposure to Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers (in mg/kg-day)	Construction Workers (in mg/kg-day)
Arsenic	5.9E-07	4.7E-08
Benzo(a)anthracene	1.6E-06	1.3E-07
Benzo(a)pyrene	1.5E-06	1.2E-07
Benzo(b)fluoranthene	3.1E-07	2.4E-08
Indeno(1,2,3-cd)pyrene	3.0E-07	2.4E-08

NOTE: COPC: Contaminant of Potential Concern, 5.9E-07 is equivalent to $5.9 * 10^{-7}$ or 0.00000059, mg/kg-day = milligram per kilogram-day

TableA10. Cancer Risks associated with Dermal Exposure to Soil by Current and Future Workers

COPC	Future Commercial/Industrial Workers	Construction Workers
Arsenic	8.8E-07	7.1E-08
Benzo(a)anthracene	1.2E-06	9.2E-08
Benzo(a)pyrene	1.1E-05	8.7E-07
Benzo(b)fluoranthene	2.2E-07	1.8E-08
Indeno(1,2,3-cd)pyrene	2.2E-07	1.8E-08
Total Cancer Risk	**1.3E-05**	**1.1E-06**

NOTE: COPC: Contaminant of Potential Concern, 1.3E-05 is equivalent to $1.3 * 10^{-5}$ or 13 excess cancer cases per million people exposed, Cancer Risks are calculated by multiplying the estimated cancer dose by the oral slope factor for the contaminant, Total cancer risk is the sum of all individual cancer risks.