Health Consultation

Residential Exposures to Contaminated Soil in Areas Adjacent to the

Koppers, Inc./Beazer East, Inc., Tie Plant Facility,

Grenada, Mississippi

EPA FACILITY ID: MSD007027543

APRIL 24, 2013

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

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

Residential Exposures to Contaminated Soil in Areas Adjacent to the Koppers, Inc./Beazer East, Inc., Tie Plant Facility, Grenada, Mississippi

EPA FACILITY ID: MSD007027543

Prepared By:

Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations
Central Branch, Headquarters

A "Public Comment Version" of this health consultation was distributed to members of the Tie Plant community, including state and local agency representatives (comment period September 4, 2012 to October 18, 2012). No comments were received so the September 4, 2012 Public Comment Version is reissued as the "Final Version."

Table of Contents

List of Tables

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations - the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Agency for Toxic Substances and Disease Registry
ATTN: Records Center
1600 Clifton Road, NE (Mail Stop F-09)
Atlanta, GA 30333

List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
AVG	average
BaP	benzo(a)pyrene
BaP-TEq	benzo(a)pyrene toxic equivalents
Bkgd	background
CREG	cancer risk evaluation guide
CV	comparison value
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
KB	Koppers, Inc./ Beazer East, Inc.
MCL	maximum contaminant level
mg/kg	milligram per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	minimal risk level
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PHC	public health consultation
PHAP	Public Health Action Plan
ppb	parts per billion
ppt	parts per trillion
RfD	reference dose
ROS	Regression on Ordered Statistics (statistical procedure)
TCDD	2,3,7,8 tetrachlorinateddibenzo(p)dioxin
TCDD-TEq	tetrachlorinateddibenzo(p)dioxin toxic equivalents
UCL	upper confidence limit

Summary

The Public Health Issues

The purpose of this public health consultation (PHC) is to determine whether exposure to chemicals in the Tie Plant community soils is a public health hazard for people who live in the area. The public health determination is based on evaluation of soil contamination data and the pathways by which people may be exposed to those soils. The soil data are from GeoTrans (2010) and earlier studies of residential locations (as reported in the GeoTrans study).

The Tie Plant community comprises about 70 households (plus the Tie Plant School) immediately east and north of the Koppers, Inc./Beazer, Inc. wood treating facility (KB site). Thirty-one residential locations, the school, a community park, and ditch/drainage areas within the community have been sampled for chemicals used at and released from the KB site. Of the many individual chemicals analyzed from soils only two chemical classes, (polycyclic aromatic compounds and dioxins) were found at concentrations above their respective health comparison values.

The polycyclic aromatic hydrocarbons were measured as benzo(a)pyrene toxic equivalents (BaP-TEq). The BaP-TEq concentration is the sum of 7 different PAHs with their concentrations adjusted for their toxicity relative to BaP. Similarly, the dioxins were measured as 2,3,7,8 tetrachlorodibenzo(p)dioxins toxic equivalents (TCDD-TEq), which is the adjusted sum of 17 different dioxin compounds.

In addition to the soil data evaluated in this PHC, ATSDR has previously evaluated air monitoring data from KB site operations and determined that the available data do not adequately characterize emissions from the KB facility (ATSDR, 2010). Prior to shutdown of the KB facility, residents living adjacent to the KB site may have had exposures to site-related contaminants from breathing the contaminants that were released to the air from the KB site.

Conclusions

ATSDR has evaluated the past, present, and future chemical exposures to residential soils in the Tie Plant community. On the basis of the likely exposure pathways and the available environmental data, ATSDR concludes the following:

BaP-TEq Long term exposures to BaP-TEq in soil at all of the 31 yards sampled represent a low increased estimated risk of skin or stomach cancers

(less than 0.0001). This low increased risk is within the EPA's acceptable risk range for Superfund cleanups. More than 67% of the yards sampled (21 of 31) in the Tie Plant community have average BaP-TEq concentrations that are greater than the 95th percentile background value (108.8 ppb). Due to the health-protective procedures used in establishing health comparison values and the likely over-estimation of soil exposures, adverse health effects (cancer and non-cancer) are not expected from short or long term BaP-TEq soil exposures at these locations.

TCDD-TEq Long term exposure to TCDD-TEq in the Tie Plant yard with the highest TCDD-TEq soil concentration is a public health hazard due to a moderately increased estimated excess cancer risk. Six of the 31 yards had average TCDD-TEq concentrations greater than the 95th percentile concentration (80.4 ppt) of background yards. Three of the 31 yards sampled have calculated exposure doses that exceed the ATSDR health comparison value but are more than 20 times lower than the dose on which the comparison value is based. Due to the health-protective procedures used in establishing health comparison values and the likely over-estimation of soil exposures, non-cancer adverse health effects are not expected from either short or long term TCDD-TEq soil exposures.

Recommendations

The three sampled yards with the highest BaP-TE concentrations have been remediated to decrease exposures to contaminants in yard and drainage area soils. The yard with the highest TCDD-TEq concentration has also been remediated. Consequently, ATSDR has no specific public health recommendations regarding exposures to soil in the Tie Plant community.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or comments related to this Public Health Consultation please call ATSDR at 1-800-CDC-INFO: Koppers Inc./Beazer East, Inc., Tie Plant, Grenada MS

.

Statement of Issues and Background

Statement of Issues

On January 31, 2011, the United States Environmental Protection Agency (Region 4; USEPA) requested that the ATSDR evaluate community exposures to potentially contaminated soil, air, and groundwater emanating from the Koppers Inc./Beazers East, Inc. Site (KB site) wood treatment facility, Tie Plant, Mississippi. ATSDR has previously evaluated the air monitoring data (AquAeTer, 2004) and determined that available data do not adequately characterize emissions from the KB facility (ATSDR, 2010). ATSDR recommended the collection of additional, representative air data. Similarly, ATSDR has previously reviewed documents for information on groundwater contaminants from the KB site and concluded that pentachlorophenol was not detected in groundwater at the KB site (other site related contaminants such as dioxins and PAHs have low solubility in water and are unlikely to be present as groundwater contaminants; ATSDR, 2009). As no new air or groundwater data have been collected, this Health Consultation will not re-evaluate the historic air or groundwater monitoring data.

Several studies of soil contamination on and adjacent to the KB site have been conducted. ATSDR has previously evaluated soil data from a 2005 study (AquAeTer, 2005; ATSDR, 2009). The USEPA has specifically requested that ATSDR review a more recent study of soil contamination around the KB site (GeoTrans, 2010). This Health Consultation evaluates the potential health effects from exposure to soils for people in the Tie Plant community based on the soil contamination data from the GeoTrans study (2010) and soil data from earlier studies of residential locations (as reported in the GeoTrans, 2010).

In addition to the assessment of the overall levels of soil contamination present in the Tie Plant community, the GeoTrans study (2010) attempts to determine whether those soil contaminants are derived from the KB site or from some other source. This Health Consultation makes no determination of the specific source of the soil contaminants and focuses only on whether the contaminants present a public health hazard.

The GeoTrans study includes analyses of soil samples from drainage areas on the KB site and evaluation of worker (on-site industrial activity) exposures to those soils. This consultation is limited to evaluation of potential off-site exposures to members of the Tie Plant community and does not evaluate KB worker exposures.

Site Description and History

The KB site, which occupies 171 acres in the unincorporated community of Tie Plant, Mississippi (Grenada County), is a wood treatment facility that has been operating in this location since 1904. The facility is currently owned and operated by Koppers Inc. (prior to 1988, it was owned and operated by Beazers East, Inc.; GeoTrans, 2010). The KB facility treats wooden products, such as railroad ties, utility poles, and bridge timbers with creosote, pentachlorophenol (PCP), and a creosote-PCP mixture. The KB facility ceased operations in July 2012. Site cleanup and closure operations are ongoing with oversight by the US EPA.

The KB site is about 1.2 miles long (trending northwest to southeast) by 0.3 miles wide and is bounded by the Illinois Central Railroad to the west and the Carver Circle neighborhood and woodlands to the east (Figure 1). Land elevations on the KB site are between 212 to 195 feet (above mean sea level) and slope gradually to the east and northeast (toward Batupan Bogue). Surface water runoff from the KB site (as analyzed by GeoTrans, 2010) flows northerly and easterly via swales, ditches, and culverts, and at least partially through the Carver Circle neighborhood.

The Tie Plant community comprises about 70 households (plus the Tie Plant School) immediately east and north of the KB site (Figure 1). About half of the houses are located along Carver Circle east of the KB site and the other half on Tie Plant, Simmons, Durr, and Widows Roads just north of the KB site (Figure 1).

It should also be noted, that in addition to the Tie Plant community, there are a number of residences located near or directly adjacent to the KB site on Koppers Road (west of KB site). An elevated railroad track separates these residences from the KB facility such that drainage from the site (soil/sediment runoff) is unlikely to affect these residences.

Figure 2 shows the population distribution and characteristics for the area (up to one mile) surrounding the KB site. Approximately 1576 people live within one mile of the KB site, including ~171 children (aged 6 or younger), ~230 adults (aged 65 or older), and ~319 females (aged 15 to 44). These population groups are highlighted because they represent people that may be especially susceptible to the effects of environmental contamination.

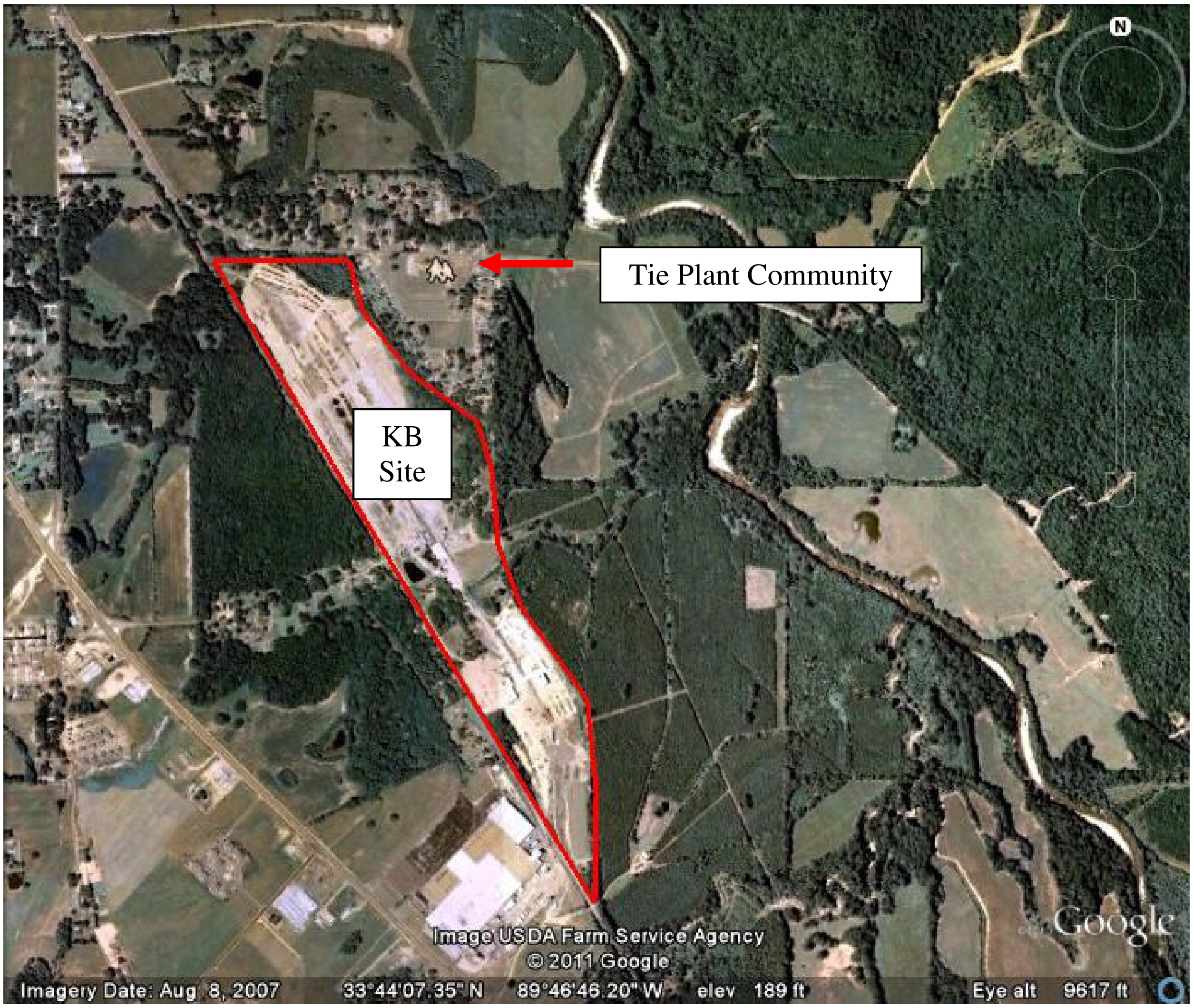


Figure 1. Location of the Koppers, Inc./Beazers East, Inc. Facility, Tie Plant Mississippi and adjacent Tie Plant community, Grenada County, Mississippi.

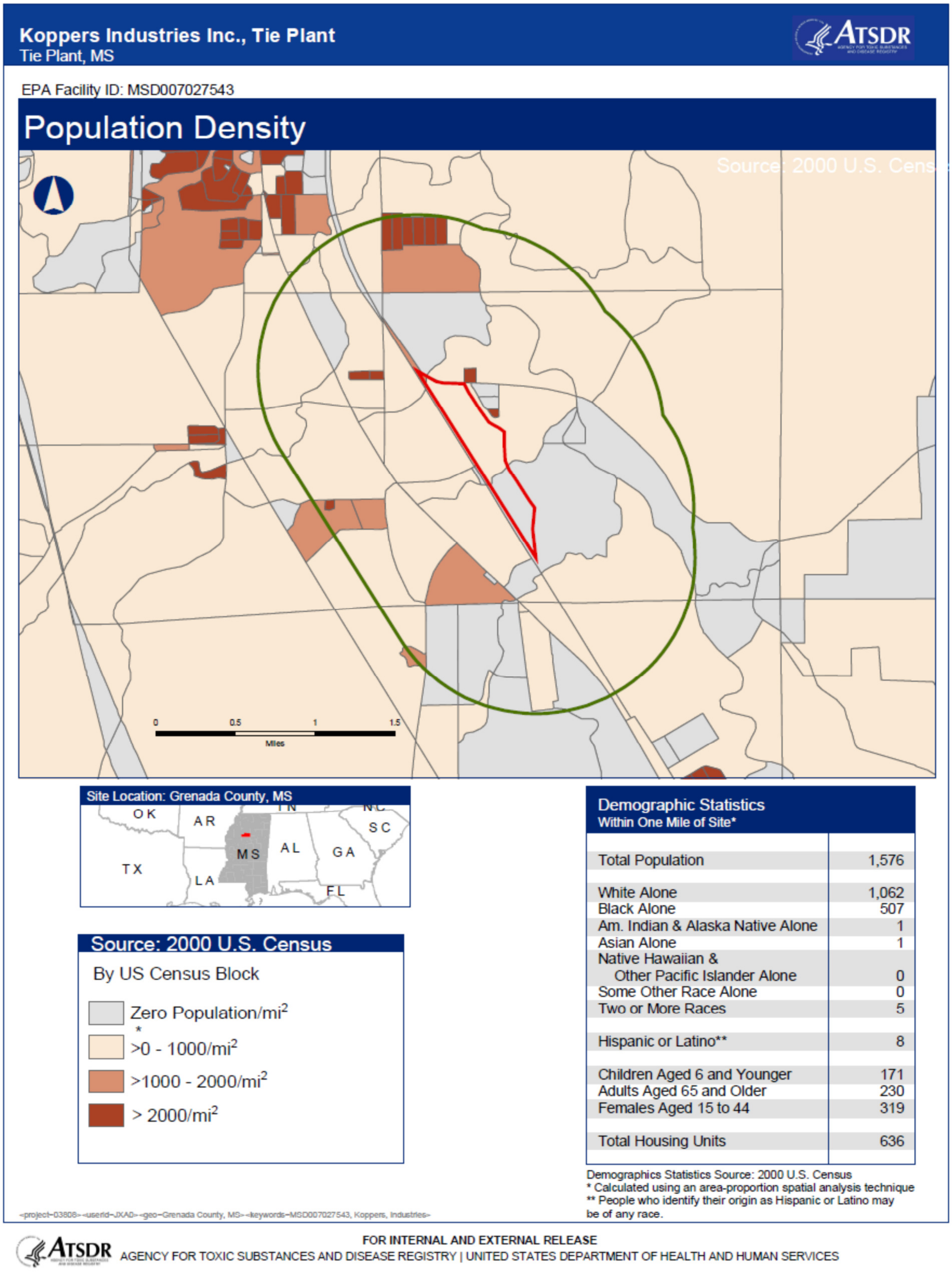


Figure 2. Population characteristics of the Tie Plant area (one mile buffer around KB site).

Soil Sampling Data and Contaminant Distributions

Soils surrounding the KB site have been sampled and analyzed in four studies (GeoTrans, 2010). All of the soil data from these studies are included in the GeoTrans (2010) report and are evaluated in this health consultation. Sampling and analytical procedures are documented and consistent with EPA requirements for the GeoTrans and "AquAeTer" datasets and are unknown for the other datasets (GeoTrans, 2010). As data values for these individual datasets are consistent with regard to contaminant values and distributions, all of the data are evaluated in this consultation.

The GeoTrans (2010) dataset was provided to ATSDR as EXCEL spreadsheets and includes analyses of 83 contaminants from 43 locations (18 yards, 23 drainage areas, 2 incinerator/burn pit samples) on or adjacent to the KB site plus 20 "regional" locations sampled to determine background contaminant concentrations. Most of the residential yards were sampled as separate 5 point composites from front and back yards. These separate front and back yard values are combined in this evaluation to represent average yard concentrations. The other three datasets (as summarized by GeoTrans, 2010) include only concentrations of benzo(a)pyrene toxic equivalents (BaP-TEq), pentachlorophenol (PCP), and tetrachlorodibenzodioxin toxic equivalents (TCDD-TEq) for thirteen additional residential yards (multiple yard samples are averaged; note that the school and playground locations are identified as yard samples for a total of 31 yards sampled).

It is important to note that the specific yards and drainage area locations sampled were cooperatively selected by representatives of the United States Environmental Protection Agency (EPA) and the KB site owners. The sample locations were selected on the basis of likely contamination and collectively represent the areas subject to runoff and direct contaminant migration from the KB site (as stated: Karen Knight, EPA at public meeting, Tie Plant School, Nov. 2, 2011). Conversely, those Tie Plant yards not selected for sampling are not subject to runoff or direct contaminant migration from the KB site and are likely to have much lower levels, if any, of site related contaminants.

All surface soil samples were collected from the top 6 inches (0 to 6 inch depth). Multiple drainage samples were collected at each location (from a 0 to 6 inch depth and from 6 to 12 inch depth). As exposure is usually limited to the uppermost few inches of soil, only drainage samples from 0 to 6 inches are evaluated in this consultation.

Tables 1 and 2 present the concentration ranges of each measured contaminant for yards and drainage areas (respectively; from the GeoTrans, 2010 data). These tables also include the respective health comparison values (CVs) for each contaminant (note that CVs are not available for most individual contaminants), the range of background concentrations for each contaminant, and the percent of sampled locations with concentrations greater than the 95th percentile background value. See Appendix A for the derivation and use of CVs. Note that BaP and BaP-TEq concentrations are presented in units of parts per billion (ppb) and TCDD-TEq concentrations in units of parts per trillion (ppt).

There are several important points presented concerning the contaminant data presented in Tables 1 and 2. First, is that of the many measured analytes, only TCDD-TEq and BaP have been measured in yard or drainage area concentrations above their respective CVs (it should be noted that most dioxin/furans and polycyclic aromatic hydrocarbons (PAHs) do not have individual

CVs). Secondly, although background concentrations of TCDD-TEq and BaP are commonly above their respective CVs, more than 19% of the yard average TCDD-TEq samples are greater than the 95^{th} % background value and more than 67% of the yard average BaP-TEq concentrations are above the 95^{th} % background concentration (Table 1).

Figure 3 shows the distribution of TCDD-TEq concentrations from regional background surface soil samples (GeoTrans, 2010) and yard samples (from all available datasets; multiple values from individual yards are averaged). While there is considerable overlap in the concentrations, the overall range of the yard samples is higher than background due to TCDD-TEq concentrations in 5 yards (shown as outliers in Figure 3). The BaP background and yard surface soil concentrations, as listed in Table 1, follow similar distributions with overlapping ranges but higher overall yard concentrations due to a small number of outlier values.

Surface soil samples from drainage area background areas and locations down-gradient from the KB site have distinctly different distributions relative to yard samples (Figures 3 and 4). Overall drainage location sample concentrations (TCDD-TEq) are significantly higher than background (regional drainage) samples such that the lower 25^{th} percentile value of drainage samples is greater than all but one background concentration (Figure 4). Consequently, all background TCDD concentrations are below the 50 ppt CV. It should be noted that the elevated drainage area concentrations is to be expected as sample locations were selected to assess potentially contaminated areas. Several of the drainage samples are within or directly adjacent to residential yards. However, only one of the drainage samples from a residential location has corresponding yard samples. Consequently, exposures to TCDD and BaP concentrations in yards and drainage areas cannot be averaged and must be evaluated independently. Exposure factors for yard and drainage area locations are discussed in the following “Pathways of Exposure” section.

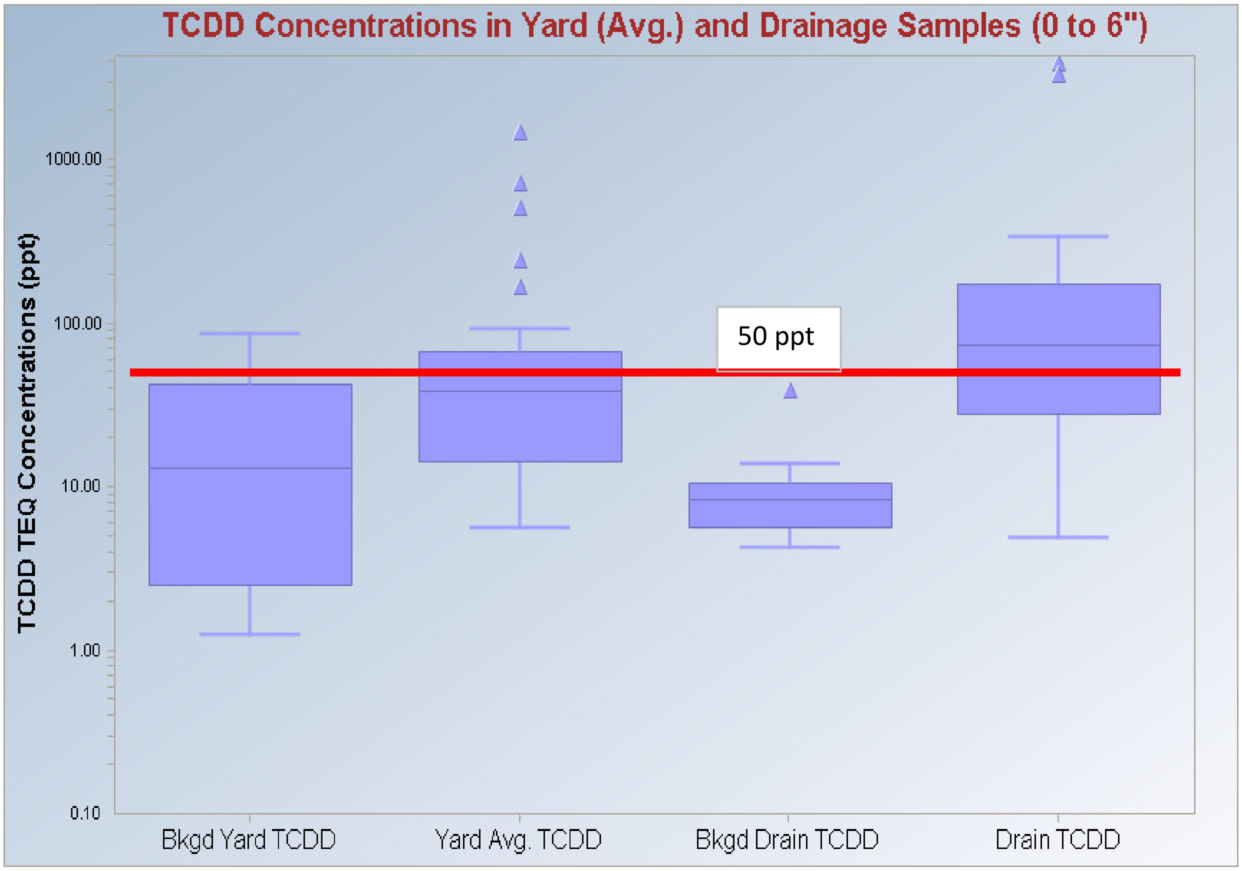


Figure 3. Box plots of TCDD-TEQ concentrations in yard and drainage samples for both background (Bkgd) and Tie Plant community Yard soil samples (Yard samples are averaged for each yard and include all available datasets). Note that the 50 ppt CV (parts per trillion; see Appendix A for definition and derivation of comparison values) of TCDD is approximately equal to the 75th percentile value of background concentrations (upper portion of box). Also, while background and yard samples have considerable overlap in values, yard samples have a higher range and high end outliers. Drainage samples from the Tie Plant community are much greater than background concentrations and most exceed the 50 ppt screening value. The lower values in each distribution are non-detections or "less than values" and should be interpreted with caution. [The line through each box is the 50th percentile or median value. The top and bottom of each box represent the 75th and 25th percentile values, respectively and the whiskers are the 75th and 25th percentiles plus or minus (resp) 1.5 x the range between the 75th and 25th percentiles.]

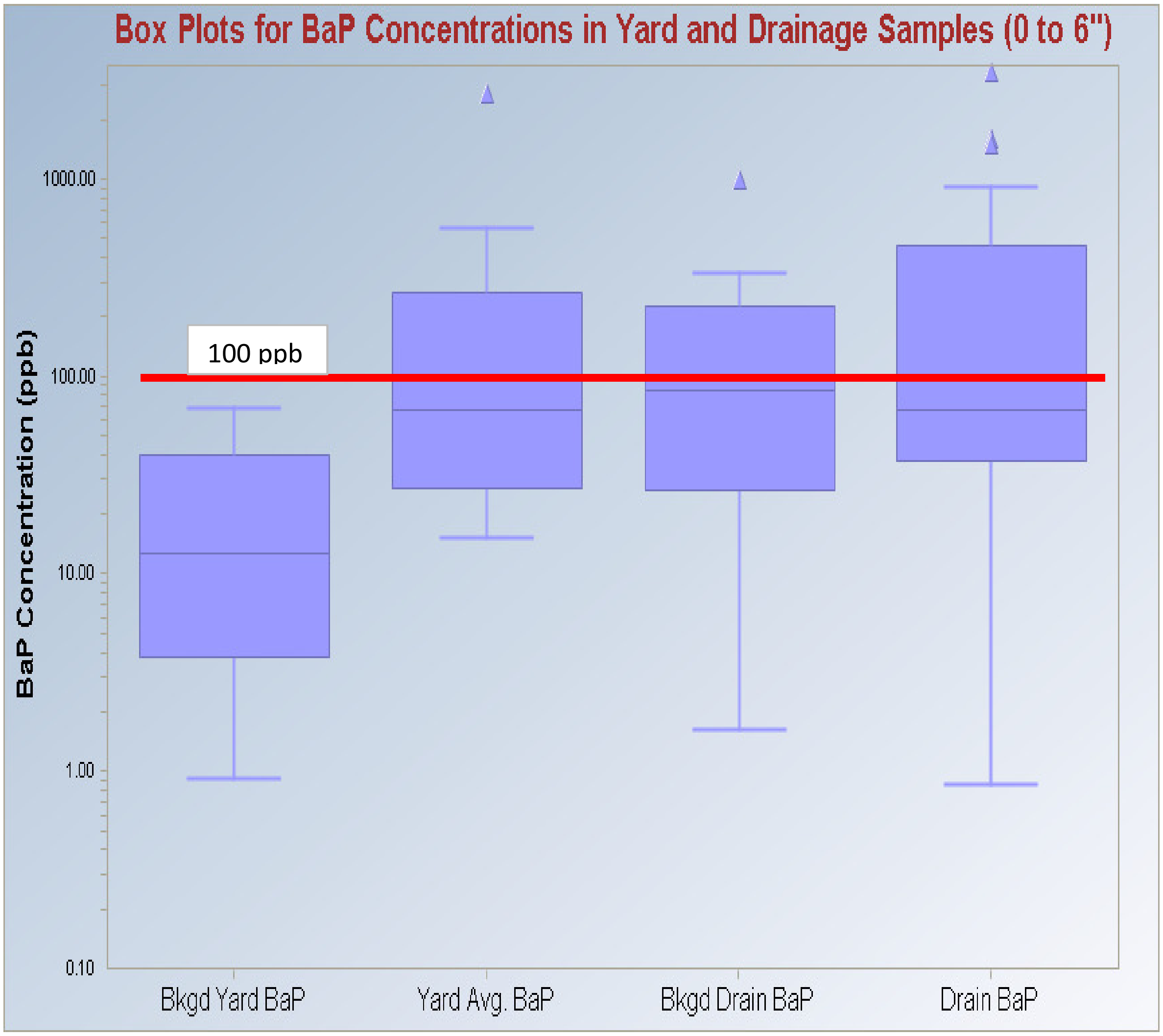


Figure 4. Box plots of BaP concentrations in Yard and Drainage samples for both background (Bkgd) and Tie Plant community Yard soil samples (all data are from the GeoTrans 2010 dataset and Yard samples are average values for each yard). Note that all background concentrations are less than the 100 ppb screening CV (parts per billion; CREG, see Appendix A for definition and derivation). The lower values in each distribution are non-detections or "less than values" and should be interpreted with caution.

Pathways of Exposure and Calculated Exposure Doses

As shown in Table 1 and 2 and Figures 3 and 4, residential soils in yards and drainage areas in the Tie Plant community are contaminated with concentrations of TCDD-TEq and BaP that exceed both regional background levels and their respective health-based CVs. People living in this area are exposed to these soils on a continuing basis. This section of the health consultation presents the doses that are the basis for determining whether these exposures represent a public health hazard for people living in this area.

Table 3 lists the average drainage area contaminant concentrations, the minimum and maximum average yard contaminant concentrations, and the child and adult doses calculated for exposures to those soil contaminants. The exposure parameters and the dose calculation procedures underlying the dose estimation procedure are presented in Appendix A. The public health implications of the calculated exposure doses are discussed in the following section.

As described in the preceding section, soil samples for BaP, BaP-TEq, and TCDD-TEq were collected and analyzed for individual residential yards and for adjoining drainage areas. Drainage samples may be near adjoining yard samples but only six sets of yard samples have a corresponding drainage sample (two other yard samples correspond with another combined drainage sample). Consequently, it is not possible to integrate most yard and drainage area samples into an overall exposure concentration for each yard.[1]

[1] Only two of the six yards with corresponding drainage samples had drainage area contaminant concentrations above the 95th % UCL of the geomean (Table 3). In both of these yards the average yard contaminant concentrations were relatively low and the drainage area concentrations only slightly greater than assumed average values such that cumulative doses are below levels of public health concern (see following section for more information on doses of public health concern).

Table 3. Soil contaminant* concentrations and calculated exposure doses.

Soil Contaminant	Drainage Area Concentration (95th % UCL Geomean)	Yard Avg. Concentration minimum maximum	Child Doses (mg/kg/day) minimum maximum	Adult Doses (mg/kg/day) minimum maximum
BaP	181 ppb	15 ppb 2,712 ppb	2.6E-7 1.7E-5	3.7E-8 2.5E-6
BaP-TEq	274 ppb	9 ppb 4,540 ppb	3.1E-7 2.8E-5	4.5E-8 8.9E-7
TCDD-TEq	134 ppt	11.6 ppt 1,471 ppt	1.9E-10 5.3E-9	2.3E-11 6.6E-10

--Doses are calculated using procedures and assumptions described in Appendix A and in units of milligrams [contaminant] per kilogram body weight per day **(mg/kg/day**).
--The listed drainage area concentrations are the lognormal average concentrations of all off-site drainage samples (95th percentile upper confidence limit of the geometric mean; **95th % UCL geomean**).
--**BaP**: benzo(a)pyrene
--**BaP-TEq**: benzo(a)pyrene toxic equivalents
--**TCDD-TEq**: tetrachlorodibenzo-p-dioxins toxic equivalents
--Procedures and assumptions for calculating **TEq**s are described in in the following section.
--**ppb**: parts per billion
--**ppt**: parts per trillion
*UCLs and averages are calculated from original GeoTrans (2010) soil contaminant data.

Discussion

Tables 1 and 2 list all of the specific analytes and their respective CVs measured in yard and drainage area soil samples in the Tie Plant community. Of the 83 specific compounds analyzed only dioxins (as TCDD-TEq) and PAHs (as BaP or BaP-TEq) were detected at concentrations above their CVs (see Appendix A for a description and definition of the CVs). The presence of a contaminant at concentrations above a CV does not necessarily indicate that exposures present a public health hazard. The following discussion reviews the exposures to soil contaminants in the Tie Plant community and how those exposures may affect the health of Tie Plant residents.

Table 3 (preceding section) lists the maximum and minimum average yard concentrations and contaminant doses from daily exposures (using the procedures and assumptions from Appendix A). These doses are calculated assuming that soil contaminants are taken into peoples bodies by both incidental soil ingestion and direct intake through their skin and include exposures to both soil from yards and nearby drainage areas (see Appendix A).

Table 4 lists the relevant health comparison values for BaP, BaP-TEq and TCDD-TEq. Note that BaP and BaP-TEq do not have applicable non-cancer minimal risk values (MRL; see appendix A). Consequently, a cancer risk of 1.0E-04 (0.0001; expressed as a theoretical excess 70 year risk) is taken as the benchmark for identifying BaP or BaP-TEq exposures that constitute a public health hazard.[2] The CV for TCDD-TEq exposure is the chronic or long term (greater than 365 days) MRL. TCDD also has MRLs for short term and intermediate exposure (24 hours to 14 days and 14 to 365 days, respectively; Table 4). However, none of the calculated doses exceeded the short or intermediate term MRLs such that chronic TCDD exposures are the primary focus for public health evaluation.

Table 4 also shows that the TCDD-TEq average yard concentration that would produce a long term exposure dose that exceeds the MRL is about 250 ppt. Only three of the 31 sampled yards have TCDD-TEq concentrations above 250 ppt. Note that the three yards with TCDD-TEq concentrations greater than 250 ppt do not include the yard that has a BaP-TEq concentration greater than 3,500 ppb such that 4 yards have either TCDD-TEq or BaP-TEq concentrations of public health concern.

Table 4 also shows that the TCDD-TEq concentration that produces a cancer risk greater than 0.0001 is about 800 ppt and that only one of the sampled yards has a TCDD-TEq concentration above that level. Consequently, TCDD exposures are of health concern for both cancer and non-cancer effects. Similarly, the average yard BaP or BaP-TEq concentration that results in a cancer risk greater than 0.0001 is about 7,700 ppb and none of the 31 yards sampled has an average

[2] "EPA uses the general 10-4 (1 in 10,000) to 10-6 (1 in 1,000,000) risk range as a "target range" within which the Agency strives to manage risks as part of a Superfund cleanup.… A specific risk estimate around 10-4 may be considered acceptable if justified based on site-specific conditions, including any remaining uncertainties on the nature and extent of contamination and associated risks. Therefore, in certain cases EPA may consider risk estimates slightly greater than 1 x 10-4 to be protective" EPA. 1991. OSWER Directive 9355.0-30. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. http://www.epa.gov/oswer/riskassessment/baseline.htm

concentration above that level. Note that the 1E-04 (0.0001) cancer risk used as a benchmark for acceptable risk (EPA, 1991) is based on a 70 year (lifetime) exposure. As the Tie Plant community was developed in the 1960s, calculated cancer risks shown in Table 4 are based on 56 year exposures (12 years of child exposure plus 44 years of adult exposure).

It is important to note that the above listed doses and cancer risks do not necessarily indicate that any Tie Plant residents will suffer health effects from their exposures to contaminated soil. The calculated doses are based on health protective assumptions regarding intake and exposure and may overestimate actual exposures. Similarly, the listed health comparison values are based on measured contaminant doses to laboratory animals that typically include significant safety factors in order to apply those results to actual human exposures. The following sections describe the potential health effects specifically related to BaP and TCDD and how the respective health comparison values are derived.

Table 4. Minimal risk levels (MRLs) for TCDD-TEq and calculated cancer risks for BaP, BaP-TEq, and TCDD-TEq exposures from soil.

	BaP	**BaP-TEq**	**TCDD-TEq**
MRL (mg/kg/day)	NA	NA	1E-9 Chronic
Avg. yard concentration with dose > MRL	NA	NA	~250 ppt 3 of 31 yards
Cancer slope factor (CSF) $(mg/kg/day)^{-1}$	7.3	7.3	130,000
Maximum Cancer risk 56 yr. exposure	2.2E-05	5.4E-05	1.9E-04
Avg. yard concentration with >1.0E-04 cancer risk (70 yr.)	7,700 ppb 0 of 31 yards	7,700 ppb 0 of 31 yards	800 ppt 1 of 31 yards

TCDD MRL for intermediate term exposure (14-365 days): 2E-8 mg/kg/day
TCDD MRL for acute term exposure (24 hours to 14 days): 2E-7 mg/kg/day
None of the calculated TCDD-TEq doses are greater than the acute or intermediate MRLs.
MRL: **minimal risk level** (see Appendix A for information on derivation and usage).
NA: MRLs are **not available** for BaP and BaP-TEq.
The cancer slope factor for TCDD-TEQ is the California Office of Environmental Health Hazard Assessment oral CSF for 2,3,7,8-TCDD (http://www.oehha.ca.gov/tcdb/index.asp).
The CSF for BaP is from the USEPA Iris database ((http://www.epa.gov/iris/subst/0136.htm#quaoral).

BaP and BaP-TEq Health Effects

ATSDR calculated that the excess cancer risks from 56 year exposures to yard and drainage area soils for the highest yard average concentration of BaP and BaP-TEq are approximately 2.2E-05 and 5.4E-05 (respectively; Table 4). The excess cancer risks for BaP and BaP-TEq are less than the EPA accepted risk level of 1.0E-04. ATSDR considers cancer risks less than 1.0E-04 to be a low increased cancer risk (for skin or stomach cancers) to long-term residents living at locations with the highest BaP-TEq soil concentrations. However, those theoretical excess cancer risks are calculated using the cancer slope factor (CSF) for BaP, which may not be directly applicable to risk estimation for the wider range of PAHs included in derivation of the BaP-TEq (Fitzgerald et.al., 2004).

The following summary of BaP health effects is primarily from the ATSDR Toxicological Profile for Polycyclic Aromatic Hydrocarbons (ATSDR, 1995) with other documents as cited. Benzo(a)pyrene (BaP) is one compound in a class of more than 100 chemicals called polycyclic aromatic hydrocarbons (or PAHs). PAHs are formed during the incomplete combustion of coal, oil, gas, wood, garbage, and other organic substances. PAHs, including BaP, occur naturally in air, water, and soil but are also found in creosote products such as those used at wood treating facilities.

The BaP toxic equivalent (TEq) is a derived concentration of the 7 most common PAHs with their specific concentrations adjusted for their toxicity relative to BaP. Those specific PAHs and relative toxicities (expressed as toxic equivalency factors; TEFs) are as follow (from EPA, 1993):

PAH compound	TEF
Benzo(a)pyrene	1
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(ah)anthracene	1
Indeno(123-cd)pyrene	0.1

BaP-TEq equals the sum of the individual compound concentrations multiplied by their respective TEF. Concentrations of 55 specific PAHs (including alkylated PAHs) in soil and drainage areas are included in Tables 1 and 2.

PAHs, including BaP, can be harmful to your health. Several PAHs, as listed above, have caused tumors in laboratory animals when they breathed, ate, or had long periods of skin exposure to these substances. Human data specifically linking benzo[a]pyrene (BaP) to a carcinogenic effect are lacking. There are, however, multiple animal studies in many species demonstrating BaP to be carcinogenic following administration by numerous routes ((http://www.epa.gov/iris/subst/0136.htm#quaoral). Workers who had long-term skin contact with creosote, especially during wood treatment or manufacturing processes, reported increases in skin cancer and cancer of the scrotum. Cancer of the scrotum has been associated with long-term exposure to soot and coal tar creosotes of chimney sweeps. Animal studies have also shown an association between creosote exposure and skin cancer (ATSDR, 2002).

The cancer slope factor (CSF) for BaP (7.3 mg/kg/day^{-1}; Table 4) is based on the geometric mean of four different dose response models using multiple species and both sexes. The EPA considers the available human cancer data to be inadequate but the animal carcinogenic data on which the CSF is based to be sufficient (http://www.epa.gov/iris/subst/0136.htm#quaoral). The above listed PAHs are considered by the Department of Health and Human Services and the EPA to be known animal carcinogens and probable human carcinogens (respectively). It should be noted that the above CSF is specifically applicable to evaluation of BaP cancer risk and inferred for evaluation of BaP-TEq cancer risks.

It is important to understand that the cancer risks calculated above are based on the most conservative assessment model available (NCRP 2001). The dose-response models used to estimate the CSF assume that there is no threshold below which there is no dose-response and actually ignore data which suggest that such a threshold exists (NCRP 2001; Fitzgerald, et.al. 2004). Using BaP and creosote exposures to mice and a benchmark dose-response model for the resulting tumor development, Fitzgerald, et.al. (2004) propose a soil guideline value of 5,000 ppb BaP is safe for human exposure. None of the Tie Plant yard average BaP concentrations were above 5,000 ppb.

Some non-cancer dermatological effects could also be associated with exposure to PAH-contaminated soil. However, those effects occur at much higher concentrations than those measured in Tie Plant yards. Creosote workers report skin rash symptoms as their most frequent complaint, as well as a high rate of photosensitivity (ATSDR, 2002). The dermatological system is particularly vulnerable to the effects of creosotes (ATSDR, 2002). In an industrial health survey (cited earlier) involving 251 employees at 4 wood preservative plants where coal tar creosote and coal tar are used, there were 82 reported instances of dermal effects, ranging from mild skin irritation, eczema, and folliculitis to benign skin growths such as warts (ATSDR, 2002). Skin irritation was described as a redness like a sunburn, lasting 2 to 3 days, along with photosensitivity that has been reported by workers who handle coal tar pitch products outdoors (ATSDR, 2002). Dermal effects were also noted as part of a site surveillance program conducted by the Texas Department of Health involving residents living in a housing development that was built on part of an abandoned creosote wood treatment plant (Koppers Company, Texarkana, Texas; Texas DOH, 1994).

Mice fed high concentrations of BaP during pregnancy (and/or their offspring) had difficulty reproducing, birth defects, and decreased birth weights. Studies of other animals have shown that BaP causes harmful effects on skin, body fluids, and immune system deficiencies. Similar effects could occur in people but have not been documented. No acute or chronic Minimal Risk Levels (MRLs) have been derived for BaP because no adequate human or animal dose-response data are available that identify threshold levels for appropriate non-cancer health effects. However, the doses at which these non-cancer health effects occurred in mice were more than a million times higher than BaP or BaP-TEq doses from soil in the Tie Plant community (ATSDR, 1995). Therefore, it is unlikely that any non-cancerous adverse health effects from PAH (BaP or BaP-TEq) exposure would occur in children or adults.

A recently submitted and EPA approved workplan (Off-Site Soil Assessment and Replacement Workplan dated April 12, 2012; cited in email from Carl Blair to Mark Evans, 7/30/2012) indicates that the three yards and two drainage areas with the highest BaP-TEq concentrations will be remediated in the near future. BaP and BaP-TEq exposures at other yards, the school, and community playground are below levels of public health concern.

TCDD-TEq Health Effects

The highest calculated TCDD-TEq dose in the Tie Plant community is 5.3E-09 mg/kg/day (child; Table 3). This dose is about 5 times greater than the MRL (1E-09 mg/kg/day) but more than 20 times lower than the dose on which this MRL is based (1.2E-07 mg/kg/day; ATSDR, 1998). While this indicates that the highest estimated TCDD-TEq doses from soil exposure are not likely to produce observable non-cancer adverse health effects, such adverse effects cannot be ruled out. ATSDR calculated that the excess cancer risk from a 56 year exposure to yard and drainage area soils for the highest yard average concentration of TCDD-TEq is 1.9E-04 (Table 4). This excess cancer risk is greater than the EPA accepted risk level of 1.0E-04.

The following summary of TCDD-TEq health effects is primarily from the ATSDR Toxicological Profile for Chlorinated dibenzo-p-dioxins (ATSDR, 1998) and other documents as cited. 2,3,7,8 Tetrachlorodibenzo-p-dioxin (TCDD) is one compound within a large class of chemicals commonly referred to as polychlorinated dioxins (or dioxins/furans). Dioxins are formed during the combustion of coal, oil, gas, wood, garbage, and other organic substances. Dioxins, including TCDD, occur naturally in air, water, and soil but are also found as a contaminant in pentachlorophenol used at wood treating facilities.

The TCDD toxic equivalent (TEq) is a derived concentration of the 17 most common dioxins with their specific concentrations adjusted for their toxicity relative to TCDD. Those specific dioxins and relative toxicities (expressed as toxic equivalency factors; TEFs) are as follow (from Van den Berg, et al. 2006):

Dioxin Compound	TEF
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
Octachlorodibenzo-p-dioxin	0.0003
2,3,7,8-Tetrachlorodibenzofuran	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.03
2,3,4,7,8-Pentachlorodibenzofuran	0.3
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
Octachlorodibenzofuran	0.0003

TCDD-TEq equals the sum of the individual compound concentrations multiplied by their respective TEF. Concentrations of 25 specific dioxins in soil and sediment are included in Tables 1 and 2.

Dioxins, and specifically 2,3,7,8-TCDD, can be harmful to your health. Many studies have looked at how dioxins can affect human health. Most of these studies examined workers exposed during the manufacture of chemicals and pesticides contaminated with 2,3,7,8-TCDD. Other studies have looked at American Vietnam veterans and Vietnamese populations exposed to Agent Orange and populations exposed to 2,3,7,8-TCDD as a result of an accident. The workers and Vietnam veterans were most likely exposed to 2,3,7,8-TCDD mainly through breathing and skin contact. People who were accidentally exposed to 2,3,7,8-TCDD in Seveso, Italy, or Times Beach, Missouri, were probably exposed through eating and drinking contaminated food and milk, breathing contaminated particles and dust, through skin contact with contaminated soil and through unintentional hand-to mouth activity.

In most human health studies, we do not know how much 2,3,7,8-TCDD people were exposed to or how long the exposures lasted. In other studies, the people were examined many years after they were exposed and some of the effects may have not have been present at the time of examination or the effects observed may not have been caused by 2,3,7,8-TCDD. Some of the more recent studies have measured 2,3,7,8-TCDD levels in the blood or fat tissue of exposed populations. The levels of 2,3,7,8-TCDD in the blood or fat tissue can be used to estimate the extent of past exposures.

2,3,7,8-TCDD has been the most extensively studied dioxin and it has been shown to cause a large number of adverse health effects in animals. There are always going to be some difficulties in using animal data to quantify health effects in people. In general, the doses used in the animal studies result in body burdens that are at least 10 times higher than human background body burdens, often the animal studies use doses that are over 1,000 times higher than human background body burdens.

The results of the oral animal studies suggest that the most sensitive non-cancer effects (effects that will occur at the lowest doses) are immune, endocrine, and developmental effects. It is reasonable to assume that these will also be the most sensitive effects in humans. The MRL for TCDD-TEq is 1E-09 mg/kg/day and is based on behavioral and developmental effects in rhesus monkeys (ATSDR, 1998). The lowest dose at which these health effects were observed was 1.2E-07 mg/kg/day. The MRL is ~100 times lower than the lowest observed dose effect to account for extrapolation of dose effects from animals to humans and other experimental considerations (ATSDR, 1998).

Exposure to 2,3,7,8-TCDD can cause reproductive damage and birth defects in animals. Decreases in fertility, altered levels of sex hormones, reduced production of sperm, and increased rates of miscarriages were found in animals exposed to 2,3,7,8-TCDD in food. Rats and mice that were exposed to small amounts of 2,3,7,8-TCDD in food for a long time developed cancer of the liver and thyroid, and other types of cancer. The cancer slope factor for 2,3,7,8-TCDD is currently under review by the US EPA. The California Office of Environmental Health Hazard

Assessment (OEHHA) has established an oral cancer slope factor of 130,000 (mg/kg/day^{-1}) for 2,3,7,8-TCDD (http://www.oehha.ca.gov/tcdb/index.asp).

TCDD is classified by EPA as a probable human carcinogen. The World Health Organization (WHO) has determined that TCDD is a human carcinogen (ATSDR 1998). The US Department of Health and Human Services (DHHS) has determined that TCDD may reasonably be anticipated to cause cancer (ATSDR 1998). As shown in Table 4, only one of the estimated excess cancer risks exceeds 1.0E-04, which is considered the baseline for acceptable risk by the EPA (EPA, 1991). Consequently, the yard with the highest TCDD-TEq soil represents a health hazard related to cancer risk and should be remediated.

Gardening and Eating Homegrown Produce

ATSDR has learned through discussions with community members, that some residents living adjacent to the site grow fruits and vegetables in their yards. Actual, measured concentrations of chemicals in fruits and vegetables grown in soil adjacent to the Tie Plant Site, as well as comparison values for home-grown produce, are not available at this time. However, ATSDR does have information about the chemicals found in soil at levels that exceeded the health-based comparison values for residential soil. ATSDR's evaluation of soil samples collected from residential property indicate levels of dioxin (as TCDD-TEq) and BaP that exceed health-based comparison values for soil. While actual exposures via homegrown produce cannot be determined based on available data, ATSDR conducted a literature search on dioxins and BaP, to better understand if these chemicals could be taken up into plants and ways that exposure to these chemicals could be reduced.

In general, plants may take up chemical contaminants either by absorbing them through their root system or through their leaves and stems. Chemicals in air may also settle on the above ground parts of plants (Simonich and Hites, 1995). Based on a review of the available scientific literature, chemicals such as dioxin and BaP are not thought to be taken into most plants by the root system, with the exception of members of the family *Curcubita,* which includes zucchinis, cucumbers, squash, melons, gourds, and pumpkins (Simonich & Hites, 1995; Rideout and Teschkle, 2004; Zhang, et.al., 2009; and Takashi, et.al., 1994). Other studies suggest that these chemicals may also get into crops such as carrots and potatoes, although the evidence suggests that dioxins are located primarily in the peel of potatoes and carrots (Rideout and Teschke, 2004).

Based on the ATSDR's review of the literature, most plants do not readily take up the chemicals found in residential soil samples collected near the Tie Plant Site. However, people may reduce their exposure to chemicals in their home-grown produce by peeling root crop vegetables, such as carrots and potatoes, which have been found to accumulate low levels of chemicals. Another way to minimize exposures to chemicals in soil is to be sure that dirt is removed from produce before bringing them into the home. Washing home-grown produce thoroughly will also remove soil particles that may contain chemicals. (Michigan DEQ, 2012; and Schuhmacher, et.al., 2006).

Appendix B contains an ATSDR fact sheet describing everyday practices that will reduce exposures to soil.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

This consultation uses child-specific exposure factors, such as body weights, intake rates, and skin exposure areas, as the basis for calculating exposures to contaminants in soil (Appendix A). The resulting exposure doses for children are higher than adult doses and represent the basis for the following public health conclusions and recommendations. Additionally, soil data evaluated in this consultation includes sample locations from a schoolyard and playground/park that are located in the Tie Plant community. Contaminant concentrations from those locations are below applicable health comparison values such that there is no public health hazard for children playing in those areas.

Adequacy of Available Data

The soil and sediment data (GeoTrans, 2010) underlying this consultation appear to be an adequate basis for the following public health determinations. Sample location, collection, and quality assurance procedures that were established (and apparently implemented) resulted in a consistent, well-documented data set. Similarly, based on topography and likely routes of contaminant migration from the KB site (GeoTrans, 2010), locations not sampled are unlikely to have significant concentrations of site-related contaminants in soil. The GeoTrans report (2010) also contains and uses data from other site-specific studies. Although documentation of the sample collection, analysis, and quality control procedures for these ancillary data sets is not available, the respective data sets are consistent (concentration distributions and values are similar between data sets) and used as appropriate in this consultation.

Although ATSDR considers the available soil and sediment data a reliable basis for the following public health determination, it should be noted that ATSDR considers the upper three inches of surface soil to be most representative of exposure (ATSDR, 1994). Soil samples integrated over the upper six inches, as are the GeoTrans data, may underestimate surface soil concentrations for contaminants such as BaP and dioxins that are strongly bound to soil particles.

It should be noted that, for this data set, a few locations have higher contaminant concentrations in deeper samples (6 to 12 inch depth) than the 0 to 6 inch surface samples.

Another source of potential uncertainty regarding the drainage area data is that ditch samples are mostly not directly related to a specific residential location (as previously described). This uncertainty is addressed by using the 95th upper confidence limit of the geometric mean (geomean) of all off-site ditch sediment samples (for each contaminant) and assuming that exposures to drainage area sediments occur at a frequency of one day per week with an intake equal to an entire daily soil ingestion rate (Appendix A). This weekly exposure, combined with a soil intake frequency of ~7 days per week (350 days per year), results in a health-protective total soil exposure to both yard and drainage area soils.

In order to verify that use of the 95th UCL of geomean (for drainage area soils) did not underestimate total soil exposure, residence-specific combined soil and drainage area contaminant doses were calculated for those six yards for which residence-specific drainage samples are available. Four of the six residences have drainage area concentrations below the 95th UCL contaminant values (Table 3). Two locations have drainage contaminant concentrations slightly greater than the 95th UCL values. In both of these yards the average yard soil contaminant concentrations were relatively low and the drainage area concentrations only slightly greater than assumed average values such that cumulative soil doses are most likely over-estimated with respect to actual soil doses for Tie Plant residents.

In addition to the soil contaminant data evaluated in this consultation, two studies have also analyzed pentachlorophenol (PCP) and dioxin concentrations in blood and house dust samples from members of the Tie Plant community (Dahlgren, et.al., 2007; Feng, et.al., 2011). As noted previously, PCP concentrations in yard soils were below levels of public health concern. The blood and house dust studies do not report blood dioxin levels for individuals (data presented are only presented as community-wide distributions) and, as such, cannot be directly related to the location specific soil sampling evaluated in this consultation. It should be noted that this health consultation assumes that an individual's soil contact and intake is derived from both yard soil and house dust and that the composition of house dust is similar to that of the yard soil.

ATSDR (2009) has previously evaluated the blood PCP data from Dahlgren, et.al. (2007). While the ATSDR report did not make any health determinations regarding the tested individuals, it did suggest that soil exposures cannot account for the measured PCP blood levels and that airborne exposures may be the most important pathway of exposure for this community. Thus, the largest source of uncertainty regarding contaminant exposures from the KB site to Tie Plant residents is the concentration of site-specific contaminants in the air. Although the estimated doses from soil exposures (Tables 3 and 4) are below levels of health concern for most of the residences evaluated, combined exposures via soil and air may result in cumulative doses that are of public health concern.

The BaP TEF values listed in the previous section are currently undergoing revision (EPA, 2010; albeit as relative potency factors [RPF], rather than TEFs). ATSDR has used the draft RPF values (Table 5) and measured PAH concentrations (Tables 1 and 2) to calculate modified BaP-TEq concentrations and the resulting cancer risks. The modified BaP-TEq concentrations and resulting estimates of cancer risk are an average of 3.4 times greater than concentrations and risks calculated using the 1993 TEF values. Note that not all of the individual PAHs listed in the 2010 draft revision (Table 5) are measured in the GeoTrans data set (Tables 1 and 2). Using the modified BaP-TEq concentrations an average yard concentration of approximately 2,600 ppb (BaP-TEq) results in a cancer risk that exceeds the 1.0E-04 threshold value. Five, instead of two, of the 29 yards sampled (Table 4) have modified BaP-TEq soil concentrations that are greater than 2,600 ppb.

Conclusions, Recommendations, and Action Plan

Conclusions

The purpose of this public health consultation is to determine if contaminants used by or released from the KB site are present in the soil of adjacent residences at concentrations that may present a public health hazard to people living at those locations. The public health determination is based on an evaluation of the concentrations of toxic substances measured in those areas and the pathways by which people may be exposed to the soil in their yards and nearby drainage areas. The KB site is an active facility that uses and releases creosote and pentachlorophenol for the treatment of wood products. These compounds are complex chemical mixtures that include significant quantities of benzo(a)pyrene (BaP; and related PAHs) and 2,3,7,8 tetrachlorinateddibenzo-p-dioxins (2,3,7,8-TCDD; and related dioxins).

Soil from 31 yards in the Tie Plant community were sampled and analyzed for 83 individual chemicals. Of the many potential contaminants analyzed, only BaP, BaP-TEq, and TCDD-TEq were detected at concentrations above health comparison values. While these contaminants are used by and released from the KB site, they also have multiple other sources and are present in background soils. However, soils in yards and drainage areas adjacent to or down-gradient of the KB site have significantly higher concentrations of these contaminants relative to background samples. As these contaminants are present in the yard and drainage area soils, people living in these areas are assumed to be exposed to these contaminants on a daily basis.

In addition to the soil data evaluated in this PHC, ATSDR has previously evaluated air monitoring data from KB site operations and determined that the available data do not adequately characterize emissions from the KB facility (ATSDR, 2010). Prior to KB facility shut down, residents living adjacent to the KB site may have had significant exposures to site-related contaminants from breathing the contaminants that were released to the air from the KB site.

On the basis of the likely exposure to soil in residential yards and drainage areas and the available environmental data, ATSDR concludes the following:

> **BaP-TEq** Long term exposures to BaP-TEq in soil at all of the 31 yards sampled represent a low increased estimated risk of skin or stomach cancers (less than 0.0001). This low increased risk is within the EPA's acceptable risk range for Superfund cleanups. More than 67% of the yards sampled (21 of 31) in the Tie Plant community have average BaP-TEq concentrations that are greater than the 95th percentile background value (108.8 ppb). Due to the health-protective procedures used in establishing health comparison values and the likely over-estimation of soil exposures, adverse health effects (cancer and non-cancer) are not expected from short or long term BaP-TEq soil exposures at these locations.
>
> **TCDD-TEq** Long term exposure to TCDD-TEq in the Tie Plant yard with the highest TCDD-TEq soil concentration is a public health hazard due to a moderately increased estimated excess cancer risk. Six of the 31 yards had average TCDD-TEq concentrations greater than the 95th percentile concentration (80.4 ppt) of background yards. Three of the 31 yards sampled have calculated exposure doses that exceed the ATSDR health comparison value but are more than 20 times lower than the dose on which the comparison value is based. Due to the health-protective procedures used in establishing

health comparison values and the likely over-estimation of soil exposures, non-cancer adverse health effects are not expected from either short or long term TCDD-TEq soil exposures.

Recommendations

The three sampled yards with the highest BaP-TE concentrations have been remediated to decrease exposures to contaminants in yard and drainage area soils. The yard with the highest TCDD-TEq concentration has also been remediated. . Consequently, ATSDR has no specific public health recommendations regarding exposures to soil in the Tie Plant community.

Public Health Action Plan

ATSDR distributed the public comment version of this health consultation to members of the Tie Plant community on September 4, 2012. No comments have been received. Although no further ATSDR actions are planned for this site, we will continue to work with EPA to evaluate community exposures from the KB site if additional data become available.

Author and Reviewers of Report

Author of Report

Mark W. Evans, Ph.D.
Environmental Geologist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Reviewers of Report

Ken Orloff, Ph.D.
Toxicologist
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

Scott Sudweeks, M.S.
Health Assessor
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

References

AMEC, 2005. Screening Level Evaluation of Potential Risks Associated with Supplemental Data Collected at and Near the KI Facility, Grenada, Misssissippi. Prepared for Beazer East, Inc. Pittsburgh, PA. September 2, 2005.

AquAeTer, 2005. Surface Soil Sampling Report for Dioxins, Furans, Polycyclic Aromatic Hydrocarbons, and Pentachlorophenol. Prepared for Wildman, Harrold, Allen, and Dixon, Chicago, IL May 2005.

ATSDR 1994. Environmental Data Needed for Public Health Assessments: A Guidance Manual. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, June 1994.

ATSDR 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, August, 1995.

ATSDR 1998. Toxicological Profile for Chlorinated Dibenzo-p-Dioxins (update). US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, December, 1998.

ATSDR 2002. Toxicological Profile for Wood Creosote, Coal Tar Creosote, Coal Tar, Coal Tar Pitch, and Coal Tar Volatiles. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, September 2002.

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

ATSDR 2009. Technical Assistance Report. Review of EPA Sampling Plan Koppers Inc./Beazer East, Inc., Tie Plant, Grenada, MS., US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, December 4, 2009.

ATSDR 2010. Technical Assist for the Koppers Tie Plant near Grenada, MS. Review of Ambient Air Monitoring Samples collected near Grenada, MS in 2003-2004. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA, March 8, 2010.

EPA, 1991. OSWER Directive 9355.0-30. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. US Environmental Protection Agency. http://www.epa.gov/oswer/riskassessment/baseline.htm

EPA 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, US Environmental Protection Agency, EPA 540-R-04-004, July, 1993.

EPA 2010. Development of a Relative Potency Factor (RPF) Approach for Polycyclic Aromatic Hydrocarbon (PAH) Mixtures. US Environmental Protection Agency, Washington, DC, EPA/635/R-08/12-A, www.epa.gov/iris, February 2010.

EPA 2011. Exposure Factors Handbook 2011 Edition. US Environmental Protection Agency, Washington, DC, EPA/600/R-09/052F, October 2011.

Feng, L. et.al. 2011. Dioxan Furan Blood Lipid and Attic Dust Concentrations in Populations Living Near Four Wood Treatment Facilities in the United States. Journal of Environmental Health 73(6): 34-46.

Fitzgerald, D. et.al. 2004. Application of Benzo(a)pyrene and Coal Tar Tumor Dose-Response Data to a Modified Benchmark Dose Method of Guideline Development. Environmental Health Perspectives 112(14): 1341-1346.

GeoTrans 2010. Final Draft Sampling Report, Additional Sampling Koppers Inc., Tie Plant Facility, Tie Plant, Mississippi. Prepared for Beazer East, Inc., Pittsburgh, PA by GeoTrans, Inc., Rancho Cordova, CA, December 2010.

Michigan DEQ 2012. Dioxins and Furans: Reducing Exposure from Agricultural Activities. Michigan Department of Environmental Quality, Community Health and Agriculture, Accessed January 24, 2012, http://www.michigan.gov/documents/deq/deq-whm-hwp-dow-Reducing-Exposure-Agricultural-Activities_251916_7.pdf .

NAS 2006. Health Risks from Dioxin and Related Compounds. Evaluation of the EPA Reassessment. Committee on EPA's Exposure and Human Health. Reassessment of TCDD and Related Compounds. Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council of the National Academies, National Academies Press, Washington, DC. http://www.nap.edu/catalog/11688.html

Ounnas, F. et.al., 2009. Relative bioavailability of soil-bound polycyclic aromatic hydrocarbons in goats. Chemosphere 77 (2009): 115-122.

Rideout, R. and Teschke, K. 2004. Potential for increased human foodborne exposure to PCDD/F when recycling sewage sludge on agricultural land. Environmental Health Perspectives 112(9): 959-969.

Schumacher, M. et.al. 2006. Air-vegetation transfer of PCDD/PCDFs: An assessment of field data and implications for modeling. Environmental Pollution 142(1): 143-150, July 2006.

Simonich, S. and Hites, R., 1995. Organic Pollutant Accumulation in Vegetation. Environmental Science and Technology 29(12):2905-2914.

Stroo, H. et.al., 2005. Improving Risk Assessments for Manufactured Gas Plant Soils by Measuring PAH Availability. Integrated Environmental Assessment and Management- Vol.1 (3): 259-266.

Texas DOH, 1994. Final Report: Site-specific Surveillance Project at the Koppers Company, Inc., National Priorities List Site. Texarkana, TX. Texas Department of Health, prepared under cooperative agreement with the Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services, Atlanta, GA., March 1994.

Van den Berg, M. et.al., 2006. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicological Science 93:223-241.

Zhang, H. et.al. 2009. Uptake by roots and translocation to shoots of polychlorinated dibenzo-p-dioxins and dibenzofurans in typical crop plants. Chemosphere 76(6):740-746.

Tables 1, 2, and 5.

Table 1: Dioxin-Furan Concentrations in Yard Surface Soil Samples (0-6" depth)				
Contaminant (TEF)	CV ppt	Bkgd Range ppt	Yard Range ppt	% Yards > 95th% Bkgd ppt
TCDD-TEq	**50 c-emeg-c**	**1.2—88.4**	**4.8—1,470**	**19% > 80.4**
2378-TCDD (1)	50 c-emeg-c	<0.1—1.8	<0.2—6.1	11% > 1.6
12378-PeCDD (1)	No CVs for these specific dioxins/furans	<0.1—11.5	0.6—44.4	22% > 8.7
123478-HxCDD (0.1)		<0.2—37.9	1.8—145	17% > 32.3
123678-HxCDD (0.1)		<0.4—90.1	5.4—3,558	33% > 90.0
123789-HxCDD (0.1)		<1.2—59.6	3.3—436	28% > 44.9
1234678-HpCDD (0.01)		18.7—2,200	164—63,450	44% > 1,654
OCDD (0.0003)		1,120—18,700	1,640—400,500	35% > 16,480
2378-TCDF (.01)		<0.1—3.4	<0.2—22.1	17% > 2.4
12378-PeCDF (0.03)		<0.1—4.2	<0.4—119	22% > 4.2
23478-PeCDF (0.3)		<0.1—42.1	<0.4—289	11% > 42.1
123478-HxCDF (.01)		0.1—36.1	0.7—412	17% > 35.7
123678-HxCDF (.01)		<0.1—32.3	0.6—194	17% > 29.5
234678-HxCDF (.01)		<0.1—58.7	1.2—398	17% > 54.4
123789-HxCDF (.01)		<0.1—0.6	<0.1—7.8	44% > 0.6
1234678-HpCDF (0.01)		1.2—2,440	25.9—5,315	11% > 2,422
1234789-HpCDF (0.01)		<0.1—39.9	1.0—417	28% > 30.2
OCDF (0.0003)		3.3—1,220	97.7—17,650	44% > 1,214
Total TCDD		<0.2—32.3	<0.7—42.4	17% > 26.0
Total PeCDD		<0.1—122	1.4—294	17% > 106
Total HxCDD		3.8—791	48.8—10,190	22% > 733
Total HpCDD		34.8—3,890	317—100,750	44% > 2,996
Total TCDF		<0.1—150	0.5—118	0% > 120
Total PeCDF		<0.1—492	2.8—2,221	11% > 444
Total HxCDF		1.0—1,520	22.0—12,205	17% > 1,508
Total HpCDF		3.2—4,100	77.4—19,035	17% > 4,064

Notes for Tables 1 and 2 (data are from GeoTrans, 2010)
--TEFs are the toxic equivalency factors for dioxin/furans and PAHs. These factors (in parentheses) are multipliers used for combining the relative toxicity of the individual dioxin/furan and PAH species into summed TCDD-TEq and BaP-TEq values (the individual specie concentrations are multiplied by their respective TEFs and summed). Note that TEFs are not available for all dioxin/furan and PAH species.
--PAHs are polycyclic aromatic hydrocarbons.
--CVs are comparison values. The derivation and usage of the CVs are described in Appendix A.
c-emeg-c: Chronic environmental media evaluation guide- child
rmeg-c: Chronic environmental media evaluation guide- child derived from EPA reference dose
creg: Cancer risk evaluation guide
ppt: parts per trillion
ppb: parts per billion

Table 1 (cont'd) : PAH/PCP Concentrations in Yard Surface Soil Samples (0-6" depth)

Contaminant (TEF)	CV ppb	Bkgd Range ppb	Yard Range ppb	% Samples > 95th% Bkgd ppb
BaP-TEq	NA	2.7—109.9	23—4,540	68% > 108.8
Acenaphthene	30,000,000 rrmeg-c	<0.9—7.9	<1.0—44.0	17% > 6.0
Acenaphthylene	NA	<0.6—9.5	<2.0—221	39% > 9.2
Anthracene	20,000,000 rmeg-c	<0.7—16.0	<2.0—192	28% > 14.8
Benz(a)-anthracene (0.1)	NA	1—64	13—2,462	44% > 59.2
Benzo(a)pyrene (1)	**100 creg**	**0.9—70**	**14—2,712**	**50% > 68**
Benzo(b)-fluoranthene (0.1)		1.8—160	34—6,541	56% > 148
Benzo(g,h,i)-perylene		0.9—76	13—2,114	44% > 72
Benzo(k)-fluoranthene (0.01)	NA	2.8—53	12—2,064	50% > 50
Chrysene (0.001)		2.9—90	19—2,374	50% > 82
Dibenz(a,h)-anthracene (1)		<1.1—13	<3.0—603	50% > 13
Fluoranthene	2,000,000 rmeg-c	<1—170	32—3,278	33% > 152
Fluorene	2,000,000 rmeg-c	<0.6—17	<1.0—29	11% > 9.7
Indeno(1,2,3-cd)pyrene (0.1)	NA	<1—72	15—3,017	50% > 70
2-Methyl-naphthalene	200,000 rmeg-c	<0.9—170	<3.0—97	0% > 140
Naphthalene	1,000,000 rmeg-c	<0.9—94	5.0—118	6% > 80
Phenanthrene	NA	2.9—180	13—610	17% > 156
Pyrene	2,000,000 rmeg-c	1.5—140	31—3,523	39% > 128
Pentachlorophenol	50,000 c-emeg-c	1.2—6	<2.0—378	72% > 6
Alkylated PAHs				
Benzo(b)thiophene	NA	<3.1	<5.0	89% > 3.0
Benzo(e)pyrene		<1.0—83	19—3,320	56% > 83
Biphenyl	3,000,000 rmeg-c	<0.8—17	<1.0—37	17% > 14.6
C1 - Benzothiophenes		<5.0	<5.0	0% > 5.0
C1 - Chrysenes		<5.0—89	8.0—420	33% > 83.6
C1 - Dibenzothiophenes		<5.0—200	<5.0—30	0% > 126
C1 - Fluoranthenes/Pyrenes		<5.0—97	13—1,761	39% > 90.4
C1 - Fluorenes		<5.0—99	<5.0—12	0% > 43
C1 - Naphthobenzothiophenes		<5.0—29	<5.0—7.0	0% > 28.4
C1 - Phenanthrenes/Anthracenes	NA	<5.0—350	<5.0—394	6% > 266
C2 - Benzothiophenes		<5.0—6.3	<5.0	0% > 5.5
C2 - Chrysenes		<5.0—54	<5.0—854	28% > 53
C2 - Dibenzothiophenes		<5.0—250	<5.0—29	0% > 119
C2 - Fluoranthenes/Pyrenes		<5.0—76	<5.0—855	28% > 75
C2 - Fluorenes		<5.0—230	<5.0—29	0% > 108
C2 - Naphthalenes	NA	<5.0—290	<5.0—130	0% > 290

C2 - Naphtho-benzothiophenes		<5.0—48	<5.0—133	11% > 35.4
C2 - Phenanthrenes/Anthracenes		<5.0—420	<5.0—434	6% > 264
C3 - Benzothiophenes		<5.0—12.0	<5.0	0% > 8.2
C3 - Chrysenes		<5.0—42	<5.0—393	22% > 39
C3 - Dibenzothiophenes		<5.0—200	<5.0—44	0% > 90
C3 - Fluoranthenes/Pyrenes		<5.0—54	<5.0—348	22% > 51
C3 - Fluorenes		<5.0—220	<5.0—63	0% > 102
C3 - Naphthalenes		<5.0—560	<5.0—120	0% > 380
C3 - Naphthobenzothiophenes		<5.0—83	<5.0—78	6% > 49
C3 - Phenanthrenes/Anthracenes		<5.0—260	<5.0—358	6% > 176
C4 - Chrysenes		<5.0—63	<5.0—138	6% > 59
C4 - Dibenzothiophenes		<5.0—100	<5.0—16	0% > 45
C4 - Naphthalenes		<5.0—430	<5.0—66	0% > 280
C4 - Phenanthrenes/Anthracenes		<5.0—140	<5.0—163	6% > 122
Dibenzofuran		<0.6—60	<3.0—122	6% > 49
Dibenzothiophene		<0.4—18	<1.0—22	11% > 9.8
2,6-Dimethylnaphthalene		<0.8—96	<1.0—37	0% > 86
1-Methylnaphthalene	4,000,000 c-emeg-c	<0.6—130	<2.0—56	0% > 111
1-Methylphenanthrene	NA	<0.9—67	<1.0—91	6% > 62
Naphthobenzothiophene		<1.3—19	<2.0—307	28% > 17.8
Perylene		<0.9—20	<3.0—552	39% > 19.4
2,3,5-Trimethylnaphthalene		<0.7—100	<1.0—37	0% > 79

Table 2: Dioxin-Furan Concentrations in Drainage Surface Samples (0-6" depth)

Contaminant (TEF)	CV ppt	Bkgd Range ppt	Drainage Range ppt	% Drain. > 95th% Bkgd ppt
TCDD-TEq	**50 c-emeg-c**	**4.1—39.3**	**4.8—3,940**	**76% > 29.2**
2378-TCDD (1)	50 c-emeg-c	<0.1—0.9	<0.2—49.6	58% > 0.74
12378-PeCDD (1)	No CVs for these specific dioxins/furans	<0.6—3.4	<0.7—958	77% > 3.1
123478-HxCDD (0.1)		<1.0—5.3	1.8—3,250	84% > 5.0
123678-HxCDD (0.1)		<1.5—38.5	4.8—12,000	77% > 28.9
123789-HxCDD (0.1)		<2.0—13.1	3.2—8,050	81% > 12.7
1234678-HpCDD (0.01)		95.8—368	161—409,000	87% > 360
OCDD (0.0003)		1,040—6,940	1,480—3,830,000	84% > 6,188
2378-TCDF (.01)		<0.1—1.6	<0.1—24.8	42% > 1.44
12378-PeCDF (0.03)		<0.2—3.0	<0.2—193	61% > 2.23
23478-PeCDF (0.3)		<0.3—14.6	<0.1—488	42% > 10.7
123478-HxCDF (.01)		<0.4—27.7	<1.1—2,470	55% > 18.6
123678-HxCDF (.01)		<0.3—22.8	<1.0—2,090	61% > 15.2
234678-HxCDF (.01)		<0.3—34.8	<1.5—4,540	61% > 23.2
123789-HxCDF (.01)		<0.1—0.6	<0.3—459	71% > 0.56
1234678-HpCDF (0.01)		3.8—1,120	29—123,000	52% > 720
1234789-HpCDF (0.01)		<0.7—11.5	2.1—11,600	81% > 8.6
OCDF (0.0003)		8.9—457	100—812,000	84% > 354
Total TCDD		<0.3—12.6	<0.4—672	48% > 11.7
Total PeCDD		1.3—38.0	6.6—4,440	81% > 30.5
Total HxCDD		21.1—252	53.3—66,000	84% > 204
Total HpCDD		204—854	380—681,000	90% > 794
Total TCDF		<0.3—64.1	<0.1—1,060	32% > 49.4
Total PeCDF		1.9—231	5.0—9,440	48% > 160
Total HxCDF		3.2—840	30.4—115,000	61% > 546
Total HpCDF		8.9—1,810	84.4—608,000	74% > 1,170

Notes for Tables 1 and 2
--TEFs are the toxic equivalency factors for dioxin/furans and PAHs. These factors (in parentheses) are multipliers used for combining the relative toxicity of the individual dioxin/furan and PAH species into summed TCDD-TEq and BaP-TEq values (the individual specie concentrations are multiplied by their respective TEFs and summed). Note that TEFs are not available for all dioxin/furan and PAH species.
--PAHs are polycyclic aromatic hydrocarbons.
--CVs are comparison values. The derivation and usage of the CVs are described in Appendix A.
c-emeg-c: Chronic environmental media evaluation guide- child
rmeg-c: Chronic environmental media evaluation guide- child derived from EPA reference dose
creg: Cancer risk evaluation guide
ppt: parts per trillion
ppb: parts per billion

Table 2 (cont'd): PAH/PCP Concentrations in Drainage Surface Samples (0-6" depth)

Contaminant (TEF)	CV ppb	Bkgd Range ppb	Drainage Range ppb	%. Drain. > 95th% Bkgd ppb
BaP-TEq	NA	4.0—1,483	6.0—5,800	23% > 1,092
Acenaphthene	3,000,000 rrmeg-c	<1.5—34	<1.0—71	15% > 22.9
Acenaphthylene	NA	<0.8—27	<1.0—410	23% > 21.4
Anthracene	20,000,000 rmeg-c	<3.0—130	<1.0—400	12% > 91.2
Benz(a)-anthracene (0.1)	NA	1.7—1,100	7—2,900	15% > 756
Benzo(a)pyrene (1)	**100 creg**	**1.6—1,000**	**<1.0—3,500**	**19% > 736**
Benzo(b)-fluoranthene (0.1)	NA	3.9—1,400	19—8,100	23% > 1,076
Benzo(g,h,i)-perylene		1.9—540	5.0—3,400	23% > 408
Benzo(k)-fluoranthene (0.01)		1.5—500	7.0—2,600	23% > 388
Chrysene (0.001)		2.3—990	11—4,300	23% > 698
Dibenz(a,h)-anthracene (1)		<0.9—160	<2.0—740	23% > 117
Fluoranthene	2,000,000 rmeg-c	3.1—1,500	14—4,200	15% > 1,056
Fluorene	2,000,000 rmeg-c	<1.9—26	<1.0—50	15% > 19.2
Indeno(1,2,3-cd)pyrene (0.1)	NA	1.7—670	9.0—4,300	23% > 506
2-Methyl-naphthalene	200,000 rmeg-c	<0.6—150	<1.0—130	0% > 134
Naphthalene	1,000,000 rmeg-c	1.1—85	<2.0—170	8% > 73
Phenanthrene	NA	2.2—490	6.0—1,100	15% > 358
Pyrene	2,000,000 rmeg-c	3.1—1,400	10—4,700	15% > 1,004
Pentachlorophenol	50,000 c-emeg-c	<1.5—6.5	<2.0—1,000	77% > 6.4
Alkylated PAHs	NA			
Benzo(b)thiophene		<0.6—3.4	<1.0—6	46% > 3.3
Benzo(e)pyrene		<2.3—730	10—4,400	23% > 566
Biphenyl	3,000,000 rmeg-c	<1.1—15	<1.0—42	12% > 14.6
C1 - Benzothiophenes	NA	<5.0	<5.0	0% > 5.0
C1 - Chrysenes		<5.0—530	<5.0—2,500	23% > 410
C1 - Dibenzothiophenes		<5.0—81	<5.0—36	0% > 73
C1 - Fluoranthenes/Pyrenes		<5.0—810	<5.0—2,400	19% > 590
C1 - Fluorenes		<5.0—17	<5.0—48	12% > 13
C1 - Naphthobenzothiophenes		<5.0—47	<5.0—11	0% > 44
C1 - Phenanthrenes/Anthracenes		<5.0—270	<5.0—560	8% > 250
C2 - Benzothiophenes		<5.0	<5.0—6	4% > 5.0
C2 - Chrysenes		<5.0—220	<5.0—1,100	23% > 165
C2 - Dibenzothiophenes		<5.0—35	<5.0—91	8% > 33.4
C2 - Fluoranthenes/Pyrenes		<5.0—140	<5.0—1,300	23% > 128
C2 - Fluorenes		<5.0—31	<5.0—60	4% > 29
C2 - Naphthalenes		<5.0—250	<5.0—160	0% > 246

Table 2 (cont'd): PAH/PCP Concentrations in Drainage Surface Samples (0-6" depth)

Contaminant (TEF)	CV ppb	Bkgd Range ppb	Drainage Range ppb	%. Drain. > 95th% Bkgd ppb
C2 - Naphtho-benzothiophenes	NA	<5.0—45	<5.0—350	23% > 38.2
C2 - Phenanthrenes/Anthracenes		<5.0—170	<5.0—770	19% > 166
C3 - Benzothiophenes		<5.0—6.6	<5.0	0% > 6.4
C3 - Chrysenes		<5.0—98	<5.0—400	23% > 84
C3 - Dibenzothiophenes		<5/0—25	<5.0—110	15% > 21.4
C3 - Fluoranthenes/Pyrenes		<5.0—74	<5.0—630	19% > 72.4
C3 - Fluorenes		<5.0—35	<5.0—140	15% > 30.2
C3 - Naphthalenes		<5.0—250	<5.0—130	0% > 246
C3 - Naphthobenzothiophenes		<5.0—60	<5.0—700	31% > 54.4
C3 - Phenanthrenes/Anthracenes		<5.0—140	<5.0—610	19% > 128
C4 - Chrysenes		<5.0—97	<5.0—150	12% > 92.6
C4 - Dibenzothiophenes		<5.0	<5.0—26	4% > 5.0
C4 - Naphthalenes		<5.0—190	<5.0—99	0% > 182
C4 - Phenanthrenes/Anthracenes		<5.0—100	<5.0—320	8% > 96.4
Dibenzofuran		<0.7—48	<1.0—180	12% > 47.6
Dibenzothiophene		<2.0—23	ND—48	12% > 17.1
2,6-Dimethylnaphthalene		<0.6—68	<1.0—58	0% > 65.2
1-Methylnaphthalene	4,000,000 c-emeg-c	<0.9—120	<1.0—80	0% > 111.2
1-Methylphenanthrene	NA	<0.7—61	<1.0—130	4% > 59.4
Naphthobenzothiophene		<1.9—230	<1.0—480	15% > 155.6
Perylene		<1.3—280	<1.0—860	15% > 201.2
2,3,5-Trimethylnaphthalene		<1.3—67	<1.0—39	0% > 62.6

Table 5. Modified PAH Relative Potency Factors (EPA, 2010)

PAH	Avg. RPF	PAH	Avg. RPF
Anthanthrene	0.4	Cyclopenta[c,d]pyrene	0.4
Anthracene	0	Cyclopenta[d,e,f]chrysene, 4H-	0.3
Benz[a]anthracene	0.2	Dibenzo[a,e]fluoranthene	0.9
Benz[b,c]aceanthrylene, 11H-	0.05	Dibenzo[a,e]pyrene	0.4
Benzo[b]fluoranthene	0.8	Dibenz[a,h]anthracene	10
Benzo[c]fluorene	20	Dibenzo[a,h]pyrene	0.9
Benz[e]aceanthrylene	0.8	Dibenzo[a,i]pyrene	0.6
Benzo[g,h,i]perylene	0.009	Dibenzo[a,l]pyrene	30
Benz[j]aceanthrylene	60	Fluoranthene	0.08
Benzo[j]fluoranthene	0.3	Indeno[1,2,3-c,d]pyrene	0.07
Benzo[k]fluoranthene	0.03	Naphtho[2,3-e]pyrene	0.3
Benz[l]aceanthrylene	5	Phenanthrene	0
Chrysene	0.1	Pyrene	0
From: http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584			

Appendices

Appendix A: Health Comparison Values and Dose Calculation Procedures

When a hazardous substance is released to the environment, people are not always exposed to it. Exposure happens when people breathe, eat, drink, or make skin contact with a contaminant. Several factors determine the type and severity of health effects associated with exposure to contaminants. Such factors include exposure concentration, frequency and duration of exposure, route of exposure, and cumulative exposures (i.e., the combination of contaminants and routes). Once exposure takes place, individual characteristics—such as age, sex, nutritional status, genetics, lifestyle, and health status—influence how that person absorbs, distributes, metabolizes, and excretes the contaminant. These characteristics, together with the exposure factors discussed above and the specific toxicological effects of the substance, determine the health effects that may result. The following summary of ATSDR's procedure for developing health comparison values and calculating exposure doses is derived from the ATSDR Public Health Assessment Guidance Manual (ATSDR, 2005).

ATSDR considers these physical and biological characteristics when developing health guidelines. Health guidelines provide a basis for evaluating exposures estimated from concentrations of contaminants in different environmental media (soil, air, water, and food) depending on the characteristics of the people who may be exposed and the length of exposure. Health guideline values are in units of dose such as milligrams (of contaminant) per kilogram of body weight per day (mg/kg/day).

ATSDR reviews health and chemical information in documents called toxicological profiles. Each toxicological profile covers a particular substance; it summarizes toxicological and adverse health effects information about that substance and includes health guidelines such as ATSDR's minimal risk level (MRL), EPA's reference dose (RfD) and reference concentration (RfC), and EPA's cancer slope factor (CSF). ATSDR uses these guidelines to determine a person's potential for developing adverse non-cancer health effects and/or cancer from exposure to a hazardous substance.

An MRL is an estimate of daily human exposure to a contaminant that is likely to be without an appreciable risk of adverse non-cancer health effects over a specified duration of exposure (acute, less than 15 days; intermediate, 15 to 364 days; chronic, 365 days or more). Oral MRLs are expressed in units of milligrams per kilogram per day (mg/kg/day); inhalation MRLs are expressed in micrograms per cubic meter ($\mu g/m^3$). MRLs are not derived for dermal exposure.

RfDs and RfCs are estimates of daily human exposure, including exposure to sensitive subpopulations that are likely to be without appreciable risk of adverse non-cancer health effects during a lifetime (70 years). These guidelines are derived from experimental data and lowest-observed-adverse-effect levels (or no-observed-adverse-effect levels), adjusted downward using uncertainty factors. The uncertainty factors are used to make the guidelines adequately protective for all people, including susceptible individuals. RfDs and RfCs should not be viewed as strict scientific boundaries between what is toxic and what is nontoxic.

For cancer-causing substances, EPA established the cancer slope factor (CSF; http://www.epa.gov/iris/help_ques.htm#cancersf). A CSF is used to estimate the theoretical excess cancer risks expected from maximal exposure for a lifetime. Cancer risk evaluation guides (CREGs) are estimated contaminant concentrations that would be expected to cause an estimated excess theoretical cancer risk less than 1.0E-06 (or 0.000001). The CREGs and CSFs represent statistical estimates of risk and are not indicative of actual health effects. Specifically, a one in a million risk does not mean that one person (out of a million exposed) will get cancer, but rather that one person exposed has a theoretical cancer risk of 1.0E-06.

Health comparison values (CVs) are estimated contaminant concentrations that are unlikely to cause detectable adverse health outcomes when these concentrations occur in specific media. CVs are used to select site contaminants for further evaluation. CVs are calculated from health guidelines and are presented in media specific units of concentration, such as micrograms/liter (µg/l) or ppm. CVs are calculated using conservative assumptions about daily intake rates by an individual of standard body weight. Because of the conservatism of the assumptions and safety factors, contaminant concentrations that exceed comparison values for an environmental medium do not necessarily indicate a health hazard.

For nonradioactive chemicals, ATSDR uses comparison values like environmental media evaluation guides (EMEGs), cancer risk evaluation guides (CREGs), reference dose (or concentration) media evaluation guides (RMEGs), and others. EMEGs, since they are derived from MRLs, apply only to specific durations of exposure. Also, they depend on the amount of a contaminant ingested or inhaled. Thus, EMEGs are determined separately for children and adults, and also separately for various durations of exposure. A CREG is an estimated concentration of a contaminant that would likely cause, at most, one excess cancer in a million people exposed over a lifetime. CREGs are calculated from CSFs. Reference dose (or concentration) media evaluation guides (RMEGs) are media guides based on EPA's RfDs and RfCs.

EPA's maximum contaminant levels (MCLs) are maximum contaminant concentrations of chemicals allowed in public drinking water systems. MCLs are regulatory standards set as close to health goals as feasible and are based on treatment technologies, costs, and other factors.

Health comparison values, such as EMEGs and MCLs, are derived using standard intake rates for inhalation of air and ingestion of water, soil, and biota. These intake rates are derived from the ATSDR Public Health Assessment Guidance Manual (ATSDR 2005) or from the EPA Exposure Factors Handbook (EPA 2011). Doses calculated using health protective exposure factors and environmental concentrations are considered "health protective doses" because it is unlikely that any real community exposures are greater than the calculated doses and are most likely to be less than the health protective doses.

After estimating the potential exposure at a site, ATSDR identifies the site's "contaminants of concern" by comparing the exposures of interest with health guidelines, or contaminant concentrations with comparison values. As a general rule, if the guideline or value is exceeded, ATSDR evaluates exposure to determine whether it is of potential health concern. Sometimes additional medical and toxicological information may indicate that these exposures are not of health concern. In other instances, exposures below the guidelines or values could be of health concern because of interactive effects with other chemicals or because of the increased sensitivity of certain individuals. Thus additional analysis is necessary to determine whether health effects are likely to occur.

Exposure doses via ingestion are calculated on the basis of the following equation:

Dose (Ingestion) = (Chemical Conc. x IR x EF x ED x ABS) / (BW x AT)

Where:

Chemical Conc.	= concentration of each contaminant (in mg/g, µg/g, mg/L, or µg/L; with appropriate unit conversion factors)
IR	= ingestion rate (in grams/day or liters/day)
EF	= exposure frequency in days per year
ED	= exposure duration in years
ABS	= a chemical-specific absorption or bioavailability factor (unitless)
BW	= body weight in kilograms
AT	= averaging time in days

For soil and sediment doses, we take an additional step to determine exposure via dermal absorption, with the total dose being the sum of the ingestion dose and the dermal dose.[3]

Dose (Dermal) = (Chemical Conc. x ABS x TSA x EF x ED) / (BW x AT)

Where all factors are as above except:

TSA	= total soil adhered in milligrams (skin surface area x soil adherence value)

The total soil exposure dose = ingestion dose + dermal dose

The specific exposure factors used to calculate doses for Tie Plant community soil exposures are listed in Table A-1. Doses to Tie Plant residents from soil exposures include exposures to both average yard and drainage area contaminants for both incidental ingestion and direct absorption through the skin. The calculation of the 50 year theoretical excess cancer risk from BaP-TEq exposure includes 6 years of exposure as a child and 44 years of exposure as an adult.

The dose calculations for both BaP-TEq and TCDD-TEq include relative absorption factors (listed as ABS in above equations). These absorptions factors account for the difference in contaminant bioavailablity for the doses administered to laboratory animals in their feed or corn

[3] Soil particle may also be inhaled as airborne dust. However, the majority of dust particles greater than ~one micron diameter are trapped in the upper respiratory system and ultimately swallowed (or ingested). As most airborne soil particles are greater than one micron diameter, the exposure is included in the ingestion dose.

oil vs. absorption from soil. Note that the ABS values are different (Table A-1) for uptake via ingestion and dermal exposure. Dermal absorption of strongly particle-bound contaminants such as PAHs and dioxins is limited (ATSDR, 1995; ATSDR, 1998; NAS, 2006).

Numerous studies have determined that the relative oral bioavailabilities of BaP and 2,3,7,8-TCDD from soil are less than 100% (as reviewed in: ATSDR, 1995; ATSDR, 1998; NAS, 2006; Kirwan, et.al., 2010). The GeoTrans report (2010, Appendix H) presents the dioxin ABS results of 10 different studies. The ABS in these studies ranged from 17% to 66% (in mice, rats, and swine) and had a cumulative average of 40%. Similar ABS values are reported for oral bioavailability of PAHs (including BaP; Stroo, et.al., 2005; Ounnas, et.al., 2009),

It should also be noted that BaP-TEq and TCDD-TEq represent the toxicity adjusted concentrations of numerous PAH and dioxin/furan species and that the relative bioavailabilities of the specific compounds may vary (NAS, 2006; Ounnas, et.al., 2009). Consequently, the ABS values listed in Table A-1 represent average ABS values across the suite of individual compounds comprising these toxicity-adjusted contaminant concentrations.

The specific ABS values listed in Table A-1 are 50% oral or ingestion bioavailablity for both BaP-TEq and TCDD-TEq and 1.75% dermal bioavailability for TCDD and 10% dermal bioavailability for BaP. The derivation and justification for these ABS values are from site specific reports by AMEC (2005) and GeoTrans (2010). The ABS values used in this consultation are the same as those derived in the GeoTrans (2010) study.

Table A-1. Exposure Parameters Used to Calculate Soil Exposure Doses

Exposure Parameters (units)	Child	Adult
Soil Ingestion (IR; grams/day)	100	50
Exposure Factor (EF; unitless) = [freq. days/yr x duration yrs]/AT [days]	Soil--0.96 Drain.--0.142	Soil--0.96 Drain.--0.142
Exposure Duration (ED; years)	6	44
TCDD Absorption-Ingestion (ABS; unitless)	0.5	0.5
BaP Absorption-Ingestion (ABS; unitless)	0.5	0.5
TCDD Absorption-Dermal (ABS; unitless)	0.0175	0.0175
BaP Absorption-Dermal (ABS; unitless)	0.1	0.1
Body Weight (BW; kilograms)	16	80
Averaging Time (AT; days)	365	365
Total Soil Adhered; (TSA; mg/day) Area skin surf.[cm^2] x adherence factor [mg/cm^2/day]	2670 cm^2 x 0.2 mg/cm^2/day =	5800 cm^2 x 0.07 mg/cm^2/day =
TSA (milligrams/day; see above)	534	406
F (frequency; day/yr)	Soil--350 Drain--52	Soil--350 Drain--52
The absorption factors for BaP and TCDD are derived in the GeoTrans report (2010).		

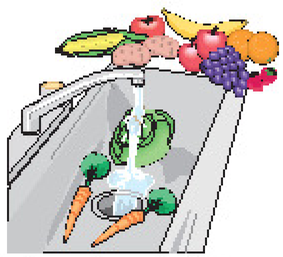
Appendix B

Ways to Protect Your Health

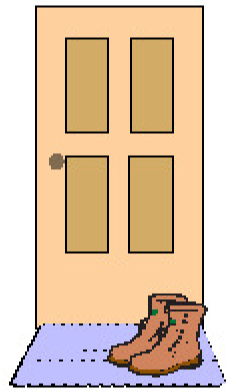
By Keeping Dirt from Getting Into Your Home and Body

Ways to protect your health

By keeping dirt from getting into your house and into your body



Wash and peel all fruits, vegetables, and root crops



Wipe shoes on doormat or remove shoes

Don't eat food, chew gum, or smoke when working in the yard

Damp mop floors and damp dust counters and furniture regularly

Wash dogs regularly

Wash children's toys regularly

Wash children's hands and feet after they have been playing outside

ATSDR