Letter Health Consultation

THE KLOUDA ESTATE SITE

FORT VALLEY, PEACH COUNTY, GEORGIA

Prepared by
Georgia Department of Public Health

SEPTEMBER 19, 2013

Prepared under a Cooperative Agreement with the
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

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

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LETTER HEALTH CONSULTATION

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Prepared By:

Georgia Department of Public Health
Chemical Hazards Program
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Georgia Department of Public Health

Brenda Fitzgerald, MD, Commissioner | Nathan Deal, Governor

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September 13, 2013

Brian Englert
Federal On-Scene Coordinator
U.S. EPA, Region 4
ERRB, 11th Floor 61 Forsyth Street, SW
Atlanta, Georgia 30303

Re: The Klouda Estate Site, Fort Valley, Peach County, Georgia

Dear Mr. Englert:

The Georgia Department of Public Health (DPH) is responding to the U.S. Environmental Protection Agency's (EPA) request to determine the potential health effects of residents exposed to pesticides in their well water. Four residential wells located on Fullwood Road and two wells located on Highway 96 (one residential and one church well) in Fort Valley, Georgia, were found to contain toxaphene and other pesticides above either the federal drinking water maximum contaminant level (MCL), the EPA tap water residential screening level (RSL), or the EPA tap water removal action level (RAL). The wells were affected by off-site migration of contaminants from the Klouda Estate site.

DPH conducted this health consultation to provide information about the public health implications of a specific exposure, and to identify populations where further health actions are needed. This document considers public health issues for human exposure that may have occurred, may be occurring, or may occur in the future.

Data Evaluation

The data used in this health consultation was provided by EPA from their spring 2012 residential well sampling events [1]. Five of the six wells were sampled one time. The residence where samples KES4 and KES5 were taken contains two wells on the property (designated west and east). This residence has a water filtration system in place. Duplicate samples of the west well (pre-filter) and one (post-filter) sample were taken. One pre-filter sample was taken from the east well (KES5). For this health consultation, DPH refers to the water wells as residential wells (inclusive of the church well).

DPH examines the types and concentrations of contaminants in groundwater, which are then screened with comparison values generally established by the Agency for Toxic Substances and Disease Registry (ATSDR) and EPA, to identify contaminants which need a more detailed evaluation. Comparison Values (CVs) are concentrations of a contaminant that can reasonably (and conservatively) be regarded as virtually harmless to human health, assuming default conditions of exposure. CVs include ample uncertainty factors to ensure protection of sensitive populations. Because CVs do not represent thresholds of toxicity, exposure to contaminant

concentrations above CVs will not necessarily result in or lead to adverse health effects [2]. The evaluation process used in this document is described in more detail in Appendix A.

Three completed exposure pathways from contaminated groundwater were identified at the Estate site; all three occurred in the past. These exposure pathways include oral ingestion, inhalation, and dermal absorption of contaminants. Inhalation and dermal absorption of contaminants occurred during showering.

Table 1 summarizes EPA's sampling data above or equal to a CV for the residential wells located immediately east and south of the Estate.

Table 1: Summary of KES1 through KES6 potable water well sampling results equal to or exceeding a comparison value for ingestion.

KES1 Contaminants	***Sample Concentration in well water ppb***	***ATSDR CV ppb***	***Type of CV***
alpha-BHC	0.1	0.0056	CREG
beta-BHC	0.3	0.019	CREG
Dieldrin	0.25	0.0022	CREG
Toxaphene	6.4	0.032	CREG
KES2 Contaminants			
alpha-BHC	0.3	0.0056	CREG
beta-BHC	0.5	0.019	CREG
Endrin ketone	3.6	11, 3	$CEMEG_a/_c$
gamma-BHC (Lindane)	0.1	0.35, 0.1	$IEMEG_a/_c$
Toxaphene	10.7	0.032	CREG
KES3 Contaminants			
alpha-BHC	1.0	0.0056	CREG
beta-BHC	0.9	0.019	CREG
4,4'-DDD	0.2	0.15	CREG
Endrin ketone	3.85	11, 3	$CEMEG_a/_c$
gamma-BHC (Lindane)	0.1	0.35, 0.1	$IEMEG_a/_c$
Toxaphene	15.9	0.032	CREG
KES4 pre-filter Contaminants			
alpha-BHC	1.9	0.0056	CREG
beta-BHC	2.35	0.019	CREG
4,4'-DDD	0.335	0.15	CREG
Endrin ketone	8.4	11, 3	$CEMEG_a/_c$
gamma-BHC (Lindane)	0.2	0.35, 0.1	$IEMEG_a/_c$
Toxaphene	19.45	0.032	CREG
KES4 post-filter Contaminants			
alpha-BHC	0.3	0.0056	CREG

beta-BHC	0.2	0.019	CREG
gamma-BHC (Lindane)	0.15	0.35, 0.1	$IEMEG_a/_c$
Toxaphene	4.6	0.032	CREG
KES5 Contaminants			
alpha-BHC	0.25	0.0056	CREG
beta-BHC	0.1	0.019	CREG
gamma-BHC (Lindane)	0.1	0.35, 0.1	$IEMEG_a/_c$
Toxaphene	4.2	0.032	CREG
KES6 Contaminants			
alpha-BHC	0.03	0.0056	CREG
beta-BHC	0.08	0.019	CREG
Toxaphene	1.2	0.032	CREG

ppb: parts per billion
CREG: Cancer Risk Evaluation Guide
$CEMEG_{a/c}$: Environmental Media Evaluation Guide (adult/child) based on chronic oral exposure (one year or more)
$IEMEG_{a/c}$: Environmental Media Evaluation Guide (adult/child) based on intermediate oral exposure (between 15 -364 days)
Source: ATSDR drinking water comparison values (March 2013)

Although sample results for KES1 (and in some cases through KES6) were below a CV for non-cancer health effects, the exposure dose contribution not only from ingesting water, but from inhalation and dermal absorption needs to be evaluated. The KES2 and KES3 well sample results for endrin and lindane equaled or exceeded a CV for non-cancer health effects and will be evaluated further. The KES4 pre-filter sample results will not be evaluated in the health consultation; only the KES4 post-filter sample results will be evaluated. The KES4 well post-filter sample results for lindane exceeded a CV for non-cancer health effects and will be evaluated further. For the purposes of this health consultation, KES5 pre-filter sample results will be evaluated as being consumed because post-filter sample results are unavailable.

Because concentrations of alpha-BHC, beta-BHC, 4,4' DDD, dieldrin and toxaphene exceed their respective CREGs, a cancer risk evaluation for these chemicals will also be conducted in this health consultation.

Exposure Evaluation

For the purpose of estimating oral exposure doses, DPH assumed that adults drank 2 liters of water per day and weighed 70 kilograms (kg), and that a child consumed 1 liter of water per day and weighed 16 kg. Estimated inhalation exposure doses were made assuming that adults breathed 15.2 cubic meters of air per day and that children breathed 10 cubic meters of air per day; and, that exposure to organochlorines from inhalation would occur during 20 minutes of daily showering activities. Exposure from dermal absorption was estimated using different skin surface areas for adults and children, the differences in skin permeability of the various pesticides, along with assuming that dermal exposure would occur during 20 minutes of daily showering activities [3]. For a detailed explanation of how DPH estimated exposure to organochlorine pesticides in contaminated water from oral, inhalation, and dermal exposures, please refer to Appendix A. In addition, the estimated exposure doses from each pathway, as well as a summation of the estimated exposure doses, are summarized in Appendix B. From the

table in Appendix B, you will notice that the exposure dose from inhaling contaminants present in well water during showering is approximately similar to the exposure dose contribution from ingestion of well water for adults and approximately the same or slightly higher for children. The highlighted exposure doses in Appendix B exceed their respective MRLs and are further evaluated below. Tables 2 through 6 show estimated exposure doses above an MRL for residents affected by contaminants in each well. At these residences, only the estimated exposure dose to children exceed the MRL

KES2 Evaluation

Table 2: Estimated past exposure doses from drinking and showering with organochlorine pesticide contaminated well water at the KES2 residence above a health-based guideline. Estimated exposure doses include the contribution from oral ingestion, inhalation from showering, and dermal absorption.

Contaminant	Estimated Dose (mg/kg/day)	MRL (mg/kg/day)
Lindane	Child: 0.000014	0.00001

mg/kg/day: milligrams per kilogram of body weight per day
MRL: chronic oral minimal risk level (for exposures lasting 1 year or longer), *intermediate oral minimal risk level (for exposures lasting 15 days to 1 year)
Source: ATSDR Health Guidelines (March 2013)

Lindane

The dose and endpoint used for the intermediate MRL determination was 0.012 mg/kg/day from a study of mice fed diets containing various amounts of lindane for up to 24 weeks. Reduced activity of lymphoid follicles (associated with the lymphatic system and concerned with immune functions) was noted, along with prominent megakaryocytes (bone marrow cells associated with platelet production) and delayed hypersensitivity to immune challenge were seen in mice receiving an exposure dose of 0.012 mg/kg/day. An uncertainty factor of 1000 was used for the use of the LOAEL (x10), for extrapolation from animals to humans (x10), and for human variability (x10) to establish 0.00001 mg/kg/day as the MRL [7].

Where the lindane concentration in water was 0.1 ppb, the estimated exposure dose for a child at the KES2 residence is essentially the same as MRL. However, this exposure dose is approximately 860 times lower than the LOAEL observed inthe aforementioned mice study . Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

KES3 Evaluation

Table 3: Estimated past exposure doses from drinking and showering with organochlorine pesticide contaminated well water at the KES3 residence above a health-based guideline. Estimated exposure doses include the contribution from oral ingestion, inhalation from showering, and dermal absorption.

Contaminant	Estimated Dose (mg/kg/day)	MRL (mg/kg/day)
Endrin	Child: 0.001	0.0003
Lindane	Child: 0.000014	0.00001
Toxaphene	Child: 0.0023	0.002*

mg/kg/day: milligrams per kilogram of body weight per day
MRL: chronic oral minimal risk level (for exposures lasting 1 year or longer), *intermediate oral minimal risk level (for exposures lasting 15 days to 1 year)
Source: ATSDR Health Guidelines (March 2013)

Endrin

The dose and endpoint used for the chronic MRL determination was 0.025 mg/kg/day from a study of Beagles fed diets containing various amounts of endrin for 2 years. In this study, one female and two male dogs fed 0.1 mg/kg/day and one female dog fed 0.05 mg/kg/day (the LOAEL) showed evidence of, or were observed having, convulsions. Endrin concentrations of 0.05 mg/kg/day and 0.1 mg/kg/day were associated with slight to moderate vacuolation of hepatic (liver) cells. Petechial hemorrhages and cerebral edema were observed in the brain of one dog having convulsions at the time of necropsy. There were occasional slight increases in the weight of livers from dogs fed diets containing endrin concentration of 0.05 and 0.1 mg/kg/day. The NOAEL was established at 0.025 mg/kg day and an uncertainty factor of 100 was used for extrapolation from animals to humans (10) and for human variability (10) to establish 0.0003 mg/kg/day as the MRL [10].

Where the endrin concentration in water was 3.85 ppb, the estimated exposure dose for a child at the KES3 residence is approximately 3 times higher than the MRL. However, this exposure dose is approximately 25 times lower than the NOAEL and approximately 50 times lower than the LOAEL observed in Beagles. Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

Lindane

Where the lindane concentration in water was 0.1 ppb, the estimated exposure dose for a child at the KES3 residence is essentially the same as the MRL. However, this exposure dose is approximately 860 times lower than the LOAEL observed in the mice study from which the MRL was derived. Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

Toxaphene

ATSDR has not established an MRL for chronic exposure to toxaphene. However, ATDSR has an MRL for intermediate exposure (between 15 to 364 days). The dose and endpoint used for this MRL derivation was 0.22 mg/kg/day. This dose was not based on the no observed adverse effects level (NOAEL) of 2 mg/kg/day, but on a default benchmark response (BMR[1]) dose where decreased immune function was noted in monkeys exposed to various concentrations of toxaphene for up to 75 weeks. Treatment with toxaphene at 0.4 mg/kg/day resulted in significant reduction in IgM responses when, after 44 weeks of toxaphene exposure, the monkeys were vaccinated with sheep red blood cells (SRBC). The response of anti-SRBC IgM was measured at weeks 1 and 4 following the immunization and was observed to be 27 and 35% lower than that of the controls. The reduced IgM response was almost 51% lower than that of the controls that received a 0.8 mg/kg/day dose of toxaphene. An uncertainty factor of 100 was used for extrapolation from animals to humans (x10) and for human variability (x10) to establish 0.002 mg/kg/day as the MRL [5].

Where the toxaphene concentration in water was 15.9 ppb, the estimated exposure dose for a child at the KES3 residence is essentially the same as the MRL. However, this exposure dose is approximately 96 times lower than the BMR and approximately 870 times lower than the NOAEL observed in monkeys. Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

KES4 Evaluation

Table 4: Estimated past exposure doses from drinking and showering with organochlorine pesticide post-filter contaminated well water at the KES4 residence above a health-based guideline. Estimated exposure doses include the contribution from oral ingestion, inhalation from showering, and dermal absorption.

Contaminant	Estimated Dose (mg/kg/day)	MRL (mg/kg/day)
Lindane	Child: 0.00002	0.00001

mg/kg/day: milligrams per kilogram of body weight per day
MRL: chronic oral minimal risk level (for exposures lasting 1 year or longer), *intermediate oral minimal risk level (for exposures lasting 15 days to 1 year)
Source: ATSDR Health Guidelines (March 2013)

Lindane

Where the lindane concentration in water was 0.15 ppb, the estimated exposure dose for a child at the KES4 residence is approximately 2 times higher that the MRL. However, this exposure dose is 600 times lower than the LOAEL observed in the mice study from which the MRL was

[1] Benchmark Response is based on a percentage of the Benchmark Dose (BMD), which is usually defined as the lower confidence limit on the dose that produces a specified magnitude of changes in a specified adverse response. For example, a BMD_{10} would be the dose at the 95% lower confidence limit on a 10% response, and the benchmark response (BMR) would be 10%. The BMD is determined by modeling the dose response curve in the region of the dose response relationship where biologically observable data are feasible.

derived . Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

KES5 Evaluation

Table 5: Estimated past exposure doses from drinking and showering with organochlorine pesticide contaminated well water at the KES5 residence above a health-based guideline. Estimated exposure doses include the contribution from oral ingestion, inhalation from showering, and dermal absorption.

Contaminant	Estimated Dose (mg/kg/day)	MRL (mg/kg/day)
Lindane	Child: 0.000014	0.00001

mg/kg/day: milligrams per kilogram of body weight per day
MRL: chronic oral minimal risk level (for exposures lasting 1 year or longer), *intermediate oral minimal risk level (for exposures lasting 15 days to 1 year)
Source: ATSDR Health Guidelines (March 2013)

Lindane

Where the lindane concentration in water was 0.15 ppb, the estimated exposure dose for a child at the KES5 residence is essentially the same as the MRL by 1.4 times. However, this exposure dose is approximately 860 times lower than the LOAEL observed in the mice study from which the MRL was derived . Therefore, it is unlikely that non-cancer adverse health effects would have occurred in a child drinking water from this well.

Chemical Mixtures

DPH concluded that non-cancer adverse health effects were unlikely for residents affected by the Estate site when toxicological evaluations were conducted for each individual organochlorine pesticide found above an MRL. However, a more accurate assessment of the potential for adverse health effects cannot be made without looking at the cumulative exposure scenario. In all instances, residents whose wells were contaminated with pesticides were exposed to a multitude of organochlorine pesticides. Some residents were exposed to up to 9 different pesticides (albeit very low concentrations [1]). Thus, DPH took into account the cumulative exposure dose at each residence via ingestion, inhalation, and dermal absorption for all pesticides found above a CV. Table 6 displays the cumulative estimated exposure doses at each residence where well water contamination was found. The range of MRLs, NOAELs, and LOAELs are also shown for comparison.

If we assume that all the organochlorine pesticides act similarly to the most toxic organochlorine pesticide (lindane) in the mixture (as identified by the lowest MRL and the lowest concentration where the LOAEL was identified), then we can expect that both children and adults may have had immune deficiencies during the period they were consuming contaminated well water. Similarly, concomitant with lindane exposure, toxaphene has also been shown to decrease immune function. Additionally, alpha-BHC, beta-BHC, dieldrin and endrin have been shown to have cellular and physical effects on the liver. We do not know if a synergistic relationship exists from concomitant exposure to these liver-affecting pesticides.

Table 6: Sum of cumulative estimated pesticide exposure dose for all residential wells where pesticide concentrations were above a CV compared to the range of MRLs, NOAELs, and LOAELs.

Residence	Sum of Cumulative Estimated Organochlorine Exposure Dose (mg/kg/day)	Range of MRLs (mg/kg/day)	Range of NOAELs (mg/kg/day)	Range of LOAELs (mg/kg/day)
KES1	Adult: 0.00035 Child: 0.001	0.00001 through 0.002	0.005 through 2.0	0.012 through 4.0
KES2	Adult: 0.0006 Child: 0.002			
KES3	Adult: 0.001 Child: 0.004			
KES4/5	Adult: 0.0005 Child: 0.005			
KES6	Adult: 0.00008 Child: 0.0002			

mg/kg/day: milligrams per kilogram of body weight per day
*Note: The yellow highlighted areas show that children living at the KES3 residence may have had an exposure dose twice as high as the least sensitive MRL (for toxaphene). For evaluation details, see Appendix A.

However, because of the lack of human studies and unknown variability in toxicity between humans and laboratory animals used to gather toxicity data, DPH assumes that this can occur. Therefore, we can expect that children at KES3 residences may have been at increased risk for liver effects (even if they were asymptomatic) during the period they were consuming contaminated well water (please see Appendix A for evaluation details). These effects would have tapered off with time after the residents started drinking bottled water provided by EPA.

Five of the organochlorine pesticides found above or equal to a CV in water wells can be categorized into two distinct chemical structural groups. One group is composed of alpha-, beta-, and gamma-BHCs. A second group, dieldrin and endrin, are stereoisomers[2] of each other. Although all of the above (as well as DDD and toxaphene) are organochlorine pesticides, structural differences play a role in the metabolism and excretion of these pesticides.

Liver enzymes play a role in the metabolism and detoxification of all the organochlorine pesticides found in the well water. Cytochrome P450 oxidases seem to be involved in rendering all of these pesticides water-soluble so that excretion can occur. However, age-related enzymatic differences exist, between early childhood and adulthood, in the ability to conjugate some of these metabolites before excretion. This may add to, or subtract from the body burden of some of these pesticides. But eventually, some faster than others, all of the pesticides will be excreted from the body.

[2] Steriosomers are isometric molecules that have the same molecular formula and sequence of bonded atoms, but that differ only in the three-dimensional orientation of their atoms in space.

Cancer Risk

Alpha-, beta-, gamma-BHC (lindane), 4,4'-DDD, and toxaphene are considered by the International Agency for Research on Cancer (IARC) to be possibly carcinogenic to humans (limited human evidence; less than sufficient evidence in animals). EPA considers alpha-BHC, 4,4'-DDD (DDD), dieldrin, and toxaphene to be probable human carcinogens (inadequate human evidence; sufficient evidence in animal studies). The National Toxicology Program (NTP) considers alpha-, beta-, gamma-BHC, and toxaphene as reasonably anticipated as being carcinogens. EPA considers beta-BHC a possible human carcinogen (no human, limited animal studies). Moreover, EPA has determined that there is suggestive evidence that gamma-BHC is carcinogenic, but the evidence is not sufficient to assess its carcinogenic potential [7]. Therefore, a slope factor, from which to estimate cancer risk, is unavailable. NTP does not consider DDD or dieldrin to be carcinogens. IARC considers dieldrin not classifiable as a carcinogen. The estimated risk for cancer from exposure to contaminants is usually calculated by multiplying the exposure dose by EPA's corresponding cancer slope factor (in $mg/kg/day)^{-1}$ for a carcinogen. This cancer slope factor (CSF) is equivalent to the upper-bound value referenced by EPA, which means that it is used by EPA for evaluation of human food-chain exposures because it provides assurance that risk is not underestimated, and it represents a value for high risk and high persistence organochlorine pesticides. For more information, see Appendix A.

Long-term oral administration of alpha-, beta-, and gamma-BHC to laboratory rodents produced liver cancer [7]. Studies in DDT-exposed workers did not show increases in cancer; however, studies in animals given DDT in their food have shown that DDT can cause liver cancer [8]. DDD is a breakdown product of DDT. Dieldrin has caused liver cancer in mice studies [4]. Toxaphene caused liver cancer in mice and possible thyroid cancer in rats that were given large amounts of toxaphene by mouth [5].

Exposure to a cancer-causing chemical, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. All the residences sampled had between 3 and 6 different organochlorines present in their drinking water. To estimate cancer risk, DPH used a conservative exposure period of seven years; the approximate period when the Estate site was placed on the Georgia HSI to the time EPA provided residents with bottled water. For each residence, DPH estimated an adult cancer risk for each chemical considered carcinogenic, then added all the estimated cancer risks together for a cumulative estimated cancer risk at each residence. The table below shows the estimated cancer risk for adults living at each residence where organochlorine pesticides were found in their wells:

Table 7: Estimated cancer risk for adults living at each residence where pesticide contamination was found in their wells. This estimated cancer risk is based on the cumulative estimated exposure dose.

Residence	Estimated Cancer Risk
KES1	6.3×10^{-5}
KES2	7.0×10^{-5}
KES3	1.5×10^{-4}

KES4, KES5	7.8×10^{-5}
KES6	9.8×10^{-6}

The estimated lifetime cancer risk for adults exposed to various organochlorine pesticides in their drinking water over this 7 year period ranges from approximately 1.5 excess cancers that can be expected from this exposure in 10,000 people with the same exposure (at the KES3 residence) to 9.8 in 1,000,000 (at the KES6 residence). For perspective, the lifetime risk in the Unites States that an individual will develop cancer from all causes is slightly less than 1 in 2 for men (50,000/100,000) and a little more than 1 in 3 for women (33,000/100,000) [9].

Conclusions

DPH evaluated past exposure to residents living adjacent to the Klouda Estate site from consuming contaminated well water. This evaluation included an estimation of exposure doses from oral ingestion, inhalation, and dermal absorption of organochlorine pesticides present in well water. The conclusions presented below were based on a review and evaluation of residential well water data provided by EPA.

1. DPH concludes that in the past, children using water from wells KES3 were exposed to organochlorine pesticides by drinking and showering at levels that could have harmed their health.
2. DPH concludes that in the past, residents using water from wells KES1 through KES6 were exposed to organochlorine pesticides by drinking and showering at levels that increased their risk of acquiring cancer from this exposure. The estimated increase in cancer risk is based on the assumption that the exposure period was 7 years. However, the exact exposure period is unknown and may likely have been much less, so the cancer risk may be over estimated.

It is important to note that DPH's conclusions were based on a one-time sampling event. More sampling results over a longer period of time would more accurately describe any temporal and seasonal fluctuation in groundwater recharge and contaminant concentrations.

Recommendations

The prompt EPA response by providing bottled water to exposed residents and arranging for municipal water connections to each of these residences mitigated exposure. However, DPH has two recommendations:

1. Now that residents who were exposed to site-related contaminants are consuming municipal water, any future use of their water wells should be limited to irrigation of non-edible crops only. Otherwise, these residents should have their wells properly abandoned to prevent future exposure to site-related contaminants.

2. EPD should monitor the migration of site-related groundwater contaminants to ensure that other residents living downgradient (who may use well water) will not be affected by site-related contaminants.

If additional data become available, DPH will consider a separate request for evaluation. If you have any questions regarding this health consultation, please contact me at (404) 657-6534.

Sincerely,

Franklin Sanchez

Franklin Sanchez, Health Assessor
Chemical Hazards Program
Environmental Health Section
Georgia Department of Public Health

References

1. Agency for Toxic Substances and Disease Registry. *Public Health Assessment Guidance Manual (update).* January 2005.

2. U. S. Environmental Protection Agency. *Risk Assessment for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).* Final. July 2004.

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4. Agency for Toxic Substances and Disease Registry. *Toxicological Profile for Toxaphene (update).* September 2010.

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9. American Cancer Society. 2012. Basic Cancer Facts. Accessed at: *http://www.cancer.org/acs/groups/content/@epidemiologysurveilance/documents/document/acspc-031941.pdf* . Last accessed 07/12/2013.

APPENDIX A

Step 1--The Screening Process

In order to evaluate the available data, DPH used comparison values (CVs) to determine which chemicals to examine more closely. CVs are contaminant concentrations found in a specific environmental media (air, soil, water, sediment, and food) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of environmental media that someone may inhale or ingest each day. CVs are generated to be conservative and non-site specific. The CV is used as a screening level during the public health assessment (PHA) process. CVs are not intended to be environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or non-carcinogenic effects. Cancer-based CVs are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factors for ingestion exposure, or inhalation risk units for inhalation exposure. Non-cancer CVs are calculated from ATSDR's minimal risk levels, EPA's reference doses, or EPA's reference concentrations for ingestion and inhalation exposure. When a cancer and non-cancer CV exist for the same chemical, the lower of these values is used as a conservative measure.

Step 2--Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Separate child and adult exposure doses (or the amount of a contaminant that gets into a person's body) are calculated for site-specific scenarios, using assumptions regarding an individual's likelihood of exposure to site contaminants. A brief explanation of the calculation of estimated exposure doses used in this PHA are presented below.

Ingestion of contaminants present in residential well water from off-site migration of Klouda Estate Site sources of contamination. Exposure doses for the ingestion of contaminants present in well water were calculated using the measured concentration of contaminants in milligrams per liter (mg/L) of water. The following equation is used to estimate the exposure doses resulting from ingestion of contaminated fish:

$$ED = \frac{C \times IR \times EF}{BW}$$

where;

ED = exposure dose from drinking water (mg/kg/day).

C = contaminant concentration (mg/L).

IR = intake rate of contaminated water based on an adult drinking 2 liters of water per day and a child drinking 1 liter of water per day.

EF = exposure factor (based on frequency of exposure, exposure duration, and time of exposure). The exposure factor used for the purpose of this analysis is 1.BW = body weight (using the standard default value of for an adult (70 kg), and the standard default value for children ages 1 to 6 (16 kg)).

For example, the following is an estimated exposure dose from toxaphene for an adult drinking 2 liters of water per day where the toxaphene concentration in water is 0.01945 mg/L:

$$ED = \frac{0.01945 \text{ mg/L} \times 2 \text{ L/day} \times 1}{70 \text{ kg}}$$

$$= \mathbf{0.00056 \text{ mg/kg/day}}$$

Inhalation of contaminants present in residential well water from off-site migration of Klouda Estate Site sources of contamination. Exposure doses for the inhalation of contaminants present in well water during showering activities were calculated using a model for inhalation exposure due to volatilization of contaminants from potable water [1]. This model was developed by the New Jersey Department of Health with input from the ATSDR Screen 2 workgroup and accounts for the impact of pesticides mass transferring from liquid to gas during showering. Because the vapor pressures of the various pesticides found in well water are very low (compared to the vapor pressures of volatile organic compounds), the contribution of inhalation to total exposure dose is much lower than would be a volatile organic compound with a high vapor pressure.

Chemical	Vapor Pressure @ 20° C
Chloroform	160 mm Hg
Alpha-BHC	0.02 mm Hg
Beta-BHC	0.005 mm Hg
4.4'-DDD	1.02E-06 mm Hg
Dieldrin	3.1E-06 mm Hg
Endrin	2.0E-07 mm Hg
Lindane	9.4E-06 mm Hg
Toxaphene*	6.69E-06 mm Hg

The air concentration in micrograms per cubic meter was estimated an equation similar to the following equation:

$$C_a = \frac{C_w \times k \times F \times t}{V}$$

where;

C_a = air concentration in micrograms per cubic meter (µg/m^3).
C_w = concentration of pesticide in well water in micrograms per cubic meter (µg/m^3).
k = volatile mass transfer coefficient in liter per minute (model for inhalation exposure provides this).
F = flow rate in liter per minute (assumer to be 6.6 liters per minute).
t = shower time in minutes (assumed to be 20 minutes).
V = shower volume in liters (assumed to be 200 liters).

***Note**: The model used did not provide for the quantitative calculation of air concentration for beta-BHC, Endrin, DDD, or toxaphene. Therefore, qualitative estimations were made for these compounds using the parameters set up in the model for compounds with vapor pressures that are close to the vapor pressures of the pesticides found in the well water. For example, because the model did not have the parameter for beta-BHC; alpha-BHC was used in its place. For endrin, the parameters for alpha-BHC were also used. For DDD, the parameters for dieldrin were used, and for toxaphene, the parameters for lindane were used.

The results of the air concentrations the model provided are shown in Appendix C. Only the shower air concentration was used for the purpose of this health consultation. The model provided not only air concentrations in the shower, but also air concentrations in the bathroom and the entire house from daily use of any water in the house including bathing, use of sinks, dishwashers, and laundry.

From the above derived air concentrations of pesticides; the following equation is used to estimate the exposure doses resulting from inhalation of contaminated water vapor:

$$ED = \frac{C \times IR \times EF}{BW}$$

where;
ED = exposure dose from inhaling water vapor (mg/kg/day).
C = contaminant concentration (mg/m^3).

IR = inhalation rate of contaminated water vapor based on a male adult breathing the default air intake rate of 15.2 cubic meters of air per day (m^3/day) and a 6 to 8 year old child breathing the default air intake rate of 10 cubic meters of air per day (m^3/day).

EF = exposure factor (based on frequency of exposure, exposure duration, and time of exposure). The exposure factor used for the purpose of this analysis is 0.04. This exposure factor assumes that an individual is showering or showering for 20 minutes per day, seven days per week.

BW = body weight (using the standard default value of for an adult (70 kg), and the standard default value for children ages 1 to 6 (16 kg)).

For example, the following is an estimated exposure dose from toxaphene for an adult inhaling water vapor in a 20 minute shower where the toxaphene concentration in water is 0.0159 mg/L,

$$ED = \frac{0.0025\ mg/m^3\ \text{(provided from model)} \times 15.2\ m^3/day \times 0.04}{70\ kg} = \mathbf{0.00002\ mg/kg/day}$$

Dermal absorption of contaminants present in residential well water from off-site migration of Klouda Estate Site sources of contamination. Exposure doses from dermal absorption of contaminants present in well water during showering activities were calculated using the measured concentration of contaminants in milligrams per liter (mg/L) of water. The following equation is used to estimate the exposure doses resulting from dermal absorption of contaminated water:

$$ED = \frac{C \times P \times SA \times ET \times CF}{BW}$$

where;

ED = exposure dose from dermal absorption (mg/kg/day).

C = contaminant concentration (mg/L).

P = permeability coefficient (cm/hr).

Chemical	Permeability Coefficient
Alpha-BHC	1.1×10^{-1} cm/hr
Beta-BHC	1.1×10^{-1} cm/hr
4.4'-DDD	1.8×10^{-1} cm/hr
Dieldrin	1.2×10^{-2} cm/hr
Endrin	1.2×10^{-2} cm/hr
Lindane	1.1×10^{-2} cm/hr
Toxaphene*	1.2×10^{-2} cm/hr

SA = exposed body surface area (cm^2). For this value, we used the mean of the 50th percentile cumulative body surface area of an adult male and female, which is 18,150 cm^2. For children, we used the mean of the 50th percentile cumulative body surface area of male and female between the ages of 3 to 6, which is 7,195 cm^2.

ET = exposure time (hours/day). For 20 minutes of showering each day, this exposure time is 0.33 hours/day.

CF = conversion factor (1 L/1,000 cm^3).

BW = body weight (using the standard default value of for an adult (70 kg), and the standard default value for children ages 1 to 6 (16 kg)).

For example, the following is an estimated exposure dose from toxaphene for an adult showering for 20 minutes/day where the toxaphene concentration in water is 0.01945 mg/L:

$$ED = \frac{0.01945\ mg/L \times 1.2 \times 10^{-2}\ cm/hr \times 0.33\ hours/day \times 18{,}150\ cm^2/1000\ cm}{70\ kg}$$

$$= 2.0 \times 10^{-5} \text{ mg/kg/day}$$

Chemical mixtures analysis assuming cumulative effects from exposure to several organochlorine pesticides in well water. The health impact of exposure to chemical mixtures can be of particular concern at hazardous waste sites, since most contain multiple chemical contaminants. While in many cases it might suffice to evaluate exposures on a chemical-by-chemical basis, in some cases one might need to examine the combined action of chemicals (e.g., additive, antagonistic, synergistic, and other interactive effects).

As part of this evaluation, DPH approached a chemical mixtures evaluation using a two-fold approach. The first approach is a screening approach and is based on the premise that all contaminants found in the water wells contained a mixture of organochlorine pesticides that DPH assumed to act similarly in the human body. For each well, the exposure doses for each chemical found above a CV (including CREGs) were added together for a cumulative exposure dose (for both adults and children). Hazards quotients were generated and compared to the most and least sensitive MRLs, the most and least sensitive NOAELs, and the most and least sensitive LOAELs in this manner:

$$\text{HQ example} = \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{MRL}_{\text{most sensitive}}} \; ; \; \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{MRL}_{\text{least sensitive}}}$$

$$\text{HQ example} = \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{NOAEL}_{\text{most sensitive}}} \; ; \; \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{NOAEL}_{\text{least sensitive}}}$$

$$\text{HQ example} = \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{LOAEL}_{\text{most sensitive}}} \; ; \; \frac{\text{Cumulative Dose}_{\text{KES1 (adult, child)}}}{\text{LOAEL}_{\text{least sensitive}}}$$

Residence	Least Sensitive MRL Hazard Quotient	Most Sensitive MRL Hazard Quotient	Least Sensitive NOAEL Hazard Quotient	Most Sensitive NOAEL Hazard Quotient	Least Sensitive LOAEL Hazard Quotient	Most Sensitive LOAEL Hazard Quotient
KES1	Adult: 0.15 Child: 0.5	Adult: 30 Child: 100	Adult: 0.06 Child: 0.2	Adult: 0.0002 Child: 0.0005	Adult: 0.03 Child: 0.08	Adult: 0.00008 Child: 0.00025
KES2	Adult: 0.3 Child: 1.0	Adult: 60 Child: 200	Adult: 0.12 Child: 0.4	Adult: 0.0003 Child: 0.001	Adult: 0.05 Child: 0.17	Adult: 0.0002 Child: 0.0005
KES3	Adult: 0.5 Child: 2.0	Adult: 100 Child: 400	Adult: 0.2 Child: 0.8	Adult: 0.0005 Child: 0.002	Adult: 0.08 Child: 0.33	Adult: 0.0003 Child: 0.001
KES4,5	Adult: 0.25 Child: 0.5	Adult: 50 Child: 100	Adult: 0.1 Child: 0.2	Adult: 0.0003 Child: 0.0005	Adult: 0.04 Child: 0.08	Adult: 0.0001 Child: 0.0003
KES6	Adult: 0.4 Child: 0.1	Adult: 80 Child: 20	Adult: 0.16 Child: 0.04	Adult: 0.0004 Child: 0.0001	Adult: 0.07 Child: 0.02	Adult: 0.0002 Child: 0.00005

The second approach DPH used, which accounts for the relative toxicity of each chemical in the mixture, was to calculate a Hazard Index (HI) for the mixture of pesticides present in well water at each residence. A HI is defined as the sum of the hazard quotients of the estimated dose of a chemical divided by its MRL or comparable value. In mathematical terms,

$$HI = \frac{Dose_1}{MRL_1} + \frac{Dose_2}{MRL_2} + \frac{Dose_3}{MRL_3} + \ldots \frac{Dose_n}{MRL_n}$$

If the HI is less than 1.0, it is highly unlikely that significant additive or toxic interactions would occur, so no further evaluation is necessary. If a HI is greater than 1.0, then further evaluation is necessary.

Residence	Hazard Index Adult	Hazard Index Child
KES1	0.5	1.2
KES2	1.2	3.2
KES 3	1.9	7.0
KES4	1.0	2.6
KES5	0.7	1.8
KES6	0.04	0.1

For chemical mixtures with a HI greater than one, one can compare the estimated doses of the individual chemicals to their NOAELs or other comparable values such as LOAELs. If the dose of one or more of the individual chemicals is within an order of magnitude of its respective NOAEL or LOAEL, then there may be a potential for additive health effects. If estimated doses of the individual chemicals are less than one-tenth or their respective NOAELs, then significant additive or interactive effects are unlikely.

Although the estimated exposure doses to children living at the KES3 residence fall within 5% of the NOAEL for endrin, and the estimated children's exposure dose to toxaphene falls within 1% of the LOAEL, the HI approaches the uncertainty factor of 10x for human variability used in the derivation of MRLs for endrin, lindane, and toxaphene. Therefore, DPH conservatively determined that additive effects were likely for children living in the KES3 residence exposed to the organochlorine pesticides found in their well.

Non-cancer Health Risks

The doses calculated for exposure to individual chemicals are then compared to an established health guideline, such as an ATSDR minimal risk level (MRL[3]) or an EPA reference dose, in order to assess whether adverse health impacts from exposure are expected. Health guidelines are chemical-specific values that are based on available scientific literature and are considered protective of human health. Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice to derive health a guideline is to identify, usually from animal toxicology experiments, a no observed adverse effect level (NOAEL). This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The values are summarized in ATSDR's *Toxicological Profiles (www.atsdr.cdc.gov/toxpro2.html).* The NOAEL is modified with an uncertainty (or safety) factor. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (e.g., children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of the available data. Thus, exposure doses at or below the established health guideline are not expected

[3] **Minimal Risk Levels (MRLs)** are developed by ATSDR for contaminants commonly found at hazardous waste sites. The MRL is developed for ingestion and inhalation exposure, and for lengths of exposures: acute (less than 14 days); intermediate (between 15-364 days), and chronic (365 days or greater). ATSDR has not developed MRLs for dermal exposure (absorption through skin).

to cause adverse health effects because these guidelines are lower (and more human health protective) than doses that do not cause adverse health effects in laboratory animal studies.

For non-cancer health effects, MRLs were used in this PHA. A direct comparison of site-specific exposures and doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely to occur. If the estimated exposure dose to an individual is less than the MRL, the exposure is unlikely to result in non-cancer health effects. If the calculated exposure dose is greater than the MRL, the exposure dose is compared to known toxicological values for the particular chemical and is discussed in more detail in the text of the PHA.

It is important to consider that the methodology used to develop health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer risk evaluation is necessary for potentially cancer-causing contaminants detected at this site.

Cancer Risks

Exposure to a cancer-causing chemical, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated risk for developing cancer from exposure to contaminants associated with the site was calculated by multiplying the site-specific doses by EPA's chemical-specific cancer slope factors (CSFs) available at *www.epa.gov/iris*. This calculation estimates an excess cancer risk expressed as a proportion of the population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million. An increased lifetime cancer risk is not a specified estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime in his or her lifetime following exposure to a particular contaminant under specific exposure scenarios. For children, the estimated excess cancer risk is not calculated for a lifetime of exposure, but from a fraction of lifetime; based on known or suspected length of exposure, or years of childhood.

Example Cancer Risk Calculation

Estimated Cancer Risk = Exposure Dose x CSF x years of exposure/70 years.

For this health consultation, although the exact time period residents were exposed to carcinogenic pesticides, DPH used a conservative exposure period of 7 years in the estimated cancer risk calculation. This is the relative period since the Klouda Estate site was placed on the Georgia Hazardous Site Index until EPA provided bottled water to the residents before residences were hooked up to a municipal water line.

The following is an example calculation for an estimated cancer risk from toxaphene exposure of adults living at the KES4 residence using the cumulative estimated exposure from oral, inhalation, and dermal exposure:

Adult Cancer Risk = 0.00344 mg/kg/day x 1.1 $(mg/kg/day)^{-1}$ for toxaphene x 7/70
= $\mathbf{3.78 \times 10^{-4}}$

Reference

1. Personal communication with Tariq Ahmed of the New Jersey Department of Health. June 10, 2013.

Appendix B: Exposure Doses

For each residential well that had contaminants at levels that exceeded a CV for either drinking water or air, the following table summarizes the estimated exposure dose contribution from ingestion, inhalation, and dermal absorption. The estimated exposure dose from each pathway is summed for a total estimated exposure dose of each contaminant found in the well water of these residences. The yellow highlighted areas indicate that these estimated exposure doses exceed their respective MRL.

KES1 Contaminants	**Estimated Ingestion Exposure Dose mg/kg/day**	**Estimated Dermal Exposure Dose mg/kg/day**	**Estimated Inhalation Exposure Dose mg/kg/day**	**Total Estimated Exposure Dose mg/kg/day**	**MRL mg/kg/day**
alpha-BHC	Adult: 2.86E-06 Child: 6.25E-06	Adult: 9.40E-07 Child: 1.60E-06	Adult:2.20E-06 Child: 6.25E-06	Adult: 6.00E-06 Child: 1.41E-05	8E-03
beta-BHC	Adult: 8.60E-06 Child: 1.87E-05	Adult: 2.80E-06 Child: 4.90E-06	Adult: 6.60E-06 Child: 1.90E-05	Adult: 1.80E-05 Child: 4.26E-05	6E-04
Dieldrin	Adult: 7.14E-06 Child: 1.56E-05	Adult: 2.60E-07 Child: 4.45E-07	Adult: 6.50E-06 Child: 1.88E-05	Adult:1.39E-05 Child: 3.48E-05	5E-05
toxaphene	Adult: 1.83E-04 Child: 4.00E-04	Adult: 6.60E-06 Child: 1.14E-06	Adult: 1.20E-04 Child: 5.00E-04	Adult: 3.10E-04 Child: 9.01E-04	2E-03*
KES2 Contaminants					
alpha-BHC	Adult: 8.57E-06 Child: 1.88E-05	Adult: 2.82E-06 Child: 4.90E-06	Adult: 6.60E-06 Child: 1.90E-06	Adult: 1.80E-05 Child: 2.56E-05	8E-03
beta-BHC	Adult: 1.43E-05 Child: 3.13E-05	Adult: 4.71E-06 Child: 8.16E-06	Adult: 8.70E-06 Child: 2.50E-05	Adult:2.77E-05 Child:6.44E-05	6E-04
Endrin ketone	Adult: 1.03E-05 Child: 2.25E-05	Adult: 3.70E-07 Child: 6.40E-07	Adult: 9.55E-05 Child: 2.75E-04	Adult:1.06E-04 Child:2.98E-04	3E-04
gamma-BHC (Lindane)	Adult: 2.86E-06 Child: 6.25E-06	Adult: 9.40E-08 Child: 1.63E-07	Adult: 2.78E-06 Child: 8.00E-06	Adult:5.73E-06 Child : 1.44E-05	1E-05
Toxaphene	Adult: 1.83E-04 Child: 4.00E-04	Adult: 6.57E-06 Child: 1.14E-05	Adult: 2.95E-04 Child: 8.50E-04	Adult:4.85E-04 Child:1.26E-03	2E-03*
KES3 Contaminants					
alpha-BHC	Adult: 2.86E-05 Child: 6.25E-05	Adult: 9.40E-06 Child: 1.63E-05	Adult: 2.20E-05 Child: 6.25E-05	Adult:6.00E-05 Child: 1.41E-04	8E-03
beta-BHC	Adult: 2.57E-05 Child: 5.63E-05	Adult: 8.50E-06 Child: 1.47E-05	Adult: 1.74E-05 Child: 5.00E-05	Adult: 5.16E-05 Child: 1.21E-04	6E-04

4,4'-DDD	Adult: 5.70E-06 Child: 1.25E-05	Adult: 3.10E-06 Child: 5.30E-06	Adult: 7.40E-06 Child: 2.10E-05	Adult: 1.62E-05 Child: 3.88E-05	None
Endrin ketone	Adult: 1.14E-04 Child: 2.50E-04	Adult: 4.10E-06 Child: 7.10E-04	Adult: 1.00E-04 Child: 3.00E-04	Adult: 2.18E-04 Child: 1.26E-03	3E-04
gamma-BHC (Lindane)	Adult: 2.86E-06 Child: 6.25E-06	Adult: 9.41E-08 Child: 1.63E-07	Adult: 2.78E-06 Child: 8.00E-06	Adult: 5.73E-06 Child: 1.44E-05	1E-05
Toxaphene	Adult: 4.57E-04 Child: 1.00E-03	Adult: 1.64E-05 Child: 2.85E-05	Adult: 4.40E-04 Child: 1.28E-03	Adult: 9.13E-04 Child: 2.30E-03	2E-03*
KES4 Contaminants					
alpha-BHC	Adult: 8.57E-06 Child: 1.88E-05	Adult: 2.80E-06 Child: 4.90E-06	Adult: 6.60E-06 Child: 1.90E-05	Adult: 1.80E-05 Child: 4.27E-05	8E-03
beta-BHC	Adult: 5.70E-06 Child: 1.25E-05	Adult: 1.88E-06 Child: 3.26E-06	Adult: 4.30E-06 Child: 1.25E-05	Adult: 1.19E-05 Child: 2.83E-05	6E-04
gamma-BHC (Lindane)	Adult: 4.30E-06 Child: 9.40E-06	Adult: 1.40E-07 Child: 2.45E-07	Adult: 4.30E-06 Child: 1.25E-05	Adult: 8.74E-06 Child: 2.21E-05	1E-05
Toxaphene	Adult: 1.30E-04 Child: 2.88E-04	Adult: 4.70E-06 Child: 8.20E-06	Adult: 1.20E-04 Child: 3.50E-04	Adult: 2.55E-04 Child: 6.46E-04	2E-03*
KES5 Contaminants					
alpha-BHC	Adult: 7.14E-06 Child: 1.56E-05	Adult: 2.35E-06 Child: 4.10E-06	Adult: 5.20E-06 Child: 1.50E-05	Adult: 1.47E-05 Child: 3.47E-05	8E-03
beta-BHC	Adult: 2.86E-06 Child: 6.25E-06	Adult: 9.40E-07 Child: 1.60E-06	Adult: 2.20E-06 Child: 6.25E-06	Adult: 6.00E-06 Child: 1.41E-05	6E-04
gamma-BHC (Lindane)	Adult: 2.86E-06 Child: 6.25E-06	Adult: 9.40E-08 Child: 1.63E-07	Adult: 2.78E-06 Child: 8.00E-06	Adult: 5.73E-06 Child: 1.44E-05	1E-05
Toxaphene	Adult: 1.20E-04 Child: 2.63E-04	Adult: 4.30E-06 Child: 7.50E-06	Adult: 1.10E-04 Child: 3.25E-04	Adult: 2.34E-04 Child: 5.96E-04	2E-03*
KES6 Contaminants					

alpha-BHC	Adult: 8.57E-07 Child: 1.88E-06	Adult: 2.80E-07 Child: 4.90E-07	Adult: 6.90E-07 Child: 2.00E-06	Adult: 1.83E-06 Child: 4.37E-06	8E-03
beta-BHC	Adult: 2.30E-06 Child: 5.00E-06	Adult: 7.50E-07 Child: 1.30E-06	Adult: 1.70E-06 Child: 5.00E-06	Adult: 4.75E-06 Child: 1.13E-05	6E-04
Toxaphene	Adult: 3.43E-05 Child: 7.50E-05	Adult: 1.23E-06 Child: 2.14E-06	Adult: 3.50E-05 Child: 1.00E-04	Adult: 7.05E-05 Child: 1.77E-04	2E-03*

mg/kg/day: milligrams per kilogram of body weight per day
MRL: chronic oral minimal risk level (for exposures lasting 1 year or longer), *intermediate oral minimal risk level (for exposures lasting 15 days to 1 year)
Source: ATSDR Health Guidelines (March 2013)

APPENDIX C: INHALATION EXPOSURES DUE TO VOLATILIZATION OF CONTAMINANTS FROM POTABLE WATER

Name of Site: Klouda Estate: KES1
Location and Description: Ft. Valley, Georgia
CAS # 319-84-6
Contaminant Name: alpha-HCH (alpha-BHC)
Aqueous Concentration = 0.1 ug/L

Maximum Concentration in Shower: 0.2536135 ug/m3
Maximum Concentration in Bathroom: 0.06018579 ug/m3
Maximum Concentration in Main Living Area: 0.003965645 ug/m3
Weighted Daily Concentration = 0.00 ug/m3

Name of Site: Klouda Estate: KES2, KES4 post-filter
Location and Description: Ft. Valley GA
CAS # 319-84-6
Contaminant Name: alpha-HCH (alpha-BHC)
Aqueous Concentration = 0.3 ug/L

Maximum Concentration in Shower: 0.7608405 ug/m3
Maximum Concentration in Bathroom: 0.1805574 ug/m3
Maximum Concentration in Main Living Area: 0.01189694 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES3
Location and Description: Ft. Valley, GA
CAS # 319-84-6
Contaminant Name: alpha-HCH (alpha-BHC)
Aqueous Concentration = 1 ug/L

Maximum Concentration in Shower: 2.536135 ug/m3
Maximum Concentration in Bathroom: 0.6018579 ug/m3
Maximum Concentration in Main Living Area: 0.03965644 ug/m3
Weighted Daily Concentration = 0.03 ug/m3

Name of Site: Klouda Estate: KES5
Location and Description: Ft. Valley, GA
CAS # 319-84-6
Contaminant Name: alpha-HCH (alpha-BHC)
Aqueous Concentration = 0.25 ug/L

Maximum Concentration in Shower: 0.6340337 ug/m3

Maximum Concentration in Bathroom: 0.1504645 ug/m3
Maximum Concentration in Main Living Area: 0.00991411 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES6
Location and Description: Ft. Valley, GA
CAS # 319-84-6
Contaminant Name: alpha-HCH (alpha-BHC)
Aqueous Concentration = 0.03 ug/L

Maximum Concentration in Shower: 0.07608406 ug/m3
Maximum Concentration in Bathroom: 0.01805574 ug/m3
Maximum Concentration in Main Living Area: 0.001189694 ug/m3
Weighted Daily Concentration = 0.00 ug/m3

Name of Site: Klouda Estate: KES2
Location and Description: Ft. Valley, GA
Contaminant Name: beta-HCH (beta-BHC)
Aqueous Concentration = 0.5 ug/L

Maximum Concentration in Shower: 1.268067 ug/m3
Maximum Concentration in Bathroom: 0.300929 ug/m3
Maximum Concentration in Main Living Area: 0.01982822 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES3
Location and Description:
Contaminant Name: beta-HCH (beta-BHC)
Aqueous Concentration = 0.9 ug/L

Maximum Concentration in Shower: 2.282522 ug/m3
Maximum Concentration in Bathroom: 0.5416722 ug/m3
Maximum Concentration in Main Living Area: 0.0356908 ug/m3
Weighted Daily Concentration = 0.03 ug/m3

Name of Site: Klouda Estate: KES4
Location and Description: Ft. Valley, GA
Contaminant Name: beta-HCH (beta-BHC)
Aqueous Concentration = 0.2 ug/L

Maximum Concentration in Shower: 0.5072269 ug/m3
Maximum Concentration in Bathroom: 0.1203716 ug/m3

Maximum Concentration in Main Living Area: 0.00793129 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES6
Location and Description: Ft. Valley GA
Contaminant Name: beta-HCH (beta-BHC)
Aqueous Concentration = 0.08 ug/L

Maximum Concentration in Shower: 0.2028908 ug/m3
Maximum Concentration in Bathroom: 0.04814864 ug/m3
Maximum Concentration in Main Living Area: 0.003172516 ug/m3
Weighted Daily Concentration = 0.00 ug/m3

Name of Site: Klouda Estate: KES3
Location and Description: Ft. Valley, GA
Contaminant Name: DDD
Aqueous Concentration = 0.2 ug/L

Maximum Concentration in Shower: 0.8552615 ug/m3
Maximum Concentration in Bathroom: 0.2031382 ug/m3
Maximum Concentration in Main Living Area: 0.01348565 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES2
Location and Description: Ft.Valley
Contaminant Name: Endrin
Aqueous Concentration = 3.6 ug/L

Maximum Concentration in Shower: 11.5382 ug/m3
Maximum Concentration in Bathroom: 2.738803 ug/m3
Maximum Concentration in Main Living Area: 0.1808174 ug/m3
Weighted Daily Concentration = 0.14 ug/m3

Name of Site: Klouda Estate: KES3
Location and Description: Ft. Valley, GA
Contaminant Name: Endrin
Aqueous Concentration = 3.85 ug/L

Maximum Concentration in Shower: 12.33946 ug/m3
Maximum Concentration in Bathroom: 2.928998 ug/m3
Maximum Concentration in Main Living Area: 0.1933742 ug/m3
Weighted Daily Concentration = 0.15 ug/m3

Name of Site: Klouda Estate: KES1
Location and Description: Ft. Valley, GA
CAS # 60-57-1
Contaminant Name: Dieldrin
Aqueous Concentration = 0.25 ug/L

Maximum Concentration in Shower: 0.7498319 ug/m3
Maximum Concentration in Bathroom: 0.1780373 ug/m3
Maximum Concentration in Main Living Area: 0.01178746 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES2, KES3, KES5,
Location and Description: Ft, Valley, Georgia
CAS # 58-89-9
Contaminant Name: gamma-HCH (Lindane)
Aqueous Concentration = 0.1 ug/L

Maximum Concentration in Shower: 0.3205054 ug/m3
Maximum Concentration in Bathroom: 0.07607786 ug/m3
Maximum Concentration in Main Living Area: 0.005022706 ug/m3
Weighted Daily Concentration = 0.00 ug/m3

Name of Site: Klouda Estate: KES4
Location and Description: Ft. Valley
CAS # 58-89-9
Contaminant Name: gamma-HCH (Lindane)
Aqueous Concentration = 0.15 ug/L

Maximum Concentration in Shower: 0.4807581 ug/m3
Maximum Concentration in Bathroom: 0.1141168 ug/m3
Maximum Concentration in Main Living Area: 0.007534061 ug/m3
Weighted Daily Concentration = 0.01 ug/m3

Name of Site: Klouda Estate: KES1
Location and Description: Ft. Valley, GA
Contaminant Name: Toxaphene
Aqueous Concentration = 6.4 ug/L

Maximum Concentration in Shower: 20.51235 ug/m3
Maximum Concentration in Bathroom: 4.868983 ug/m3
Maximum Concentration in Main Living Area: 0.3214532 ug/m3

Weighted Daily Concentration = 0.24 ug/m3

Name of Site: Klouda Estate: KES2
Location and Description: Ft. Valley
Contaminant Name: Toxaphene
Aqueous Concentration = 10.7 ug/L

Maximum Concentration in Shower: 34.29408 ug/m3
Maximum Concentration in Bathroom: 8.140329 ug/m3
Maximum Concentration in Main Living Area: 0.5374295 ug/m3
Weighted Daily Concentration = 0.40 ug/m3

Name of Site: Klouda Estate: KES3
Location and Description: Ft. Valley, GA
Contaminant Name: Toxaphene
Aqueous Concentration = 15.9 ug/L

Maximum Concentration in Shower: 50.96036 ug/m3
Maximum Concentration in Bathroom: 12.09638 ug/m3
Maximum Concentration in Main Living Area: 0.7986103 ug/m3
Weighted Daily Concentration = 0.60 ug/m3

Name of Site: Klouda Estate: KES4 post-filter
Location and Description: Ft. Valley, GA
Contaminant Name: Toxaphene
Aqueous Concentration = 4.6 ug/L

Maximum Concentration in Shower: 14.74325 ug/m3
Maximum Concentration in Bathroom: 3.499582 ug/m3
Maximum Concentration in Main Living Area: 0.2310445 ug/m3
Weighted Daily Concentration = 0.17 ug/m3

Name of Site: Klouda Estate: KES5
Location and Description:
Contaminant Name: Toxaphene
Aqueous Concentration = 4.2 ug/L

Maximum Concentration in Shower: 13.46123 ug/m3
Maximum Concentration in Bathroom: 3.19527 ug/m3
Maximum Concentration in Main Living Area: 0.2109537 ug/m3
Weighted Daily Concentration = 0.16 ug/m3

Name of Site: Klouda Estate: KES6
Location and Description: Ft. Valley, GA
Contaminant Name: Toxaphene
Aqueous Concentration = 1.2 ug/L

Maximum Concentration in Shower: 3.846065 ug/m3
Maximum Concentration in Bathroom: 0.9129345 ug/m3
Maximum Concentration in Main Living Area: 0.06027249 ug/m3
Weighted Daily Concentration = 0.05 ug/m3