Health Consultation

Follow-up Evaluation of the Potential Health Risks Associated with Recreational Use of Willow Springs Ponds

SCHLAGE LOCK COMPANY

SECURITY, EL PASO COUNTY, COLORADO

EPA FACILITY ID: COD082657420

Prepared by the
Colorado Department of Public Health and Environment

JANUARY 19, 2012

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

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

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

HEALTH CONSULTATION

Follow-up Evaluation of the Potential Health Risks Associated with Recreational Use of Willow Springs Pond

SCHLAGE LOCK COMPANY

SECURITY, EL PASO COUNTY, COLORADO

EPA FACILITY ID: COD082657420

Prepared By:

The Colorado Department of Public Health and Environment
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Colorado Cooperative Program for Environmental Health Assessments has prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the United States Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local department of public health can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred, may be occurring, or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding the contents of this health consultation, please contact the author of this document or the Principal Investigator/Program Manager of the CCPEHA:

Author: Thomas Simmons
Colorado Cooperative Program for Environmental Health Assessments
Environmental Epidemiology Section
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South Denver Colorado, 80246-1530
(303) 692-2961
FAX (303) 782-0904
Email: tom.simmons@state.co.us

Principal Investigator/Program Manager: Dr. Raj Goyal
Colorado Cooperative Program for Environmental Health Assessments
Environmental Epidemiology Section
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South Denver Colorado, 80246-1530
(303) 692-2634
FAX (303) 782-0904
Email: raj.goyal@state.co.us

Table of Contents

Statement and Summary of Issues

Introduction

The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) and the Agency for Toxic Substances and Disease (ATSDR) Registry's top priority is to ensure that all stakeholders have the best health information possible to protect the community from current and future health hazards associated with recreational use of Willow Springs Ponds in El Paso County, Colorado.

Willow Springs Ponds (WSP) is located within Fountain Creek Regional Park in Fountain, Colorado. The source water for the ponds is the Widefield Aquifer, which was found to be contaminated with tetrachloroethene (PCE) in the late 1980's. The PCE plume originates at the Schlage Lock manufacturing facility, which is located approximately 4 miles to the north of the ponds in Security, Colorado. In 1996, tetrachloroethene (PCE) was discovered in the spring-fed ponds, and subsequent investigation revealed that PCE was also accumulating in fish tissue at potentially harmful levels. Accordingly, the ponds were closed to fishing by the El Paso Board of Commissioners in September 1997 and all park equipment (parking lots, playground, picnic tables, fish cleaning stations, etc.) were either closed off or removed.

A large amount of remedial activity and environmental sampling has occurred throughout the plume area. In relation to the ponds, Schlage installed the first mechanical aerator at the northern end of Pond 1 in 1998. A monthly surface water sampling program was also initiated at that time. The second aerator was installed in the southern end of Pond 1 in 2003. In 2007, a sparge treatment unit was installed upgradient of the ponds in John Ceresa Park to remove PCE from the Widefield Aquifer prior to entering WSP. These systems are run in conjunction and have been very effective at keeping PCE concentrations in Willow Springs Ponds below the state surface water quality standard of 0.69 µg/L,

A large amount of fish tissue data (roughly 200 samples) has been collected since 1997. Previous health consultations in 2006 and 2007 indicated potential for theoretical cancer risks for high-end consumers of fish contaminated with PCE. However, it was found that people could safely catch and eat fish within certain limits. With a Fish Consumption Advisory in place, the ponds were reopened to the public on April 27, 2007. A fish stocking program

was also initiated around this time to restore the ecosystem of the ponds, which had degraded since the ponds' closure. Fish tissue and water quality data collection has continued since the ponds were reopened to the public in 2007, and a number of fish tissue and water quality samples are currently available for review.

The Hazardous Materials and Waste Management Division (HMWMD) of the Colorado Department of Public Health and Environment (CDPHE) requested assistance from the Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) to evaluate the fish tissue and water quality data that has been collected since 2007 when Willow Spring Ponds (WSP) were reopened to the public. The purpose of this follow up health consultation is to evaluate the potential health risks to recreational users based on the new fish tissue and water quality data. Two of the primary questions to be answered are 1) if fish consumption still poses a theoretical cancer risk to high-end consumers and, 2) if exposure to PCE while swimming and/or wading in WSP is a public health hazard since the ponds have been reopened and swimming/wading are likely to occur on a more frequent basis than when previously evaluated.

Overview

CCPEHA and ATSDR have reached two conclusions regarding the public health implications of recreational use of Willow Springs Ponds.

Conclusion 1

It cannot currently be determined if consumption of fish caught from Willow Springs Ponds could harm people's health.

Basis for Decision

This conclusion was reached because the recent fish tissue data collected from Willow Springs Ponds is inadequate to evaluate the public health implications of fish consumption. In particular, there were a number of errors in the analytical results as discussed in Appendix C. The major errors in the analysis were poor reproducibility, sampling results outside the calibration range, and measurements outside of quality control/quality assurance limits. In addition, there is limited amount of fish tissue data available particularly for bluegill (1 sample), largemouth bass (3 samples), and wiper (5 samples).

Although we cannot make definitive conclusions regarding the public health implications of consuming the fish from the pond, the PCE levels found in these fish (if present at all) were at or below the reporting limit of 5 ppb which is below the CDPHE action level of 5.7ppb (at 1 $*10^{-5}$ cancer risk level). The PCE levels below the CDPHE action level would result in a low or very

low increased risk of developing cancer. However, it should be noted that these risks are highly uncertain because of the inadequate data (e.g., poor analytical quality) and may not be representative of the actual risk (i.e., over- or underestimate risk).

Conclusion 2

Swimming and/or wading in Willow Springs Ponds is not likely to harm people's health.

Basis for Decision

This conclusion was reached because the estimated non-cancer exposure doses are well below health-based guidelines, which indicate a very low risk of developing non-cancer adverse health effects associated with PCE exposure. In addition, the estimated theoretical lifetime excess cancer risks are significantly below the CDPHE target cancer risk level of $1 * 10^{-6}$, or 1 excess cancer case per million exposed individuals. This indicates a very low increased risk of developing cancer.

Next Steps

Additional fish tissue data should be collected from Willow Springs Ponds because there were numerous analytical errors in the current fish tissue data and there are a limited number of samples particularly for bluegill, largemouth bass, and wiper. At this time, the results of this evaluation also suggest that Schlage Lock should continue operating the sparge treatment unit located in John Ceresa Park and/or aerators to keep the concentration of PCE in the ponds below the surface water standard applied to WSP. Upon request, CCPEHA will review any additional fish tissue and/or water data that is collected from Willow Springs Ponds and update the health consultation accordingly.

For More Information

If you have immediate concerns about your health, you should contact your health care provider. Please call Thomas Simmons at 303-692-2961 for more information on the information contained in this health consultation.

Purpose

The Hazardous Materials and Waste Management Division (HMWMD) of the Colorado Department of Public Health and Environment (CDPHE) requested assistance from the Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) to evaluate the fish tissue and water quality data that has been collected since 2007 when Willow Spring Ponds (WSP) were reopened to the public. The purpose of this follow-up evaluation is to determine if there is any potential public health concern from consuming fish caught from WSP or swimming/wading within WSP.

Background

Willow Springs Ponds are located at the distal extent of a tetrachloroethene (PCE) plume that originates at the Schlage Lock manufacturing facility approximately 4 miles to the north of the ponds in Security, El Paso County, Colorado. PCE is a volatile organic compound (VOC), which Schlage used as a metal cleaner and degreaser from 1977 through 1992. In 1996 PCE was discovered in the spring-fed ponds and a subsequent investigation revealed that PCE was also accumulating in fish tissue at potentially harmful levels. Accordingly, the ponds were closed to fishing by the El Paso Board of Commissioners in September 1997 and all park equipment (parking lots, playground, picnic tables, fish cleaning stations, etc.) were either closed off or removed. In 1998 Schlage installed a mechanical aerator at the northern end of Pond 1 to treat PCE contamination in the pond. A monthly surface water sampling program was also initiated at that time. A second aerator was installed in the southern end of Pond 1 in 2003.

Schlage has conducted regular sampling events of fish tissue and water quality in WSP since 1997. In 2006, the HMWMD of CDPHE requested that the CCPEHA review the available fish tissue, sediment, and water quality data collected from the ponds to determine any potential health effects of exposure to PCE from recreational use of the ponds including the consumption of fish (ATSDR 2006). The 2006 evaluation indicated that PCE in fish taken from the ponds could result in theoretical cancer risks above the acceptable cancer risk range for individuals consuming substantial amounts of certain types of fish, based on the limited data collected in 2004. It was recommended that the ponds remained closed to fishing until more current fish tissue data was collected and analyzed for PCE. An additional health consultation conducted in 2007 (ATSDR 2007) that was based on newly collected data also reached the same conclusion. Specifically, the results of the health consultation concluded that there was an increased potential for developing cancer from eating large amounts of certain types of fish including largemouth bass, western white suckers, and European rudd. However, it was also determined at this time that fish from WSP could be safely consumed within certain limits.

Surface water and sediment samples were also evaluated for PCE contamination in the previous health consultations (ATSDR 2006, 2007). Over 200 water quality samples, collected between 1996 and 2005, were reviewed in the previous health consultation (ATSDR 2006). The water data was split into phases to account for exposures prior to the

installation of the first aerator (1), after the installation of the first aerator (2), and after the installation of the second aerator (3). The evaluation indicated that swimming and wading in WSP did not present a public health hazard for recreational users during any phase of exposure. Between 1997 and 2004, Schlage Lock and El Paso County collected sediment data on four separate occasions. A total of 18 sediment samples (with an estimated maximum detected concentration of 6.1 ppb) were collected, primarily from the north pond (Pond #1) and were evaluated for public health implications by CCPEHA in 2007 (ATSDR 2007). It was determined that contact with PCE in WSP sediments was not likely to result in adverse human health effects.

In January 2007, Schlage Lock, El Paso County, and the State of Colorado (Division of Wildlife) entered into a settlement agreement. This included a commitment by Schlage to install a sparge system upgradient of WSP to remove PCE from groundwater prior to entering the ponds to allow for eventual removal of the pond aerators (El Paso County 2007). In addition, it was agreed that Schlage would provide funding for the Colorado Division of Wildlife to stock the ponds for a period of 3 years to replenish the fish population and restore the ecosystem in the ponds that had degraded since the ponds closure. As a result of this agreement, El Paso County agreed to reopen the ponds under a fish consumption advisory issued by the CDPHE, which informed the public of the risks associated with fish consumption from the ponds and specifically sought to limit the amount of largemouth bass, western white suckers, and European rudd. With the advisory in place, WSP were reopened in April of 2007.

Since the ponds were reopened to the public, 5 fish tissue sampling events have occurred and a total of 53 edible fish tissue samples have been collected. In addition, water quality data has been collected from the ponds on at least one occasion every month for a total of 257 water samples. The overall goal of this evaluation is to update the previous health consultations by reviewing the available fish tissue and water quality data collected since the ponds were reopened. The primary questions to be answered are 1) if fish consumption still poses unacceptable theoretical cancer risk for high-end or subsistence consumers, and 2) if exposure to PCE while swimming and/or wading in WSP is a public health hazard since the ponds are reopened and exposures are likely to occur more frequently.

Demographics

The most frequent users of WSP are likely those individuals that live within a close proximity to Fountain Creek Regional Park. U.S. Census 2000 data for this area does not possess any striking demographic characteristics that would normally have an effect on this evaluation (e.g., subsistence fishing). However, El Paso County health officials have raised concerns that a substantial Asian population exists in the area that may have used WSP for subsistence fishing before the closure. The overall percentage of Asians within El Paso County is approximately 2.5 percent or 13,099 individuals (U.S. Census 2000, Population of one race, Asian alone). Moreover, some census tracts near WSP were in the highest tier of percent Asian of total tract population for all census tracts in El Paso County.

Community Health Concerns

Community health concerns regarding the PCE contamination within the Widefield Aquifer were solicited and documented in the "Community Involvement and Health Issues Communication Plan" (CDPHE 2004). In addition, Schlage Lock and the Hazardous Waste and Waste Management Division (HWWMD) at CDPHE have also conducted public involvement activities in the affected communities. Their findings were documented in the "Community Involvement Plan for the Schlage Lock Company Site" (Schlage 2001). Community concerns from both documents are summarized below.

Previously Identified Community Concerns (Schlage 2001):

- Safety of the drinking water supply,
- Property Values,
- Progress on the Willow Springs Ponds remediation, and
- Testing of pumping wells west of U.S. Highways 85 and 87 (Municipal water supply well that are being treated).

Previously Identified Community Concerns (CDPHE 2004):

- The possibility of PCE exposure causing brain cancer, lymphatic cancer, or other types of cancer,
- The possibility of PCE exposure resulting in respiratory problems, and
- The health of domestic dogs that have swam in Willow Springs Ponds.
- The primary health concerns within the community from exposure to PCE appeared to be cancer and other non-carcinogenic health effects, such as respiratory problems. The intent of this health consultation is to evaluate any potential adverse human health effects, including cancer, from exposure to PCE in surface water and fish tissue at WSP. Other pathways of exposure have been evaluated for carcinogenic risk in separate health consultations available at: http://www.cdphe.state.co.us/dc/envtox/ccpehasites.html

Please see the "Public Health Action Plan" section of this document for a list of all other health consultations available on this site. These activities have helped to address community concerns.

Discussion

The overall goal of this health consultation is to determine if site-related contamination poses a public health hazard and to make recommendations to protect public health if need be. The first steps of the health consultation process include an examination of the currently available environmental data and how individuals could be exposed to contaminants of potential concern (COPCs). If exposure pathways to COPCs exist, exposure doses are estimated and compared to health-based guidelines established by the ATSDR and EPA. This is followed by an in-depth evaluation if the estimated exposure doses exceed health-based guidelines.

Environmental Data

Fish Tissue Data

The fish tissue data used as the basis of this evaluation have been collected from Willow Springs Ponds since the ponds reopened in April 2007. Since this time, five sampling events have occurred resulting in the collection and analysis of approximately 53 fish tissue samples. The fish were caught by the Colorado Division of Wildlife (CDOW) using gill nets. Edible, skin-on filet samples were then collected and sent to GPL/Centauri Laboratory in Fredrick, Maryland for VOC analysis by EPA method 8260B. Prior to the ponds reopening, whole and edible fish tissue samples were collected from Willow Springs Ponds. Whole fish tissue samples typically have higher concentrations of VOCs (i.e., PCE) since many of these compounds are lipophilic (accumulate in fat). However, edible fish filets may be a more appropriate measure of actual exposure unless there is site-specific information to suggest that individuals are consuming whole fish.

Six different species of fish have been collected from the ponds since they reopened. The majority of samples collected are western white sucker (20), channel catfish (12), and trout (12). The CDOW has been stocking channel catfish, bluegill, largemouth bass, and wiper since the ponds reopened. Each species of stocked fish has been sampled, but there are a low number of samples for wiper, largemouth bass, and bluegill. This may be due to these fish being preferentially caught and taken from the ponds by the anglers, thus reducing the number of these species available for sampling. The following Table 1 lists the fish species collected by sampling date.

In comparison to the fish tissue that was collected prior to the reopening of WSP, the recent fish tissue data does not include sunfish, crappie, or European rudd. However, it is possible that these fish are no longer present in WSP since CDOW began their stocking and rehabilitation of the ecosystem in the ponds, which in part sought to root out the rough fish population that had proliferated since the ponds' closure in 1997 (El Paso County 2007). Five wipers were collected in the recent data, which had not been collected previously. It appears that this type of fish was not present in the ponds before the CDOW reinstated the stocking program in 2007.

Table 1. List of fish species collected since WSP reopened in April 2007

Collection Date	Western White Sucker	Catfish	Trout	LM Bass	Wiper	Bluegill
8/6/2008	5	5	2	0	0	0
12/12/2008	4	0	1	0	0	0
4/16/2009	4	2	4	0	1	1
8/6/2009	4	5	2	0	1	0
10/19/2010	3	0	3	3	3	0
Total	**20**	**12**	**12**	**3**	**5**	**1**

NOTE: A total of 53 fish have been collected and analyzed, LM Bass = Largemouth bass

Surface Water Quality Data

Since WSP reopened in 2007, water samples have been collected from Pond 1 at least once a month. The primary sampling locations are in the northern and southern section of Pond 1 as shown in Figure A1. These samples are collected from 5 ft. below the surface of the water. In addition to the surface water samples, influent water samples are also collected from the locations where groundwater from the Widefield aquifer enters the pond (Figure A1). The water samples collected from WSP are analyzed for PCE, TCE, DCE, and VC by EPA Method 8260B. However, TCE, DCE, and VC were not detected in the water data collected from WSP and only PCE is discussed further. In addition, it is important to note that the surface water is in an aerobic condition, which prevents PCE from breaking down to its daughter products. The treatment in the pond, via aeration, increases this condition.

As mentioned previously, there are two types of treatment units currently operating at the ponds, the sparge unit and the aerators. The influent samples are collected to evaluate the effectiveness of the sparge treatment unit, located in John Ceresa Park. The samples collected at 5 ft. are representative of water quality after aeration and volatilization of PCE from the water. The surface water samples (collected at a depth of 5ft.) are more representative of the water that swimmers and waders would come into contact with and are used as the basis of this evaluation. However, a quantitative evaluation of the influent water samples was also included.

The water sampling data indicates that small amounts of PCE are still entering WSP from the Widefield Aquifer. A total of 169 surface water samples and 88 influent water samples were collected between May 2007 and March 2011 (the latest sampling data included in this evaluation). In general, the influent water samples had higher levels of PCE than the surface water samples. The influent samples had a PCE concentration range of 0.066 ppb to 3.0 ppb with a mean concentration of 0.35 ppb and a detection frequency of 85%. Surface water samples had a PCE concentration range of 0.066 ppb to 0.58 ppb with a mean concentration of 0.18 ppb with a detection frequency of 70%. No other site related contaminants were found in water samples collected from WSP.

Table 2. Willow Springs Ponds Water Quality Data Summary

Data Source	Minimum (in µg/L)	Maximum (in µg/L)	Mean (in µg/L)	Detection Frequency	*n*
Surface Water	0.066	0.58	0.18	70%	169
Influent	0.066	3.0	0.35	85%	88

NOTE: µg/L = micrograms of PCE per liter of water, *n* = number of samples

Selection of Contaminants of Concern

Identifying Contaminants of Potential Concern (COPCs) involves screening the available fish tissue and water quality data for contaminants that exceed the health-based screening values established by the Agency for Toxic Substances and Disease Registry (ATSDR) and/or the Environmental Protection Agency (EPA). If the maximum concentration of any detected contaminant is below the respective screening value, it is dropped from further evaluation since it is unlikely to result in any significant adverse health effects. If

the concentration of a contaminant exceeds the screening value, it is retained for further evaluation. In accordance with CDPHE and EPA Region 8 protocols, the screening values for non-carcinogenic compounds were multiplied by 0.1 to account for additive adverse health effects resulting from exposure to multiple compounds.

Fish Tissue COPC Selection

The Environmental Protection Agency's (EPA) Region 3 Fish Screening Values were used to identify COPCs (EPA 2011). The Region 3 Fish Screening Values are based on the assumption of adults ingesting 54 grams of fish per day (approximately 2 oz. per day), 350 days per year, for a period of 30 years. This is a conservative screening value in that it is unlikely any individual would catch and consume fish from Willow Springs Ponds at this rate.

As mentioned previously, PCE is the major contaminant of concern from the Schlage site. PCE will naturally degrade in the environment via bacterial reductive dechlorination, which produces trichloroethene, dichloroethene, vinyl chloride, and ultimately ethene. In the recent fish tissue data collected from the ponds, PCE was not detected in any of the 53 samples. Vinyl chloride (VC) and cis-1,2-dichloroethene (DCE) were detected in one wiper sample and trichloroethene (TCE) was detected in one catfish sample. The concentration of VC and cis-1,2-DCE in the wiper sample exceeds the EPA Region 3 Fish Screening Values. However, these compounds were only detected in one fish (Wiper) and the detections were outside the calibration range of the gas chromatograph during analysis. When the wiper sample was diluted and reanalyzed to bring the analyte response for these compounds within range, the concentration was much lower than the previous sample, which could indicate an erroneous result. The laboratory report on the reanalysis of this fish were not available, so it is unknown if the results that were within calibration range exceeded the screening value. It should also be noted that cis1,2-DCE and VC were not present in three samples of wiper samples that were analyzed in 2011. Therefore, VC and cis-1,2-DCE were not considered COPCs in this evaluation (Table 3). However, due to the poor quality of the analytical data in fish tissue, it is recommended that laboratory analysis of these compounds continues until it has been determined that the levels of these compounds do not present a public health hazard to anglers.

Table 3. Selection of Fish Tissue Contaminants of Potential Concern

Contaminant	Maximum Detected Value (All Fish, n =53) (in µg/kg)	EPA Region 3 Fish Tissue Screening Level* (in µg/kg)	Contaminant of Potential Concern?
Tetrachloroethene	ND (at Reporting limit of 5)	5.8	No
Trichloroethene	3.6 (j-qualified)	530	No
Vinyl chloride	290 (estimate)	4.4	No [a]
Cis-1,2-Dichloroethene	1,100 (estimate)	270	No[a]

Note: µg/kg = microgram of contaminant per kilogram fish tissue
* The value presented is 10% of the actual Regional Screening Value to account for multiple chemical exposures
j-qualified indicates that the response for the contaminant is above the minimum detection limit, but below the reporting limit of the analytical method
Estimate indicates that the response for the contaminant is outside the range of calibration of the analytical method
[a] These are not carried forward as COPCs for further evaluation at this time because these compounds were only detected in one fish (wiper) in April 2009 and the detections were outside the calibration range of the gas chromatograph during analysis. Also, these chemicals were below the detection limit in re-analysis of duplicate samples. Furthermore, three samples of wiper analyzed in 2011 contained these chemicals below the detection limit.

Surface Water COPC Selection

The EPA's Regional Screening Level (RSL) for PCE was selected as the screening value for water quality samples. The RSL for PCE in tapwater is 0.11 ppb, which accounts for residential consumption of drinking water at 2L per day, 350 days per year over a period of 30 yrs. The RSL also accounts for dermal exposure and inhalation of volatiles. Therefore, the RSL is considered a conservative screening value and PCE concentrations less than the RSL are not likely to result in adverse health effects for individuals using WSP to swim and/or wade.

As shown in Table 4, the maximum concentration of PCE in surface water and influent samples exceeds the RSL and PCE was retained for further evaluation. All other site-related contaminants were not detected in surface water samples collected from WSP.

Table 4. Selection of Surface Water Contaminants of Potential Concern

Contaminant	Maximum Detected Value (in µg/L)	EPA Regional Screening Level (in µg/L)	Contaminant of Potential Concern?
Tetrachloroethene (Surface water data)	0.58	0.11	Yes
Tetrachloroethene (Influent water data)*	3.0	0.11	Yes

* Presented for informational purposes only. Influent water data was not quantitatively evaluated because it is not representative of recreational exposures.

Exposure Assessment (Pathway Analysis)

The exposure evaluation examines current and future use of Willow Springs Ponds to develop a conceptual site model that describes how people could come into contact with site-related contamination. Simply having contamination in the environment does not indicate there is a public health hazard. Therefore, it is necessary to determine if and how individuals can be exposed to the contamination.

Willow Springs Ponds is a popular recreational area that is used for a variety of purposes ranging from family gatherings to fishing. WSP was a popular recreational area for the surrounding communities prior to its closure to the general public on September 10,

1997. At this time, PCE was present in fish tissues and pond water. Individuals were allowed to catch and take fish for consumption. Swimming and/or wading was not allowed at WSP prior to closure. However, some evidence, gathered through community interviews, indicates that teenagers often times trespassed onto the property to swim during summer months after WSP were closed. If people were swimming in the ponds after they were closed to the public, it is reasonable to assume that at least some swimming/wading currently takes place at WSP. Dermal contact and incidental ingestion of water while swimming/wading is considered a complete exposure pathway since PCE was identified as COPC in the water data collected from the ponds. Exposure dose calculations will be performed for dermal contact and incidental ingestion while swimming/wading for the time period after the date of WSP reopening.

COPCs were not identified in the recent fish tissue data collected from WSP. However, due to the poor quality of the analytical data, the fish consumption pathway cannot be quantitatively evaluated at this time. The public health implication of fish consumption remains an area of concern that cannot be ruled out until additional data is collected and analyzed. Therefore, this pathway was dropped from further quantitative evaluation in this health consultation. A qualitative evaluation of the contaminants "present" in fish tissue based on the data that has been collected was conducted in this health consultation.

Due to the fact that people do not use the ponds for drinking water, exposure to PCE does not occur for a drinking water pathway. In addition, PCE is a VOC that will vaporize into the atmosphere when groundwater is exposed to the surface as at Willow Springs Ponds. However, the air concentration of PCE is likely to be so low that it is considered an insignificant exposure pathway to recreational users. Therefore, inhalation of PCE vapors was not evaluated further. The exposure pathways evaluated in this health consultation are summarized below in Table 5.

Table 5. Conceptual Site Model

Source	Point of Exposure*	Affected Environmental Medium	Potentially Exposed Populations	Timeframe of Exposure	Route of Exposure
Industrial Waste	Willow Springs Ponds	Groundwater and Surface Water	Anglers and other Recreational Users	Current and Future	1) Fish Consumption 2) Incidental Ingestion and Dermal Exposure to Surface Water 3) Inhalation of PCE vapors**

NOTE: * Willow Springs Ponds are the focus of this evaluation. Other points of exposure to PCE contamination in the Widefield Aquifer exist and have been evaluated. Additional information on the other

health consultations conducted on this site is available at:
http://www.cdphe.state.co.us/dc/envtox/ccpehasites.html.

**Inhalation of tetrachloroethene (PCE) is a complete, but insignificant exposure pathway that was dropped from further evaluation (see discussion above).

Exposure Point Concentration

Fish Tissue
EPCs were not estimated for fish tissue because all COPCs were dropper from further evaluation in this health consultation due to the following limitations: (1) poor data quality due to errors including poor reproducibility, detections outside calibration range, and failed quality control measures; and (2) only a limited number of samples currently available, particularly for wiper, bluegill, and largemouth bass.

Surface water
The exposure point concentration (EPC) describes the concentration of PCE in surface water and fish that people are likely to come into contact with. It is assumed that the typical user would be exposed to PCE over a broad area in the pond. Therefore, it was assumed that the entire pond was the exposure unit (or area) of concern. Thus, the surface water data that was collected was combined for use in estimating the EPCs for each PCE. The data were inserted into EPA's ProUCL software, which calculates the Upper Confidence Limit (UCL) of the mean for a data set by various statistical methods, and recommends the appropriate EPC (EPA 2011b). For example, with a normally distributed data set, the resulting concentration estimation is typically the 95% UCL of the mean concentration of all data. The EPCs are shown in Table B3. For estimating EPCs, ½ the detection limit was not used as a substitute for values below the detection limit. Instead, ProUCL recommended statistically rigorous methods (e.g., Kaplan-Meier) were applied.

Public Health Implications

Public Health Implications Associated with Fish Tissue
The maximum concentrations of all detected compounds are below the EPA Region 3 Fish Screening Values with the exception of trichloroethene and vinyl chloride, which were only detected in one sample. This sample cannot be fully evaluated at this time because the results were an estimated concentration due to detection outside the calibration range of the analytical method. Analytical errors were a major issue in the fish tissue data results that were reviewed for this evaluation. Typical errors included poor reproducibility, detections outside calibration range, and failed quality control measures (Appendix C). In addition, there are only a limited number of samples currently available, particularly for wiper, bluegill, and largemouth bass. Therefore, it cannot be determined at this time if fish consumption at WSP could harm peoples' health.

Although we cannot make definitive conclusions regarding the public health implications of consuming the fish from the pond, the PCE levels found in these fish (if present at all) were at or below the reporting limit of 5 ppb which is below the CDPHE action level of

5.7ppb (at 1 *10^{-5} cancer risk level). CDPHE action level is based on a cancer risk level of ten excess cancer cases in a million (1 *10^{-5}) and a fish ingestion rate of 227 g (8 oz.) per day, 30 days per month over a period of 70 years. Under these assumptions, consumption of PCE in fish at the reporting limit would result in a theoretical lifetime excess cancer risk of 8.77 * 10^{-6} (or 9 excess cancer cases in a million people). This level of cancer risk is within EPA's acceptable cancer risk level range (1 * 10^{-4}- 1*10^{-6}) and is also below CDPHE's risk management action level for fish consumption of 1 * 10^{-5}. These risks would result in a low or very low increased risk of developing cancer. However, it should be noted that these risks are highly uncertain because of the inadequate data (e.g., poor analytical quality) and may not be representative of the actual risk (i.e., over- or underestimate risk).

Public Health Implications Associated with Surface Water Exposures

The exposure dose results for surface water exposures were based on the assumptions of child and/or adults swimming/wading in WSP 100 days per year over a period of 6 years for children and 30 years for adults. Dermal and incidental ingestion will occur while swimming and wading and the exposures are simultaneous. Thus, the results from each exposure pathway were combined to evaluate the cumulative exposure dose while swimming/wading. Non-cancer doses are compared with health-based guidelines established by the ATSDR and the EPA. PCE is considered a probable human carcinogen by the U.S. Department of Health and Human Services based on sufficient evidence of carcinogenicity in animal studies and limited carcinogenicity in human studies (ATSDR 1997). Therefore, cancer doses were also estimated and evaluated using a cancer slope factor developed by the California Environmental Protection Agency. The slope factor is used to estimate the lifetime excess cancer risk, which is compared to the EPA acceptable cancer risk level of 1 * 10^{-6} to 1* 10^{-4}, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

As shown in Tables A1 and B5, the estimated non-cancer doses for children and adults swimming and wading in WSP is below a level of concern for all exposure pathways (combined dermal and ingestion). For children, the dermal component of the non-cancer dose is 0.00000173 mg/kg-day and the ingestion component is 0.000000260 mg/kg-day, which equals 0.00000199 mg/kg-day cumulative dose. For adults, the dermal component is 0.00000101 mg/kg-day and the ingestion component is 0.0000000394 mg/kg-day, which equals 0.00000105 mg/kg-day cumulative dose. These dose estimates are well below the non-cancer health-based guideline of 0.01 mg/kg-day (EPA Oral Reference Dose). The influent PCE concentration is approximately three times the surface water concentration and the corresponding dose would also be around three times the non-cancer dose estimates for surface water (cumulative doses of 0.00000462 mg/kg-day for children and 0.00000243 mg/kg-day for adults). As mentioned previously, using the influent data is a very conservative assumption because it does not take into account the PCE concentration decline after dilution, aeration or natural vaporization of PCE. However, the cumulative estimated non-cancer doses using the influent PCE concentration are still more than 2,100 times lower than the health-based guideline. Therefore, non-cancer adverse health effects are not likely to occur as a result of swimming/wading in WSP based on the assumptions used in this evaluation.

This evaluation also indicates that there is a very low risk of developing cancer from swimming and/or wading in Willow Springs Ponds based on the estimated excess lifetime cancer risks, which are well below the EPA's acceptable cancer risk range (Table A2). For instance, the estimated lifetime excess cancer risk for children is $8*10^{-8}$ from dermal exposure and $1*10^{-8}$ from incidental ingestion while swimming/wading in WSP. Thus, the cumulative lifetime excess cancer risk for children based on the surface water data is estimated to be $9*10^{-8}$, or 9 excess cancer cases per 100 million exposed swimmers. Based on the influent water data, the estimated lifetime excess cancer risk is $2*10^{-7}$, or 2 excess cancer cases per 10 million exposed swimmers. The estimated theoretical lifetime excess cancer risk for children is slightly higher (2-fold) than adults for the incidental ingestion of water but significantly below the CDPHE target cancer risk level of one in a million (or below the low-end of EPA's acceptable cancer risk range of one to 100 in a million). However, the estimated lifetime excess cancer risk for children is slightly lower (2.5-fold) than adults for the dermal contact pathway. The estimated lifetime excess cancer risk for adults from dermal exposure to PCE is $2*10^{-7}$ and $9*10^{-9}$ from incidental ingestion. The cumulative estimated lifetime excess cancer risk for adults is $2*10^{-7}$, or 2 excess cancer cases per 10 million exposed swimmers based on the surface water data. The estimated cumulative lifetime excess cancer risk for adults based on the influent data is $6.0*10^{-7}$ or 6 excess cancer cases per 10 million exposed swimmers. These cancer risk estimates are well below the EPA acceptable cancer risk range of $1*10^{-6}$ to $1*10^{-4}$, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals.

Uncertainties and Limitations

In general, health consultations and risk assessments may over- or underestimate cancer and non-cancer risks to any one individual. However, in this health consultation, the cancer and non-cancer risks are more likely overestimated than underestimated due to a conservative screening approach used to determine contaminants of potential concern and the use of conservative exposure assumptions. It should be noted that the following major uncertainties and limitations are associated with this evaluation of fish tissue:

- This evaluation is based on a limited number of fish tissue samples collected during 2008-2010. This is especially true for three fish species (wiper, n = 5; bluegill n = 1; and largemouth bass n = 3). In addition, it is not clear if all fish species have been collected from the ponds or if the samples collected since the ponds reopening in 2007 are completely representative of the types of fish in WSP. For example, no fish tissue samples of European rudd have been collected and only one bluegill sample is available from the 3 year time period since the ponds were reopened. Overall, more samples are needed to better evaluate the public health impacts of consuming fish from WSP.

- The reporting limit for the major site related compound (PCE) in fish tissue samples of 5 parts per billion is very close to the CDPHE Action Level of 5.7 ppb.

- There were a number of errors during the analysis of VOCs in fish tissue. This reduces the confidence in the actual contaminant levels present in fish tissue collected from WSP. In addition, there is some uncertainty associated with analysis of vinyl chloride and 1,2-DCE in wiper, which could be addressed by analyzing more wiper samples. The analytical errors noted in the laboratory reports are summarized in Appendix C.

- Whole fish tissue samples have not been collected since the ponds reopened, which could result in an underestimation of risk if people are consuming the fatty portions of fish from WSP.

- This evaluation did not take into account any loss or transfer of site-related VOCs during the cooking process because no cooked fish data are available. This could result in an over- estimation of risk. However, there could be underestimation of risk due to possible inhalation of PCE lost during cooking.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical and behavioral 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.

Child exposure estimates for swimming and wading were calculated in this assessment and the results indicate a very low increased risk of developing non-cancer or cancer adverse health effects. Specifically, the cumulative cancer risks for children is less than the CDPHE target cancer risk level of $1 * 10^{-6}$, or 1 excess cancer case per million exposed individuals. In addition, the estimated exposure doses for children are well below the non-cancer health-based guidelines, which indicate a very low increased risk of non-carcinogenic adverse health effects through dermal and incidental ingestion pathways. It cannot currently be determined if consuming fish caught from Willow Springs Ponds could harm children's health. However, the limited available data indicates that children's consumption of fish tissue from Willow Springs Ponds is associated with a low risk of developing cancer. In addition, the CDPHE risk management action level of 5.7 ppb at the cancer risk level of $1 * 10^{-5}$ is protective of children and adults. In general, it is important to adjust meal size for children (i.e.,

smaller meal size than adults). No other special public health considerations are indicated for children in this consultation.

Conclusions

CCPEHA has reached the following two conclusions based on the evaluation of available fish and surface water data:

It cannot currently be determined if consuming fish caught from Willow Springs Ponds could harm people's health. This conclusion was reached because the recent fish tissue data collected from Willow Springs Ponds is inadequate to evaluate the public health implications of fish consumption. In particular, there were a number of errors in the analytical results as shown in Appendix C. The major errors in the analysis were poor reproducibility, sampling results outside the calibration range, and measurements outside of quality control/quality assurance limits. In addition, there is limited amount of fish tissue data available particularly for bluegill (1 sample), largemouth bass (3 samples), and wiper (5 samples).

Although we cannot make definitive conclusions regarding the public health implications of consuming the fish from the pond, the PCE levels found in these fish (if present at all) were at or below the reporting limit of 5 ppb which is below the CDPHE action level of 5.7ppb (at $1 * 10^{-5}$ cancer risk level). Under these assumptions, consumption of PCE in fish at the reporting limit would result in a theoretical lifetime excess cancer risk of $8.77 * 10^{-6}$ (or 9 excess cancer cases in a million people). These risks would result in a low or very low increased risk of developing cancer. However, it should be noted that these risks are highly uncertain because of the inadequate data (e.g., poor analytical quality) and may not be representative of the actual risk (i.e., over- or underestimate risk).

Swimming and/or wading in Willow Springs Ponds is not likely to harm people's health. This conclusion was reached because the estimated non-cancer exposure doses are well below health based guidelines, which indicates a very low risk of developing non-cancer adverse health effects associated with PCE exposure. In addition, the estimated theoretical lifetime excess cancer risks are significantly below the CDPHE target cancer risk level of $1 * 10^{-6}$ as well as the low end of EPA's acceptable cancer risk range of $1 * 10^{-6}$ to $1* 10^{-4}$, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals. This indicates a very low increased of developing cancer.

Recommendations

The following recommendations have been made by CCPEHA as a result of this evaluation to protect public health at WSP.

- Since PCE is still present in the Widefield Aquifer, which is the water source for Willow Springs Ponds, continued groundwater and surface water monitoring and operation of the aerators and upgradient sparge treatment unit is recommended to ensure that site related contamination remains below levels of health concern.

- Continue to sample fish tissues annually with a detection limit lower than 5 ppb for PCE, if possible. In particular, it is important to collect a sufficient number of three fish species (wiper, bluegill, and largemouth bass) and analyze for PCE, trichloroethene, vinyl chloride, and dichloroethene. In addition, some whole fish tissue data should be collected to ensure that levels of PCE in whole fish are protective of ethnic subpopulations who consume whole fish.

- Ensure that the samples collected since the ponds reopened are completely representative of the types of fish in WSP. For example, sunfish, crappie, and European rudd have not been sampled at all since the stocking program was reinstated. In addition, there are a limited number of samples for bluegill, largemouth bass, and wiper currently available. Alternatively, it could be demonstrated that these fish species are no longer present in the ponds.

- Ensure that levels of site related contaminants continue to be below state standards in surface water and sediment.

Public Health Action Plan

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

Completed Activities

- The CCPEHA at CDPHE conducted an evaluation of fish consumption and dermal contact with PCE in WSP in a health consultation published in 2006. The health consultation examined the potential public health effects, identified data gaps, and recommended additional data collection (ATSDR 2006).

- The responsible parties collected additional data to determine the current levels of PCE in fish tissue, surface water, and sediment. This data was evaluated by the CCPEHA to determine if it is “safe” to reopen WSP to public fishing and other recreational activities (ATSDR 2007).

- CCPEHA conducted a variety of public outreach and health education activities by attending public meetings, sending surveys and health education materials, and posting all of the health consultations on the CCPEHA web site and providing copies in the local library.

- CCPEHA completed an evaluation of other exposure pathways through the various PCE contaminated media (e.g., indoor air, residential well drinking water,

and municipal water supply) related to the Schlage Lock PCE plume. These health consultations are available at:
http://www.cdphe.state.co.us/dc/envtox/ccpehasites.html

Future Activities:

Public health actions that will be implemented include:

- CCPEHA will make the findings of this document available to the public and other stakeholders.

- If questions arise regarding the health consultation, CCPEHA will conduct the appropriate level of health education to address the concerns.

- Upon request, CCPEHA will review any additional fish tissue and/or water data that is collected from Willow Springs Ponds and update the health consultation accordingly.

Report Preparation

This Health Consultation on the recreational use of Willow Springs Ponds in Fountain, Colorado was prepared by the Colorado Department of Public Health and Environment (CDPHE) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this health consultation and concurs with its findings based on the information presented in this report. ATSDR's approval of this document has been captured in an electronic database.

Author:
Thomas Simmons
Health Assessor
Environmental Epidemiology Section
Colorado Dept. of Public Health and Environment
Phone: 303-692-2961
Fax: 303-782-0904
E-mail: tom.simmons@state.co.us

State Reviewer:
Raj Goyal Ph.D
Principal Investigator
Environmental Epidemiology Section
Colorado Dept. of Public Health and Environment
Phone: 303-692-2634
Fax: 303-782-0904
E-mail: raj.goyal@state.co.us

ATSDR Reviewer:

Gregory Ulirsch, ATSDR/DHAC
Technical Project Officer

References

Agency for Toxic Substances and Disease Registry (ATSDR 1997). *Toxicological Profile for Tetrachloroethene*, Revised September 1997. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=265&tid=48, accessed December 2011.

Agency for Toxic Substances and Disease Registry (ATSDR 2005). *Public Health Assessment Guidance Manual*, Revised January 2005. Available on the Internet at: http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html, accessed December 2011.

Agency for Toxic Substances and Disease Registry, Colorado Cooperative Program for Environmental Health Assessments (ATSDR 2006). *Exposure and health Effects Evaluation of PCE Contamination in Willow Springs Ponds*, August 30, 2006. Available on the Internet at: http://www.cdphe.state.co.us/dc/ehs/SchlageLockCo-WillowSpringsPondHC083006.pdf.

Agency for Toxic Substances and Disease Registry, Colorado Cooperative Program for Environmental Health Assessments (ATSDR 2007).*Evaluation of Current and Future Fish Consumption from Willow Springs Ponds*, May 1, 2007. Available on the Internet at: http://www.cdphe.state.co.us/dc/ehs/SchlageLockCompanyHC050107.pdf.

El Paso County, Board of Commissioners (El Paso County 2007). *Settlement Agreement, Indemnity, and Release between El Paso County and Schlage Lock Company for the purposes of settling issues related to the Willow Springs Pond Nos. 1 and 2*, January 10, 2007.

U.S. Environmental Protection Agency, Region 8 Superfund Technical Guidance, (EPA 1994). *Evaluating and Identifying Contaminants of Concern for Human Health*, September 1994.

U.S. Environmental Protection Agency, Region 3 Risk Assessment, (EPA 2011a). *Region 3 Fish Tissue Screening Levels*, Last update June 2011. Available on the Internet at: http://www.epa.gov/reg3hwmd/risk/human/pdf/JUNE_2011_FISH.pdf.

U.S. Environmental Protection Agency, Technical Support Center for Monitoring and Site Characterization, (EPA 2011b). *Statistical Software ProUCL 4.0 for Environmental Applications For Data Sets with and without Nondetect Observations, Version 4.00.05*. Last update February 2011. Available on the Internet at: http://www.epa.gov/esd/tsc/software.htm#ProUCL.

Appendices

Appendix A. Additional Tables and Figures

Table A1. Non-cancer Hazard Quotients for Recreational Surface Water Exposures

Water Data	Receptor	Water Ingestion Non-cancer Hazard Quotient	Dermal Exposure to Water Non-cancer Hazard Quotient	Cumulative Non-cancer Hazard Quotient
Surface	Child	2.60E-05	1.73E-04	1.99E-04
Influent	Child	6.03E-05	4.02E-04	4.62E-04
Surface	Adult	3.94E-06	1.01E-04	1.05E-04
Influent	Adult	9.13E-06	2.34E-04	2.43E-04

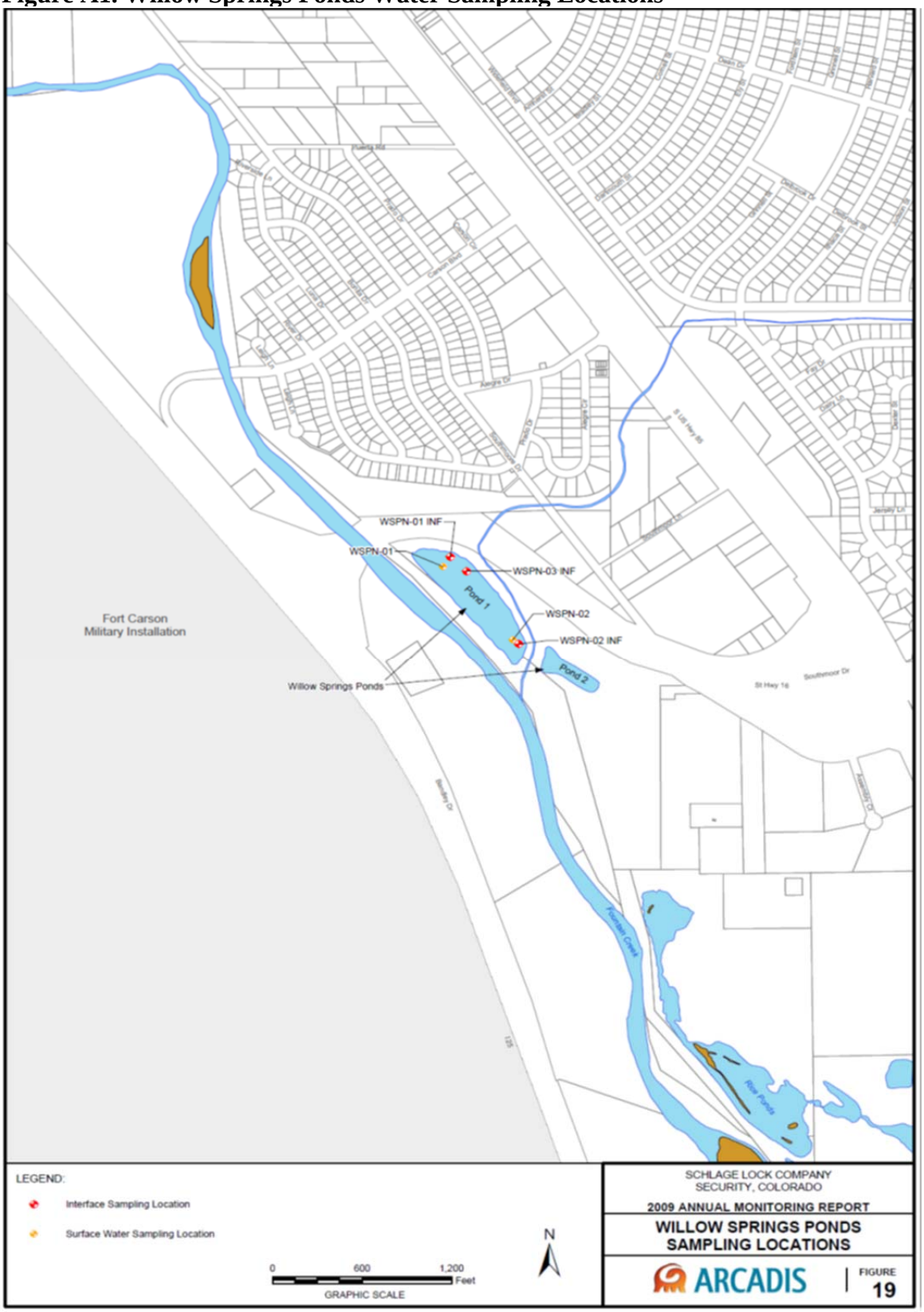
NOTE: HQ = Hazard Quotient. The hazard quotient is equal to the estimated exposure dose divided by the non-cancer health-based guideline. Values greater than 1 indicate the estimated non-cancer dose is greater than the health-based guideline.

Table A2. Theoretical Cancer Risks for Recreational Surface Water Exposures

Water Data	Receptor	Water Ingestion Cancer Risks	Dermal Exposure to Water Cancer Risks	Cumulative Cancer Risks
Surface	Child	1.20E-08	7.99E-08	9.19E-08
Influent	Child	2.79E-08	1.85E-07	2.13E-07
Surface	Adult	9.12E-09	2.33E-07	2.42E-07
Influent	Adult	2.11E-08	5.41E-07	5.62E-07

NOTE: Theoretical cancer risks are lifetime excess risks of developing cancer that are expressed in excess cancer cases per number of people exposed. For instance, 1.20E-08 represents 1.20 excess cancer cases per 100,000,000 exposed individuals and 5.62E-07 represents 5.62 excess cancer cases per 10,000,000 exposed individuals. Theoretical cancer risks are often rounded to the nearest whole number.

Figure A1. Willow Springs Ponds Water Sampling Locations



SOURCE: ARCADIS 2009

Appendix B. Exposure Dose Calculations

The first step to determine if adverse health effects are likely to occur from exposure to contamination found in Willow Springs Ponds water is to estimate exposure doses for the people that are likely to come into contact with site-related contamination. The estimated exposure doses are designed to be conservative estimations of actual contaminant intake, accounting for the majority of potential exposures at the site. As mentioned previously in the document, exposure doses are only estimated for Contaminants of Potential Concern (COPC), which have exceeded the comparison values (CVs). Estimating the exposure dose requires assumptions to be made regarding various exposure parameters such as the frequency of a particular activity, duration of exposure to site-related contamination, and the amount of a particular substance that is taken in by an individual during a given activity. Site-specific exposure information is always preferable when estimating exposure doses. However, site-specific information is rarely available due to time and financial constraints. In lieu of site-specific information, default exposure parameters that are established by the U.S. Environmental Protection Agency (EPA) and Agency for Toxic Substances and Disease (ATSDR) are used in the exposure dose estimation. At times, professional judgment is used when default values are not available or seem unreasonable for the site exposures.

Two primary receptors were identified in this evaluation that are likely to come into contact with site-related contamination now or in the future, child and adult recreational users. The major exposure factors used are listed below in Table A1. The primary exposure pathway evaluated in this health consultation is swimming and wading exposures. Overall, the main dose estimations calculated in this evaluation assume individuals will swim/wade for 100 days per year over a period of 6 yrs. (children) or 30 yrs. (adults). Two routes of exposure exist in this exposure pathway scenario: 1) dermal exposure to water containing VOCs and 2) incidental ingestion of water containing VOCs. Since both routes of exposure occur at the same time, the estimated doses for each exposure route are combined to form a total dose for each contaminant. Non-cancer and cancer exposure doses are estimated for both pathways. The major difference between estimating non-cancer and cancer doses are that non-cancer doses are averaged over the exposure duration and cancer doses are averaged over a lifetime.

Table B1. Exposure Parameters

Exposure Pathway	Exposure Parameter	Units	Child	Adult
General	Body Weight (BW)	kg	15[a]	70[b]
	Exposure Frequency (EF)	days/yr	100[d]	100[d]
	Exposure Duration (ED_{NC})	years	6[e]	30[e]
	Exposure Duration$_C$ (ED_C)	years	6	24
	Averaging Time$_{N\,C}$ (AT_{NC})	days	2190[f]	10950[f]
	Averaging Time$_C$ (AT_C)	days	25550[f]	25550[f]
Incidental Water Ingestion	Conversion Factor (CF)	mg/ml	1.0E-06	1.0E-06
	Ingestion Rate$_{NC}$ (IRW_{NC})	ml/hour	100[a]	71[g]
	Ingestion Rate$_{ADJ}$ (IRW_{ADJ})	(ml-yr)/ (kg-day)	N/a	
	Swim Time (ET)	hour	0.75[g]	0.75[g]
Dermal Exposure	Skin Surface Area (SA)	cm^2	6600[h]	18000[h]
	Age-Adjusted Skin Surface Area (SA_{adj})	cm2-yr/kg-event	8811*	8811*
	Conversion Factor (CF)	mg/μg	1.0E-03	1.0E-03

NOTE: CTE = Central Tendency Exposure, RME = Reasonable Maximum Exposure, N/a = Not applicable (age-adjusted equation was used), $_{NC}$ = Non-cancer, $_C$ = Cancer, $_{ADJ}$ =Age-adjusted

[a] EPA, Child-specific Exposure Factors Handbook (2008)

[b] ATSDR, Public Health Assessment Guidance Manual (2005)

[c] CDPHE, standard default exposure frequency for recreational users EPA, Exposure Factors Handbook (1997)

[d] Professional judgment based on site-specific information from the community survey (Appendix E)

[e] EPA, Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (1993)

[f] EPA, Risk Assessment Guidance for Superfund (1989)

[g] EPA, Exposure Factors Handbook 2009 Update, External Review Draft (2009)

[h] EPA, Risk Assessment Guidance for Superfund, Part E (2004)

* Age-adjusted equation was used to calculate theoretical cancer doses. The age-adjusted calculation accounts for exposure over two years of ages 0-6 years and 7 years as an adult for the CTE wader/swimmer and 6 years of ages 0-6 years and 24 years as adult for the RME wader/swimmer.

Table B2. Chemical-Specific Dermal Exposure Factors (EPA RAGS, Part E 2004)

COPC	Fraction Absorbed FA (dimensionless)	Dermal Permeability Coefficient of Compound in Water K_p (cm./hr.)	Lag Time per event τ_{event} (hour/event)	Time to reach steady-state t^* (in hours)
Tetrachloroethene	1.0	3.3E-02	0.91	2.18

NOTE: cm./hr. = centimeters per hour

Another critical component of the exposure dose estimation is the concentration of chemicals of potential concern that individuals are likely to be exposed to in a particular medium, which is referred to as the Exposure Point Concentration (EPC). EPCs were estimated using EPA's ProUCL Version 4.00.05. The EPCs used in this evaluation are presented in Table B3.

Table B3. Willow Springs Ponds Water Exposure Point Concentrations

Data Source	PCE Exposure Point Concentration (in μg/L)	EPC Estimation Method
Surface Water	0.19	95% KM (Percentile Bootstrap) UCL
Influent	0.44	95% KM (BCA) UCL

Non-Cancer Surface Water Ingestion Dose

Non-Cancer Dose = $(C_w * IRW * CF * EF * ED) / (BW * AT_{NC})$

Where:
C_w = Chemical Concentration in Water (in ug/L or micrograms contaminant per liter of water)
IRW = Ingestion Rate of Water (in liters of water per event)
CF = Conversion Factor (in milligrams per microgram)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
BW = Body Weight (in kilograms)
AT_{NC} = Non-Cancer Averaging Time (in days)

*Example: Non-cancer child incidental ingestion dose of PCE while swimming/wading (Table B5, Surface Data) => (0.19 ug/L * 0.075L * 10^{-3} mg/ug * 100 days * 6 years)/(15kg * 2190 days)= 2.60* 10^{7} mg/kg-day*

Surface Water Ingestion Cancer Dose

Cancer Dose = $(C_w * CF * IRW * EF * ED) / (AT_C * BW)$

Where:
C_w = Chemical Concentration in Water (in μg/L or micrograms contaminant per liter of water)
IRW = Ingestion Rate of Water (in Liters per event)
CF = Conversion Factor (in milligrams per microgram)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
AT_C = Cancer Averaging Time (in days)
BW = Body Weight (in kilograms)

*Example: Cancer adult incidental ingestion dose of PCE while swimming/wading (Table B6, Influent Data) => (0.44 ug/L * 10^{-3} mg/ug * 0.053L * 100 days * 30 years)/(25550 days * 70 kg)= 3.91 * 10^{-8}mg/kg-day*

Non-Cancer Dermal Absorbed Dose

DA event (mg/cm^2-event) = 2 FA * K_p * C_w * CF $\sqrt{(\ 6\tau ev * tev \div \pi\ )}$ (EPA 2004, Equation 3-2)

DAD (mg/kg-day) = $\frac{\textbf{DAev * EF * ED *SA}}{\textbf{BW * AT}_{\textbf{NC}}}$ (EPA 2004, Equation 3-1)

Where:
DAev = Absorbed dose per event (in milligrams per square centimeter event)
FA = Fraction Absorbed Water (dimensionless)
K_p = Dermal permeability coefficient of compound in water (in centimeters per hour)
C_w = Chemical concentration in water (in micrograms per liter)
CF = Conversion factor (in milligrams per microgram or milliliters per liter)
τev = Lag time per event (in hours)
tev = Event Duration (in hours)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
SA = Skin Surface Area (in square centimeters)
BW = Body Weight (in kilograms)
AT_{NC} = Non-Cancer Averaging Time (in days)

Example: Non-cancer child dermal absorbed dose while swimming/wading (Tables B4 & B5, Surface Water Data) =

$DA_{ev} = 2 * 1 * 3.3 * 10^{-2} cm/hr * 0.19 \mu g/L * 10^{-3} mg/ug * 10^{-3} mL/L \sqrt{(\ 6 * 0.91 * 0.75 \div \pi\ )} = 1.43 * 10^{-8}\ mg/cm^2\text{-}event$

$DAD = (1.43 * 10^{-8} mg/cm^2\text{-}event * 100\ days * 6\ years * 6600 cm^2) / (15 kg * 2190\ days) = 1.72 * 10^{-6} mg/kg\text{-}day$

Theoretical Cancer Dermal Absorbed Dose

DA event (mg/cm^2-event) = 2 FA * K_p * C_w * CF $\sqrt{(6\tau ev * tev \div \pi)}$ (EPA 2004, Equation 3-2)

DAD (mg/kg-day) = $\frac{\textbf{DAev * EF * ED *SA}}{\textbf{NC}}$ (EPA 2004, Equation 3-1)

Where:
DAev = Absorbed dose per event (in milligrams per square centimeter event)
FA = Fraction Absorbed Water (dimensionless)
K_p = Dermal permeability coefficient of compound in water (in centimeters per hour)
C_w = Chemical concentration in water (in micrograms per liter)
CF = Conversion factor (in milligrams per microgram or milliliters per liter)
τev = Lag time per event (in hours)
tev = Event Duration (in hours)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
SA = Skin Surface Area (in square centimeters)
BW = Body Weight (in kilograms)
AT_C = Non-Cancer Averaging Time (in days)

BW * AT

Example: Non-cancer child dermal absorbed dose while swimming/wading (Tables B4 & B5, Surface Water Data) =

$DA_{ev} = 2 * 1 * 3.3 * 10^{-2} cm/hr * 0.44 \mu g/L * 10^{-3} mg/ug * 10^{-3} mL/L \sqrt{(6 * 0.91 * 0.75 \div \pi)} = 3.31 * 10^{-8}$ *mg/cm^2-event*

*DAD = (3.31 * 10^{-8}mg/cm^2-event * 100 days * 30 years * 18000cm^2)/ (70kg * 25550 days)= 1.00 * 10^{-6}mg/kg-day*

Table B4. Dermal Absorbed Dose Per Event (DA_{ev})

Dermal Absorbed Per Event	Child and Adult Swimmer/Wader
5ft. Samples	1.43E-08
Influent Samples	3.32E-08

NOTE : DA_{ev} is the same for both cancer and non-cancer dose equations

Table B5. Non-cancer Doses for Recreational Surface Water Exposures

Type of Water Data	Receptor	Water Ingestion Non-cancer Exposure Dose (in mg/kg-day)	Dermal Exposure to Water Non-cancer Exposure Dose (in mg/kg-day)	Cumulative Non-cancer Exposure Dose (in mg/kg-day)
Surface	Child	2.60E-07	1.73E-06	1.99E-06
Influent	Child	6.03E-07	4.02E-06	4.62E-06
Surface	Adult	3.94E-08	1.01E-06	1.05E-06
Influent	Adult	9.13E-08	2.34E-06	2.43E-06

Table B6. Theoretical Cancer Doses for Recreational Surface Water Exposures

Type of Water Data	Receptor	Water Ingestion Cancer Exposure Dose (in mg/kg-day)	Dermal Exposure to Water Cancer Exposure Dose (in mg/kg-day)	Cumulative Cancer Exposure Dose (in mg/kg-day)
Surface	Child	2.23E-08	1.48E-07	1.70E-07
Influent	Child	5.17E-08	3.43E-07	3.94E-07
Surface	Adult	1.69E-08	4.32E-07	4.49E-07
Influent	Adult	3.91E-08	1.00E-06	1.04E-06

Appendix C. Willow Springs Ponds Analytical Errors of Fish Tissue Analyses (2008-2010)

Sampling Date: 8/6/2008

Remarks: No laboratory notes are available for this data set. It appears that Trout #1 was diluted and reanalyzed for some reason. However, there were no detections in the first run. Quality Assurance and Quality Control (QA/QC) information is absent for this data set.

The following errors were reported in lab reports:

Sampling Date: 12/13/2008

Remarks: Twelve samples were submitted to laboratory from this sampling event. The twelve samples were also prepped, but results were only reported for 5 samples. No notes were made regarding the other 7 fish tissue samples.

- Sucker #2 had analyte recovery slight above the instrument calibration limit. The sample was diluted, reanalyzed, and the analyte recovery was within instrument calibration. Sucker #2 also had surrogate recoveries and internal standards outside of QC limits due to "matrix interference". The diluted (Sucker #2DL) sample had internal standards within the QC limits.

- Sucker #3 and Sucker #4 had surrogate recoveries outside the QC limits due to "matrix interference". The samples were reanalyzed (undiluted) and the results were similar to the first run. All of the forms were included in the laboratory report; however, the results remain outside QA/QC limits.

- Rainbow Trout #2 showed internal standard responses and surrogate recoveries well outside of the QC limits due to "heavy matrix interference". The sample was reanalyzed and the recoveries were much closer to the QC limits, although the recoveries were still outside of QC limits.

- The matrix spike and matrix spike duplicate were analyzed on Sucker #2DL. Seven out of seventy Relative Percent Differences (RPD) were outside QC limits and 47/140 spike recoveries were outside QC limits.

- Laboratory controls were ran with each sample batch. 1st batch: 4/70 outside QC limits, 2nd batch: 6/70 outside QC limits.

Sampling Date: 4/16/2009

Remarks:

- Sucker #1 had an analyte recovery slightly above the instrument calibration limit. The sample was diluted, reanalyzed, and the analyte recovery was within instrument calibration limit.

- Sucker #2, Sucker #3, and Sucker #4 were analyzed and exhibited surrogate recoveries outside of QC limits. The samples were diluted (x5), reanalyzed, and the surrogate recoveries were within QC limits. However, it was noted that the initial analysis of these samples should be reported and the reanalyses were included for QA/QC purposes.

- Wiper #1 had an analyte responses (toluene, vinyl chloride, cis-1,2-Dichloroethene) well above the instrument calibration. The sample was diluted, reanalyzed, and the target analytes were within the instrument calibration; however, the responses were much lower than expected based on the responses from the initial analysis. It was stated that "This incongruity is most likely the result of the inhomogeneous nature of fish tissue". Data from the initial analysis should be reported. The results of the reanalysis were not found in the laboratory package.

- Bluegill #1 and Catfish #2 had surrogate recoveries outside of QC limits. The samples were reanalyzed (undiluted) and the results were similar.

- Several samples had internal standard responses above the QC limits. The samples were reanalyzed and the internal standards were within QC limits.

- The matrix spike and matrix spike duplicate analyses were performed on Sucker #1. Forty-four RPDs out of seventy were outside RPD QC limits. Eighty-four spike recoveries out of one hundred forty were outside the QC limits.

- Laboratory controls were run with each sample batch. Batch 1: 11/70 outside QC limits, Batch 2: 2/70 were outside QC limits.

- Manual integration was performed on some of the compounds that were improperly integrated by the software.

Sampling Date: 8/6/2009

Remarks:

- Trout #1 did not have surrogate recoveries and internal standard recoveries due to "matrix interference".

- All other samples, aside from Catfish #3, had surrogate recoveries and internal standard responses outside of the QC limits. The samples were reanalyzed (undiluted) and the results were similar.

- Wiper #1 had an analyte recovery (acetone) outside of instrument calibration. The sample was diluted and the analyte response was within instrument calibration.

Sampling Date: 10/19/2010

Remarks:

- The samples had internal standard responses and surrogate recoveries outside of QC limits due to "matrix interference". The samples were reanalyzed and the results were similar.

- Recovery of 1 surrogate was above the advisory limits for the matrix spike. The responses for two internal standards were below the advisory limits for the matrix spike and matrix spike duplicate.

- The analyte response for 2-butanone was outside the instrument calibration in LBass-1-101910 and RTrout-3-10-19-10. The samples were diluted, reanalyzed, and the recovery of 2-butanone was still outside of instrument calibration range.

- The matrix spike and matrix spike duplicate analyses were performed on LBass-2-101910. Twenty-four and twenty-eight analytes were outside QC limits. The percent RPD for one compound was outside QC limits for the pair.

- Laboratory controls were run with each sample batch. Batch 1: 1 compound outside QC limits. The percent RPD for one compound was outside QC limits for the pair. Batch 2: the RPD for 2-butanone was above the QC limit for the pair.

Appendix D. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxic effects of a chemical also depend on the route of exposure (oral, inhalation, dermal), the duration of exposure (acute, subchronic, chronic or lifetime), the health condition of the person, the nutritional status of the person, and the life style and family traits of the person. In general, acute and chronic neurological changes, and liver and kidney toxicity, have been observed in humans and animals exposed to PCE (See http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=265&tid=48 for PCE health effect fact sheet). It is important to note that estimates of human health risks may be based on evidence of health effects in humans and/or animals depending upon the availability of data. In this evaluation, chronic oral and dermal exposures were evaluated.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the cancer effects of the chemical, while the second addresses the non-cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the risk assessment methods used to assess cancer and non-cancer effects. For example, cancer risks are expressed as a probability of suffering an adverse effect (cancer) during a lifetime and noncancer hazards are expressed, semi-quantitatively, in terms of the hazard quotient (HQ), defined as the ratio between an individual's estimated exposure and the health guideline (MRL or RfD). HQs are not an estimate of the likelihood that an effect will occur, but rather an indication of whether there is potential cause for concern for adverse health effects.

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence that the chemical does or does not cause cancer in humans. Typically, this evaluation is performed by the EPA, using the system summarized in the table below:

Category	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans.
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans.
B2	Probable human carcinogen	Sufficient evidence of cancer in animals, but lack of data or insufficient data from humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low dose (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose. Conversely, the inhalation unit risk (IUR) is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 ug/m 3 in air.

Estimating the cancer SF and/or IUR is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95% probability that the true cancer potency is lower than the value chosen for the Slope Factor. This approach ensures that there is a margin of safety in cancer risk estimates.

At the current time, the International Agency for Cancer Research (IARC) has classified PCE as a Group 2a carcinogen (IARC 1995). The USEPA has not established in the EPA Integrated Risk Information System (IRIS) an inhalation reference concentration as well as a carcinogenicity assessment for lifetime exposures to PCE. However, in the absence of relevant values in the EPA IRIS, the EPA Office of Solid Waste and Emergency Response (OSWER) recommends using the California EPA oral cancer slope factor of 0.54 per mg/kg-day^{-1} and inhalation cancer slope factor of 0.021 per mg/kg-day^{-1} for PCE (EPA, 2003, OSWER Directive No. 9285.7-75). The Cal EPA classifies PCE to be an animal carcinogen and a possible human carcinogen. This classification is based on the observed increased incidence of hepatocellular carcinoma in male and female mice exposed orally to PCE. In addition, human epidemiological studies suggest that PCE is possibly carcinogenic in humans.

The most consistent tumor sites in humans are the esophagus and lymphatic system, but the available information is insufficient to quantify cancer risks. Therefore, quantitative estimates of the potential of PCE to induce human cancer are inferred from animal data.

The U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease (ATSDR) have established oral reference doses (RfD) and minimal risk levels (MRL) for non-cancer effects. An RfD is the daily dose in humans (with uncertainty spanning perhaps an order of magnitude), including sensitive subpopulations, that is likely to be without an appreciable risk of non-cancer adverse health effects during a lifetime of exposure to a particular contaminated substance. An MRL is the dose of a compound that is an estimate of daily human exposure that is likely to be without an appreciable risk of adverse non-cancer effects of a specified duration of exposure. The

acute, intermediate, and chronic MRLs address exposures of 14 days or less, 14 days to 365 days, and 1-year to lifetime, respectively. The health-based guidelines for the contaminants of potential concern for this evaluation are listed below.

Table B1. Oral Health-based Guidelines for the contaminants of potential concern

Contaminant Of Potential Concern	Oral Health-based Guideline (mg/kg-day)	Source of Oral Health-based Guideline	Oral Slope Factor ($mg/kg-day^{-1}$)	Source of Oral Slope Factor
Tetrachloroethene	1.00E-02	EPA IRIS	5.40E-01	California EPA

Note: The same values were used for the dermal exposure pathway without adjustment for gastrointestinal absorption in accordance with EPA RAGs Part E.
mg/kg-day = milligrams of contaminant per kilogram day
IRIS = Integrated Risk Information System