Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Lower Leon Creek

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INTRODUCTION

Kelly Air Force Base (Kelly AFB; Kelly; KAFB), decommissioned in 2001 under the 1995 Base Closure and Realignment Commission, was once the largest military installation in Texas. Renamed "KellyUSA," and scheduled for civilian development, the base – located on 4,000 acres in southwest San Antonio, Texas – was for half a century a major United States Air Force (USAF) aircraft maintenance station. Industrial wastes from activities conducted at KAFB are alleged to have contaminated shallow groundwater and soil in and around KAFB with organic solvents and other toxic compounds.[1] Trichloroethene (trichloroethylene; TCE) and tetrachloroethene (perchloroethylene; PCE) are among several contaminants discovered in the groundwater under the base.[2] In the early 1980's, the federal government began to examine the extent of contamination and to clean up hazardous waste generated by base activities. The USAF continues, under various federal initiatives, site monitoring and remediation efforts. In 1999, in response to petitions from area citizens concerned about possible adverse health effects from exposure to environmental contaminants attributed to base activities, the Agency for Toxic Substances and Disease Registry (ATSDR) completed a public health assessment of Kelly AFB.[3] That assessment included an examination of fish from Lower Leon Creek, a small stream that meanders southeasterly through Kelly AFB in both suburban and metropolitan areas of San Antonio – the third largest metropolitan statistical area (MSA) in Texas[4] – to the Medina River. With its shallow banks, Lower Leon Creek is easily accessible through public parks and bridge crossings, increasing the possibility that people will consume fish taken from its waters. On the other hand, this creek courses through heavily urban areas, a characteristic that may decrease the probability that people will fish there. Using techniques and assumptions that may differ from those used by the Texas Department of Health (TDH)[a] to assess exposure and characterize risk, the ATSDR concluded that exposure to toxicants in air, soil, water, and fish from around Kelly AFB should not adversely affect human health.[3]

As part of its routine monitoring of environmental conditions at KAFB, the USAF collected and analyzed samples of whole fish from Lower Leon Creek at a site near the Kelly AFB golf course in July 2000. That assessment confirmed that whole fish samples from Lower Leon Creek contained polychlorinated biphenyls (PCBs) and organochlorine pesticides.[2] Although whole-fish samples are useful for identifying contaminants in fish and shellfish, such analyses may not accurately reflect toxicant distribution in edible tissues and may over- or underestimate exposure to environmental contaminants because people often remove the skin from fish and are more liable to consume fillets than whole fish.[5] Therefore, the USAF collaborated with TDH to assess contamination in edible portions of fish from Lower Leon Creek and to characterize possible risks to human health from consuming fish from Lower Leon Creek. To this end, the TDH Seafood Safety Division (SSD)[b] collected fish from three sites along Lower Leon Creek in August 2002. The TDH laboratory analyzed skin-off fillets of these samples for contaminants that could potentially result in adverse effects on the health of people who eat fish from Lower Leon Creek.

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[a] Now the Department of State Health Services (DSHS)

[b] Now the Seafood and Aquatic Life Group (SALG)

On August 27, 2003, based on data from that survey, the TDH issued Advisory 26 (ADV-26).[6] ADV-26 recommended that no one consume fish taken from Leon Creek from State Highway (SH) 90 downstream to Military Drive. PCB concentrations in the fish samples collected for the 2002 survey exceeded health department guidelines for protecting human health. Subsequently, the Texas Commission on Environmental Quality (TCEQ) listed Leon Creek on the 2004 Texas 303(d) list.[7] The TCEQ requested the survey discussed in the present risk characterization as a part of its TMDL 5-year follow-up program for previously adopted TMDLs.[8]

Description of Leon Creek

Leon Creek originates as a spring-fed stream in the Edwards Plateau Region of south central Texas.[9] The creek is a 57-mile stream in the San Antonio River Basin that extends from its confluence with the Medina River to its headwaters in northern Bexar County, Texas. The Leon Creek watershed includes the municipalities of Cross Mountain, Helotes, Leon Valley, and San Antonio and is classified into two stream segments: Upper Leon Creek and Lower Leon Creek. Major land use in the Leon Creek watershed ranges from evergreen forests in Upper Leon Creek–a 25-mile segment–to the highly urbanized 32-mile segment of Lower Leon Creek.[10]

Demographics of Bexar County Surrounding the Area of Lower Leon Creek

Lower Leon Creek flows through a predominantly urban landscape adjacent to the San Antonio metropolitan statistical area (MSA), the third largest MSA in Texas.[4] In 2008, the census bureau reported the estimated population of Bexar County to be 1,622,899 people.[11] San Antonio, the county seat of Bexar County, Texas, is the county's largest city, with an estimated population in 2008 of 1,328,984 people.[12]

Subsistence Fishing in Leon Creek

The United States Environmental Protection Agency (USEPA or EPA) suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to any determination of the rate of subsistence fishing in an area.[13] The USEPA and the Texas Department of State Health Services (DSHS) find, in concert with the USEPA, it is important to consider subsistence fishing to occur at any water body because subsistence fishers (as well as recreational anglers and certain tribal and ethnic groups) usually consume more locally caught fish than the general population. These groups sometimes harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. Should local water bodies contain chemically contaminated fish or shellfish, people who routinely eat fish from the water body or those who eat large quantities of fish from the same waters, could increase their risk of adverse health effects. The USEPA suggests that states assume that at least 10% of licensed fishers in any area are subsistence fishers. Subsistence fishing, while not explicitly documented by the DSHS, likely occurs. The DSHS assumes the rate of subsistence fishing to be similar to that estimated by the USEPA.[13]

The TMDL Program at the TCEQ and the Relationship between DSHS Consumption Advisories or Possession Bans

The TCEQ enforces federal and state laws that promote judicious use of water bodies under state jurisdiction and protects state-controlled water bodies from pollution. Pursuant to the federal Clean Water Act, Section 303(d),[14] all states must establish a "total maximum daily load" (TMDL) for each pollutant contributing to the impairment of a water body for one or more designated uses. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. TMDLs incorporate margins of safety to ensure the usability of the water body for all designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support) along with the scientific criteria designated to support each specified use.[7]

Fish consumption is a recognized use for many waters. A water body is impaired if fish from that water body contain contaminants that make those fish unfit for human consumption or if consumption of those contaminants potentially could harm human health. Although a water body and its aquatic life may clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those devised by the TCEQ. Thus, whenever the DSHS issues a fish consumption advisory or prohibits possession of environmentally contaminated fish, the TCEQ automatically places the water body on its current draft 303(d) List.[7] The TCEQ is responsible for confirming the impairment and , if necessary, the TMDL program, then prepares a TMDL for each contaminant present at concentrations that, if consumed, would be capable of negatively affecting human health. After approval of the TMDL, the stakeholders in the watershed prepare an Implementation Plan for each contaminant. These plans are designed to facilitate the rehabilitation of the water body over time. Successful remediation should result in return of the water body to conditions compatible with all stated uses, including consumption of fish from the water body. When the DSHS lifts a consumption advisory or possession ban, people may once again keep and consume fish from the water body. If fish in a water body are contaminated, one of the several items on an Implementation Plan for a water body on a state's 303(d) list consists of the periodic reassessment of contaminant levels in resident fish.

METHODS

Fish Sampling, Preparation, and Analysis

The DSHS Seafood and Aquatic Life Group (SALG) collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures from the DSHS *Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual.*[15] The SALG bases its sampling and analysis protocols, in part, on procedures recommended by the USEPA in that agency's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1.*[16] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee (TSCC) Fish Sampling Advisory Subcommittee (FSAS).*[17] Samples usually represent species, trophic levels, and legal-sized specimens available for consumption from a water body.

When practical, the DSHS collects samples from two or more sites within a water body to better characterize geographical distributions of contaminants.

Fish Sampling Methods and Description of the Lower Leon Creek 2007 Sample Set

In November 2007, SALG staff collected 50 fish samples from Leon Creek. Risk assessors used data from these fish to assess the potential for adverse human health outcomes from consuming fish from this creek.

The SALG selected five sample sites to provide spatial coverage of the study area (Figure 1). Site 1 was located near Commerce Street and Rodriguez Park, Site 2 located at U.S. 90, Site 3 at KAFB golf course, Site 4 at Ruiz Ranch, and Site 5 at I.H. 35. Species collected represent distinct ecological groups (i.e. predators and bottom-dwellers) that have some potential to bio-accumulate chemical contaminants, have a wide geographic distribution, are of local recreational fishing value, and/or that anglers and their families commonly consume. The 50 fish collected from Leon Creek in November 2007 represented all species targeted for collection from this water body (Table 1). Targeted species and numbers collected are listed in descending order: largemouth bass (17), common carp (15), channel catfish (6), spotted gar (5), bluegill (3), Guadalupe bass (1), redbreast sunfish (1), redear sunfish (1), and Rio Grande cichlid (1).

The SALG utilized a boat-mounted electrofisher to collect fish. SALG staff conducted electrofishing activities during daylight hours, using pulsed direct current (Smith Root 5.0 GPP electrofishing system settings: 4.0-6.0 amps, 60 pulses per second [pps], low range 50-500 volts, 60% duty cycle and 1.0-2.0 amps, 15pps, low range, 50-500 volts, 100% duty cycle (catfish species) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation.

SALG staff processed fish onsite at Leon Creek**.** Staff weighed each sample to the nearest gram (g) on an electronic scale and measured total length (tip of nose to tip of tail fin) to the nearest millimeter (mm). After weighing and measuring a fish, staff used a cutting board covered with aluminum foil and a fillet knife to prepare two skin-off fillets from each fish. The foil was changed and the knife cleaned with distilled water after each sample was processed. The team wrapped fillet(s) in two layers of fresh aluminum foil, placed in an unused, clean, pre-labeled plastic freezer bag, and stored on wet ice in an insulated chest until further processing. The SALG staff transported tissue samples on wet ice to their Austin, Texas, headquarters, where the samples were stored temporarily at -5° Fahrenheit (-20° Celsius) in a locked freezer. The freezer key is accessible only to authorized SALG staff members to ensure the chain of custody remains intact while samples are in the possession of agency staff. The week following the collection trip, the SALG shipped frozen fish tissue samples by commercial carrier to the Geochemical and Environmental Research Group (GERG) Laboratory, Texas A&M University, College Station, Texas, for contaminant analysis.

Analytical Laboratory Information

Upon arrival of the samples at the laboratory, GERG personnel notified the SALG of receipt of the 50 Leon Creek samples and recorded the condition of each sample along with its DSHS identification number.

Using established EPA methods, the GERG laboratory analyzed fish fillets from Leon Creek for inorganic and organic contaminants commonly identified in polluted environmental media. Analyses included seven metals (arsenic, cadmium, copper, lead, total mercury, selenium, and zinc), 123 semivolatile organic compounds (SVOCs), 70 volatile organic compounds (VOCs), 34 pesticides, 209 PCB congeners, and 17 polychlorinated dibenzofurans and/or dibenzo-*p*- dioxins (PCDFs/PCDDs) congeners. The laboratory analyzed all 50 samples for metals and PCBs and a subset of 10 (LEC2, LEC5, LEC12, LEC14, LEC22, LEC29, LEC33, LEC36, LEC48, and LEC51) of the original 50 samples for PCDFs/PCDDs, pesticides, SVOCs, and VOCs[18]

Details of Some Analyses with Explanatory Notes

Arsenic

The GERG laboratory analyzed all 50 fish for total (inorganic arsenic + organic arsenic = total arsenic) arsenic. Although the proportions of each form of arsenic may differ among fish species, under different water conditions, and, perhaps, with other variables, the literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form of arsenic that is virtually non-toxic to humans.[19] DSHS, taking a conservative approach, estimates 10% of the total arsenic in any fish is inorganic arsenic, deriving estimates of inorganic arsenic concentration in each fish by multiplying reported total arsenic concentration in the sample by a factor of 0.1.[19]

Mercury

Nearly all mercury in upper trophic level fish three years of age or older is methylmercury.[20] Thus, the total mercury concentration in a fish of legal size for possession in Texas serves well as a surrogate for methylmercury concentration. Because methylmercury analyses are difficult to perform accurately and are more expensive than total mercury analyses, the USEPA recommends that states determine total mercury concentration in a fish and that – to protect human health – states conservatively assume that all reported mercury in fish or shellfish is methylmercury. The GERG laboratory thus analyzed fish tissues for total mercury. In its risk characterizations, DSHS compares mercury concentrations in tissues to a comparison value derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL) for methylmercury.[21] (In these risk characterizations, the DSHS may interchangeably utilize the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish.)

Polychlorinated Biphenyls (PCBs)

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs or Aroclors® because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[18] Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the U.S., the GERG laboratory analyzes and reports the presence and concentrations of all 209 possible PCB congeners. From the congener analyses, the laboratory also computes and reports concentrations of PCB homologs and of Aroclor® mixtures. Despite the USEPA's suggestion that the states utilize PCB congeners rather than Aroclors® or homologs for toxicity estimates, the toxicity literature does not reflect state-of-the-art laboratory science. To accommodate this inconsistency, the DSHS utilizes recommendations from the National Oceanic and Atmospheric Administration (NOAA),[22] from McFarland and Clarke,[23] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish[16, 18] to address PCB congeners in fish and shellfish samples, selecting the 43 congeners encompassed by the McFarland and Clark and the NOAA articles. The referenced authors chose to use congeners that were relatively abundant in the environment, were likely to occur in aquatic life, and likely to show toxic effects.[22, 23] SALG risk assessors summed the 43 congeners to derive "total" PCB concentration in each sample.[22,23] SALG risk assessors then averaged the summed congeners within each group (e.g., fish species, sample site, or combination of species and site) to derive a mean PCB concentration for each group.

Using only a few PCB congeners to determine total PCB concentrations could underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. Therefore, SALG risk assessors compare average PCB concentrations of the 43 congeners with health assessment comparison (HAC) values derived from information on PCB mixtures held in the USEPA's Integrated Risk Information System (IRIS) database.[24] IRIS currently contains systemic toxicity information for five Aroclor® mixtures: Aroclors® 1016, 1242, 1248, 1254, and 1260. IRIS does not contain all information for all mixtures. For instance, only one other reference dose (RfD) occurs in IRIS – the one derived for Aroclor 1016, a commercial mixture produced in the latter years of commercial production of PCBs in the US. Aroclor 1016 was a fraction of Aroclor 1254 that was supposedly devoid of dibenzofurans, in contrast to Aroclor 1254..[25] Systemic toxicity estimates in the present document reflect comparisons derived from the USEPA's RfD for Aroclor 1254 because Aroclor 1254 contains many of the 43 congeners selected by McFarland and Clark and NOAA. As of yet, IRIS does not contain information on the systemic toxicity of individual PCB congeners.

For assessment of cancer risk from exposure to PCBs, the SALG uses the USEPA's highest slope factor of 2.0 per (mg/kg/day) to calculate the probability of lifetime excess cancer risk from PCB ingestion. The SALG based its decision to use the most restrictive slope factor available for PCBs on factors such as food chain exposure; the presence of dioxin-like, tumor-promoting, or persistent congeners; and the likelihood of early-life exposure.[26]

Calculation of Toxicity Equivalent Quotients (TEQs) for Dioxins

PCDDs/PCDFs are families of aromatic chemicals containing one to eight chlorine atoms. The molecular structures differ not only with respect to the number of chlorines on the molecule, but also with the positions of those chlorines on the carbons atoms of the molecule. The number and positions of the chlorines on the dibenzofuran or dibenzo-*p*-dioxin nucleus directly affects the toxicity of the various congeners. Toxicity increases as the number of chlorines increases to four chlorines, then decreases with increasing numbers of chlorine atoms - up to a maximum of eight. With respect to the position of chlorines on the dibenzo-*p*-dioxin/dibenzofuran nucleus, it appears that those congeners with chlorine substitutions in the 2, 3, 7, and 8 positions are more toxic than congeners with chlorine substitutions in other positions. To illustrate, the most toxic of PCDDs is 2,3,7,8–tetrachlorodibenzo-*p*-dioxin (2,3,7,8–TCDD), a 4-chlorine molecule having one chlorine substituted for hydrogen at each of the 2, 3, 7, and 8 carbon positions on the dibenzo-*p*-dioxin. To gain some measure of toxic equivalence, 2,3,7,8–TCDD – assigned a toxicity equivalency factor (TEF) of 1.0 – is the standard against which other congeners are measured. Other congeners are given weighting factors or TEFs of 1.0 or less based on experiments comparing the toxicity of the congener relative to that of 2,3,7,8-TCDD.[27, 28] Using this technique, risk assessors from the DSHS converted PCDF or PCDD congeners in each tissue sample from the present survey to TEQs by multiplying each congener's concentration by its TEF, producing a dose roughly equivalent in toxicity to that of the same dose of 2,3,7,8-TCDD. The total TEQ for any sample is the sum of the TEQs for each of the congeners in the sample, calculated according to the following formula.[29]

$$\text{Total TEQs} = \sum_{i=1}^{n}(\text{CI} \times \text{TEF})$$

CI = concentration of a given congener
TEF = toxicity equivalence factor for the given congener
n = # of congeners
i = initial congener
∑ = sum

Derivation and Application of Health-Based Assessment Comparison Values for Systemic Effects (HAC_{nonca}) of Consumed Chemical Contaminants

The effects of exposure to any hazardous substance depend, among other factors, on the dose, the route of exposure, the duration of exposure, the manner in which the exposure occurs, the genetic makeup, personal traits, habits of the exposed, or the presence of other chemicals.[30] People who regularly consume contaminated fish or shellfish conceivably suffer repeated low-dose exposures to contaminants in fish or shellfish over extended periods (episodic exposures to low doses). Such exposures are unlikely to result in acute toxicity but may increase risk of subtle, chronic, and/or delayed adverse health effects that may include cancer, benign tumors, birth defects, infertility, blood disorders, brain damage, peripheral nerve damage, lung disease, and kidney disease.[30]

If diverse species of fish or shellfish are available, the SALG presumes that people eat a variety of species from a water body. Further, SALG risk assessors assume that most fish species are mobile. SALG risk assessors may combine data from different fish species, largemouth bass, and/or sampling sites within a water body to evaluate mean contaminant concentrations of toxicants in all samples as a whole. This approach intuitively reflects consumers' likely exposure over time to contaminants in fish or shellfish from any water body but may not reflect the reality of exposure at a specific water body or a single point in time. The DSHS reserves the right to project risks associated with ingestion of individual species of fish or shellfish from separate collection sites within a water body or at higher than average concentrations (e.g. the upper 95 percent confidence limit on the mean). The SALG derives confidence intervals from Monte Carlo simulations using software developed by a DSHS medical epidemiologist.[31] The SALG evaluates contaminants in fish or shellfish by comparing the mean or the 95% upper confidence limit on the mean concentration of a contaminant to its HAC value (in mg/kg) for non-cancer or cancer endpoints.

In deriving HAC values for systemic (HAC_{nonca}) effects, the SALG assumes a standard adult weighs 70 kilograms and consumes 30 grams of fish or shellfish per day (about one 8-ounce meal per week) and uses the USEPA's RfD[32] or the ATSDR's chronic oral MRLs.[33] The USEPA defines an RfD as

> *An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.*[34]

The USEPA also states that the RfD

> *… is derived from a BMDL* (benchmark dose lower confidence limit)*, a NOAEL* (no observed adverse effect level)*, a LOAEL* (lowest observed adverse effect level)*, or another suitable point of departure, with uncertainty/variability factors applied to reflect limitations of the data used. [Durations include acute, short-term, subchronic, and chronic and are defined individually in this glossary]* and *RfDs are generally reserved for health effects thought to have a threshold or a low dose limit for producing effects.*[34]

The ATSDR uses a similar technique to derive its MRLs.[33] The DSHS divides the estimated daily dose derived from the measured concentration in fish tissue by the contaminant's RfD or MRL to derive a hazard quotient (HQ). The USEPA defines a HQ as

> *…the ratio of the estimated exposure dose of a contaminant (mg/kg/day) to the contaminant's RfD or MRL (mg/kg/day).*[35]

Note that, according to the USEPA, a linear increase in the HQ for a toxicant does not imply a linear increase in the likelihood or severity of systemic adverse effects. Thus, a HQ of 4.0 does not mean the concentration in the dose will be four times as toxic as that same substance would be if the HQ were equal to 1.0. A HQ of 4.0 also does not imply that adverse events will occur four times as often as if the HQ for the substance in question were 1.0. Rather, the USEPA suggests that a HQ or a hazard index (HI) – defined as the sum of HQs for contaminants to which an individual is exposed simultaneously) – that computes to less than 1.0 should be interpreted as "no cause for concern" whereas a HQ or HI greater than 1.0 "should indicate some cause for concern."

The SALG does not utilize HQs to determine the likelihood of occurrence of adverse systemic health effects. Instead, in a manner similar to the USEPA's decision process, the SALG may utilize computed HQs as a qualitative measurement. Qualitatively, HQs less than 1.0 are unlikely to be an issue while HQs greater than 1.0 might suggest a regulatory action to ensure protection of public health. Similarly, risk assessors at the DSHS may utilize a HQ to determine the need for further study of a water body's fauna. Notwithstanding the above discussion, the oral RfD derived by the USEPA represents chronic consumption. Thus, regularly eating fish containing a toxic chemical, the HQ of which is less than 1.0 is unlikely to cause adverse systemic health effects, whereas routine consumption of fish or shellfish in which the HQ exceeds 1.0 represents a qualitatively unacceptable increase in the likelihood of systemic adverse health outcomes.

Although the DSHS utilizes chemical specific RfDs when possible, if an RfD is not available for a contaminant, the USEPA advises risk assessors to consider evaluating the contaminant by comparing it to the published RfD (or the MRL) of a contaminant of similar molecular structure or one with a similar mode or mechanism of action. For instance, Aroclor® 1260 has no RfD, so the DSHS uses the reference dose for Aroclor 1254 to assess the likelihood of systemic (noncarcinogenic) effects of Aroclor 1260.[32]

In developing oral RfDs and MRLs, federal scientists review the extant literature to devise NOAELs, LOAELs, or benchmark doses (BMDs) from experimental studies. Uncertainty factors are then utilized to minimize potential systemic adverse health effects in people who are exposed through consumption of contaminated materials by accounting for certain conditions that may be undetermined by the experimental data. These include extrapolation from animals to humans (interspecies variability), intra-human variability, and use of a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, and database insufficiencies.[32,34] Vulnerable groups such as women who are pregnant or lactating, women who may become pregnant, infants, children, people with chronic illnesses, those with compromised immune systems, the elderly, or those who consume exceptionally large servings are considered sensitive populations by risk assessors and USEPA and also receive special consideration in calculation of a RfD.[34, 36]

The primary method for assessing the toxicity of component-based mixtures of chemicals in environmental media is the HI. The USEPA recommends HI methodology for groups of toxicologically similar chemicals or chemicals that affect the same target organ. The HI for the toxic effects of a chemical mixture on a single target organ is actually a simulated HQ calculated as if the mixture were a single chemical. The default procedure for calculating the HI for the exposure mixture is to add the hazard quotients (the ratio of the external exposure dose to the RfD) for all the mixture's component chemicals that affect the same target organ, e.g., the liver. The toxicity of a particular mixture on the liver represented by the HI should approximate the toxicity that would have occurred were the observed effects caused by a higher dose of a single toxicant (additive effects). The components to be included in the HI calculation are any chemical components of the mixture that show the effect described by the HI, regardless of the critical effect from which the RfD came. Assessors should calculate a separate HI for each toxic effect.

Because the RfD is derived for the critical effect (the "toxic effect occurring at the lowest dose of a chemical"), a HI computed from HQs based on the RfDs for the separate chemicals may be overly conservative. That is, using RfDs to calculate HIs may exaggerate health risks from consumption of specific mixtures for which no experimentally derived information is available.

The USEPA states that

> *the HI is a quantitative decision aid that requires toxicity values as well as exposure estimates. When each organ-specific HI for a mixture is less than one and all relevant effects have been considered in the assessment, the exposure being assessed for potential systemic toxicity should be interpreted as unlikely to result in significant toxicity.*

And

> *When any effect-specific HI exceeds one, concern exists over potential toxicity. As more HIs for different effects exceed one, the potential for human toxicity also increases.*

Thus,

> *Concern should increase as the number of effect-specific HI's exceeding one increases. As a larger number of effect-specific HIs exceed one, concern over potential toxicity should also increase. As with HQs, this potential for risk is not the same as probabilistic risk; a doubling of the HI does not necessarily indicate a doubling of toxic risk.*

Derivation and Application of Health-Based Assessment Comparison Values for Application to the Carcinogenic Effects (HAC_{ca}) of Consumed Chemical Contaminants

The DSHS calculates cancer-risk comparison values (HAC_{ca}) from the USEPA's chemical-specific cancer potency factors (CPFs), also known as cancer slope factors (CSFs), derived through mathematical modeling from carcinogenicity studies. For carcinogenic outcomes, the DSHS calculates a theoretical lifetime excess risk of cancer for specific exposure scenarios for carcinogens, using a standard 70-kg body weight and assuming an adult consumes 30 grams of edible tissue per day. The SALG risk assessors incorporate two additional factors into determinations of theoretical lifetime excess cancer risk: (1) an acceptable lifetime risk level (ARL) [34] of one excess cancer case in 10,000 persons whose average daily exposure is equivalent and (2) daily exposure for 30 years, a modification of the 70-year lifetime exposure assumed by the USEPA. Comparison values used to assess the probability of cancer do not contain "uncertainty" factors. However, conclusions drawn from probability determinations infer substantial safety margins for all people by virtue of the models utilized to derive the slope factors (cancer potency factors) used in calculating the HAC_{ca}.

Because the calculated comparison values (HAC values) are conservative, exceeding a HAC value does not necessarily mean adverse health effects will occur. The perceived strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool used by risk managers along with other information to make decisions about the degree of risk incurred by those who consume contaminated fish or shellfish. Moreover, comparison values for adverse health effects do not represent sharp dividing lines (obvious demarcations) between safe and unsafe exposures. For example, the DSHS considers it unacceptable when consumption of four or fewer meals per month of contaminated fish or shellfish would result in exposure to contaminant(s) in excess of a HAC value or other measure of risk. The DSHS also advises people who wish to minimize exposure to contaminants in fish or shellfish to eat a variety of fish and/or shellfish and to limit consumption of those species most likely to contain toxic contaminants. The DSHS aims to protect vulnerable subpopulations with its consumption advice, assuming that advice protective of vulnerable subgroups will also protect the general population from potential adverse health effects associated with consumption of contaminated fish or shellfish.

Children's Health Considerations

The DSHS recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and suggests that exceptional susceptibilities demand special attention.[37, 38] Windows of special vulnerability (known as "critical developmental periods") exist during development. Critical periods occur particularly during early gestation (weeks 0 through 8) but can occur at any time during development (pregnancy, infancy, childhood, or adolescence) at times when toxicants can impair or alter the structure or function of susceptible systems.[39] Unique early sensitivities may exist after birth because organs and body systems are structurally or functionally immature at birth, continuing to develop throughout infancy, childhood, and adolescence. Developmental variables may influence the mechanisms or rates of absorption, metabolism, storage, or excretion of toxicants. Any of these factors could alter the concentration of biologically effective toxicant at the target organ(s) or could modulate target organ response to the toxicant. Children's exposures to toxicants may be more extensive than adults' exposures because children consume more food and liquids in proportion to their body weights than adults consume. Infants can ingest toxicants through breast milk, an exposure pathway that often goes unrecognized. Nonetheless, the advantages of breastfeeding outweigh the probability of significant exposure to infants through breast milk and women are encouraged to continue breastfeeding and to limit exposure of their infants by limiting intake of the contaminated foodstuff. Children may experience effects at a lower exposure dose than might adults because children's organs may be more sensitive to the effects of toxicants. Stated differently, children's systems could respond more extensively or with greater severity to a given dose than would an adult organ exposed to an equivalent dose of a toxicant. Children could be more prone to developing certain cancers from chemical exposures than are adults.[40] In any case, if a chemical or a class of chemicals is observed to be, or is thought to be, more toxic to fetuses, infants, or children, the constants (e.g., RfD, MRL, or CPF) are usually modified further to assure the immature systems' potentially greater susceptibilities are not perturbed.[32] Additionally, in accordance with the ATSDR's *Child Health Initiative*[41] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[42] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that recommends consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 meals of the contaminated fish or shellfish per year and should not eat such fish or shellfish more than twice per month.

Data Analysis and Statistical Methods

The SALG risk assessors imported Excel© files into SPSS® statistical software, version 13.0 installed on IBM-compatible microcomputers (Dell, Inc), using SPSS® to generate descriptive statistics (mean, standard deviation, median, minimum and maximum concentrations, and range) on measured compounds.[43] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values)[b]. PCDFs/PCDDs descriptive statistics are calculated using estimated concentrations (J-values) and assuming zero for PCDFs/PCDDs designated as ND.[c] The change in methodology for computing PCDFs/PCDDS descriptive statistics is due to the proximity of the reporting limits to the HAC value. Assuming ½ the RL for PCDFs/PCDDs designated as ND or J-values would unnecessarily overestimate the concentration of PCDFs/PCDDs in each fish tissue sample. The SALG used the descriptive statistics from the above calculations to generate the present report. SALG protocols do not require hypothesis testing. Nevertheless, when data are of sufficient quantity and quality, and, should it be necessary, the SALG may determine significant differences among contaminant concentrations in species and/or at collection sites as needed. The SALG employed Microsoft Excel® spreadsheets to generate figures, to compute HAC_{nonca} and HAC_{ca} values for contaminants, and to calculate HQs, HIs, cancer risk probabilities, and meal consumption limits for fish from Lower Leon Creek.[44] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the EPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether consumption of lead-contaminated fish could cause a child's blood lead (PbB) level to exceed the Centers for Disease Control and Prevention's (CDC) lead concentration of concern in children's blood (10 mcg/dL).[45,46]

RESULTS

The GERG laboratory completed analyses and electronically transmitted the results of the Lower Leon Creek samples collected in November 2007 to the SALG on March 30, 2009. The

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[b] *"J-value" is standard laboratory nomenclature for analyte concentrations that are detected and reported below the reporting limit (<RL). The reported concentration is considered an estimate, quantitation of which may be suspect and may not be reproducible. The DSHS treats J-Values as "not detected" in its statistical analyses of a sample set.*

[c] *The SALG risk assessors' rationale for computing PCDFs/PCDDs descriptive statistics using the aforementioned method is based on the proximity of the laboratory reporting limits and the health assessment comparison value for PCDFs/PCDDs. Thus, applying the standard SALG method utilizing ½ the reporting limit for analytes designated as not detected (ND) or estimated (J) will likely overestimate the PCDFs/PCDDs fish tissue concentration.*

laboratory reported the analytical results for metals, pesticides, PCBs, PCDFs/PCDDs, SVOCs, and VOCs.

For reference, Table 1 contains the total number of samples collected. Tables 2a through 2d present the results of metals analyses. Table 3 contains summary results of 4,4-DDE and chlordane analyses, tables 4a and 4b summarize the PCB analyses, and table 5 summarizes PCDFs/PCDDs analyses. This paper does not display SVOC and VOC data because these contaminants were not present at concentrations of interest in fish collected from Lower Leon Creek during the described survey. Unless otherwise stated, table summaries present the number of samples containing a specific toxicant/number tested, the mean concentration ± 1 standard deviation (68% of samples should fall within one standard deviation of the arithmetic mean in a sample from a normally-distributed population), and, in parentheses under the mean and standard deviation, the minimum and the maximum detected concentrations. Those who prefer to use the range may derive this statistic by subtracting the minimum concentration of a given toxicant from its maximum concentration. In the tables, results may be reported as ND (not detected), BDL (below detection limit), or as measured concentrations. According to the laboratory's quality control/quality assurance materials, results reported as "BDL" rely upon the laboratory's method detection limit (MDL) or its reporting limit (RL). The MDL is the minimum concentration of an analyte that be reported with 99% confidence that the analyte concentration is greater than zero, while the RL is the concentration of an analyte reliably achieved within specified limits of precision and accuracy during routine analyses. Contaminant concentrations reported below the RL are qualified as "J-values" in the laboratory data report.[47]

Inorganic Contaminants

Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc

All 50 fish tissue samples from Lower Leon Creek contained some level of copper, lead, mercury, selenium, and zinc (Tables 2b-2d).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. All 50 fish tissue samples contained copper (Table 2b). The mean copper concentration in fish sampled from Lower Leon Creek was 0.296±0.217 mg/kg. Common carp had the highest average concentration of copper (0.585±0.173 mg/kg). All fish tissue samples contained selenium. The average selenium concentration in fish from Lower Leon Creek was 0.292 mg/kg with a standard deviation of ±0.105 mg/kg (Table 2d). Selenium in fish from Lower Leon Creek ranged from 0.154 to 0.640 mg/kg. All samples also contained zinc (Table 2d). The mean zinc concentration in fish tissue samples from Lower Leon Creek was 4.894±2.149 mg/kg. At 6.442±2.964 mg/kg, common carp also had the highest mean tissue zinc levels.

The SALG evaluated four toxic metalloids having no known human physiological function (arsenic, cadmium, lead, and mercury) in the samples collected from Lower Leon Creek. Thirty-one of 50 fish assayed contained arsenic ranging from ND-0.092 mg/kg (Table 2a). No fish from this stream contained cadmium at a concentration exceeding the laboratory's RL (Table 2b). Three species (common carp, largemouth bass, and spotted gar) contained lead at concentrations greater than the RL (Table 2c). The average lead concentration in all fish combined was 0.055±0.033 mg/kg (Table 2c).

All species of fish collected in 2007 from Lower Leon Creek contained mercury (Table 2c). Bluegill and the single Rio Grande cichlid collected contained the lowest concentration of mercury, while the highest concentration occurred in spotted gar (0.528 mg/kg). The mean mercury concentration in fish (collapsed across species and sites) was 0.221±0.139 mg/kg (Table 2c).

Organic Contaminants

<u>Pesticides</u>

The GERG laboratory analyzed 10 fish for 34 pesticides. Ten of 10 samples examined contained concentrations of 4,4′-DDE and chlordane (Table 3). Common carp contained the highest concentration of 4,4′-DDE (0.440 mg/kg). The mean 4,4′-DDE concentration in fish (*n*=10) was 0.144±0.185 mg/kg. Chlordane concentrations ranged from BDL-0.088 mg/kg in fish (Table 3; *n*=10). Nine of 10 samples contained low concentrations of 4,4′-DDD (data not presented). Seven of 10 samples contained low concentrations of 2,4′-DDD, while two of 10 samples contained low concentrations (> RL) of 4,4′-DDT (data not presented). Four of 10 samples contained low concentrations of Endosulfan I (data not presented). Trace[d] quantities of mirex and 2,4′-DDE were present in some fish samples (data not presented).

<u>PCBs</u>

The present study marks the first instance in which the SALG required analysis of fish tissue samples from Lower Leon Creek for PCB congeners rather than Aroclors®. Thus, it is important that readers do not attempt to make direct comparisons between PCB concentrations in this report and Aroclor® concentrations from previous studies of Lower Leon Creek.

All fish tissue samples contained concentrations of one or more PCB congeners (Table 4b). No fish tissue sample contained all PCB congeners (data not shown). Across all sites and species, PCB concentrations in fish ranged from BDL (bluegill and Rio Grande cichlid) to 0.961 mg/kg (common carp; Table 4b). Four of nine fish species evaluated had mean PCB congener concentrations that exceeded the DSHS HAC_{nonca} value for PCBs (0.047 mg/kg; Table 4b). Common carp contained the highest mean concentration of PCBs (0.218±0.261 mg/kg), followed by spotted gar (0.186±0.194 mg/kg), followed by channel catfish (0.090±0.041 mg/kg), and then by largemouth bass (0.080±0.100 mg/kg). Collectively, the sunfish (i.e. bluegill, redbreast sunfish, and redear sunfish) and Rio Grande cichlid contained the lowest concentration of PCBs (Tables 4a and 4b). The mean PCB concentration in all 50 fish tissue samples assayed was 0.126±0.177 mg/kg (Table 4b).

[d] *Trace: in analytical chemistry, a trace is an extremely small amount of a chemical compound, one present in a sample at a concentration below a standard limit. Trace quantities may be designated with the "less than" (<) sign or may also be represented by the alpha character "J" – called a "J-value" defining the concentration of a substance as near zero or one that is detected at a low level but that is not guaranteed quantitatively replicable.*

The DSHS SALG considered the use one-way analysis of variance (ANOVA) to test for differences in fish tissue PCB concentrations between sample sites. However, the data failed to meet the assumptions of the ANOVA. Figures 2, 3, and 4 display means plots (mean PCB concentration) by sample site for all fish combined, common carp, and largemouth bass, respectively.

PCDFs/PCDDs

The GERG laboratory analyzed ten fish tissue samples for 17 of the 210 possible PCDF/PCDD (135 PCDFs + 75 PCDDs) congeners from Lower Leon Creek. The congeners examined consist of 10 PCDFs and 7 PCDDs that contain chlorine substitutions in, at a minimum, the 2, 3, 7, and 8 positions on the dibenzofuran or dibenzo-*p*-dioxin nucleus and are the only congeners reported to pose dioxin-like adverse human health effects.[48] Although 12 of the 209 PCB congeners – those often referred to as "coplanar PCBs," meaning the molecule can assume a flat configuration with both phenyl rings in the same plane – may also have dioxin-like toxicity, the SALG does not assess PCBs for dioxin-like qualities because the dioxin-like behavior has been less extensively evaluated. Table 5 contains site and species-specific summary statistics for PCDFs/PCDDs in fish collected from Lower Leon Creek. Before generating summary statistics for PCDFs/PCDDs, the SALG risk assessors converted the reported concentration of each PCDF or PCDD congener reported present in a tissue sample to a concentration equivalent in toxicity to that of 2,3,7,8-TCDD (a TEQ concentration - expressed as pg/g or ng/kg). Eight of 10 fish tissue samples contained at least one of the 17 congeners assayed (minimum – to – maximum concentration after conversion: ND-1.669 pg/g; Table 5). No samples contained all 17 congeners (data not shown). Channel catfish contained the highest mean TEQ concentration (1.125±0.842 pg/), followed by common carp (0.449±0.543 pg/g –or ng/kg). Two samples (one largemouth bass and one common carp) analyzed for PCDFs/PCDDs contained no identifiable PCDFs/PCDDs (Table 5).

SVOCs

The GERG laboratory analyzed 10 Lower Leon Creek fish tissue samples for SVOCs. Trace concentrations of phenol, bis(2-ethylhexyl) phthalate (BEHP or di-(2-ethylhexyl)phthalate or DEHP), di-n-butyl phthalate (DBP), and diethyl phthalate were present in some fish samples assayed (data not presented). The laboratory detected no other SVOCs in fish from Lower Leon Creek.

VOCs

The GERG laboratory reported the 10 fish tissue samples selected for analysis from Lower Leon Creek to contain quantifiable concentrations of one or more VOCs: carbon disulfide, trichlorofluoromethane, methylene chloride, toluene, and acetone (data not presented). Trace quantities[d] of 1,1-dichloroethene, trans-1,2-dichloroethene, cis-1,2-dichloroethene, chloroform, 1,2-dichloroethane, dibromomethane, 1,1,1-trichloroethane, benzene, trichloroethene, 1,2-dichloropropane, cis,-1,3-dichloropropene, bromodichloromethane, ethyl methacrylate, dibromochloromethane, 1,2-dibromomethane, bromoform, 4-methyl-2-pentanone, tetrachloroethene, 1,3-dichloropropane, 2-hexanone, chlorobenzene, ethylbenzene, m+p-xylene, o-xylene, styrene, isopropylbenzene, bromobenzene, 1,1,1,2-tetrachloroethane, 2-chlorotoluene, 4-chlorotoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, n-propylbenzene, 4-isopropyl toluene, tert-butylbenzene, sec-butylbenzene, n-butylbenzene, 1,2-dibromo-3-chloropropane, 1,2,3-trichlorbenzene, 1,2,4-trichlorobenzene, hexachlorobutadiene, and naphthalene were also present in one or more fish tissue samples assayed from Lower Leon Creek (data not present). Concentrations of carbon disulfide, trichlorofluoromethane, methylene chloride, toluene, acetone chloroform, dibromomethane, 1,1,1-trichloroethane, benzene, trichloroethene, 1,2-dichloropropane, dibromochloromethane, 1,2-dibromomethane, bromoform, tetrachloroethene, chlorobenzene, ethylbenzene, m+p-xylene, o-xylene, styrene, isopropylbenzene, bromobenzene, 1,1,1,2-tetrachloroethane, 2-chlorotoluene, 4-chlorotoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2-dichlorobenzene, n-propylbenzene, 4-isopropyl toluene, tert-butylbenzene, sec-butylbenzene, n-butylbenzene, 1,2-dibromo-3-chloropropane, 1,2,3-trichlorbenzene, 1,2,4-trichlorobenzene, hexachlorobutadiene, and naphthalene were also identified in one or more of the procedural blanks, indicating the possibility that these compounds were introduced during sample preparation. VOC concentrations <RL are difficult to interpret due to their uncertainty and may represent a false positive. The presence of many VOCs at concentrations <RL may be the result of incomplete removal of the calibration standard from the adsorbent trap, so they are observed in the blank (VOCs analytical methodology requires that VOCs are thermally released from the adsorbent trap, transferred to the gas chromatograph (GC), and into the GC/mass spectrometer (MS) for quantification). No other VOCs were reported present in fish collected from Lower Leon Creek.

DISCUSSION

Risk Characterization

Because variability and uncertainty are inherent to quantitative assessment of risk, the calculated risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below actual risks. Variability in calculated and in actual risk may depend upon factors such as the use of animal instead of human studies, use of subchronic rather than chronic studies, interspecies variability, intra-species variability, and database insufficiency. Since most factors used to calculate comparison values result from experimental studies conducted in the laboratory on nonhuman subjects, variability and uncertainty might arise from the study chosen as the "critical" one, the species/strain of animal used in the critical study, the target organ selected as the "critical organ," exposure periods, exposure route, doses, or uncontrolled variations in other conditions.[32] Despite such limitations, risk assessors must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media. The DSHS calculated risk parameters for systemic and carcinogenic endpoints in those who would consume fish from Leon Creek. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow the discussion of the relevance of findings to risk.

Characterization of Systemic (Noncancerous) Health Effects from Consumption of Fish from Lower Leon Creek

PCBs were the only contaminant observed in fish from Lower Leon Creek that equaled or exceeded its HAC_{nonca} (0.047 mg/kg). No species of fish collected from Lower Leon Creek contained any other inorganic or organic contaminants at concentrations that equaled or exceeded the DSHS guidelines for protection of human health or would likely cause systemic risk to human health from consumption of fish from Lower Leon Creek (Tables 2a-5a). Potential systemic health risks related to the consumption of fish from Lower Leon Creek containing inorganic and organic contaminants (other than PCBs) are not of public health concern. Consequently, this risk characterization concentrates on assessing the likelihood of adverse health outcomes that could occur from consumption of Lower Leon Creek PCB-contaminated fish. Tables 6a through 7a provide hazard quotients for PCBs and PCDFs/PCDDs in each species of fish collected from Lower Leon Creek and the recommended weekly consumption rate for each species.

PCBs

All fish collected from Lower Leon Creek in 2007 contained PCBs (Tables 4a and 4b). Fifty-two percent of all samples (N = 50) analyzed contained PCB concentrations that equaled or exceeded the HAC_{nonca} for PCBs (0.047 mg/kg). Mean PCB concentrations for channel catfish, common carp, largemouth bass, and spotted gar assayed exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4b and 6b), and the *All Species* mean PCB concentration (0.126 mg/kg) exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4b and 6b) representing potential systemic health risks related to the consumption of fish from Lower Leon Creek. Collectively, the sunfish (i.e. bluegill, redbreast sunfish, and redear sunfish) and Rio Grande cichlid do not contain PCB concentrations that equaled or exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4b and 6b) indicating that lower trophic level fish do not bioconcentrate PCBs similar to higher trophic level fish.

Meal consumption calculations may be useful for decisions about consumption advice or regulatory actions. The SALG risk assessors calculated the number of 8-ounce meals of fish from Lower Leon Creek that healthy adults could consume without significant risk of adverse systemic effects (Table 6b). The SALG estimated this group could consume 0.3 (8-ounce) meals per week of fish containing PCBs (Table 6b), suggesting that fish from Lower Leon Creek contain PCBs at concentrations that could result in adverse effects on human health and that people limit their consumption of fish from Lower Leon Creek. The developing nervous system of the human fetus may be especially susceptible to these effects. Because calculated systemic risks associated with consumption of PCB-contaminated fish from Lower Leon Creek varied by collection site, this report also discussed findings for each site.

<u>Site 1 Lower Leon Creek at Commerce St. and Rodriguez Park</u>

At Site 1, upstream of KAFB and U.S. 90, the *All Species* mean fish tissue PCB concentration did not exceed the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4a and 6a). The mean fish tissue PCB concentrations of the four fish species (bluegill, common carp, largemouth bass, and Rio Grande cichlid) examined from Site 1 also did not exceed the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4a and 6a). PCBs concentrations observed in fish from Site 1 do not exceed the DSHS guidelines for protection of human health or are not likely to cause systemic risk to human health from consumption of fish (Tables 4a-6a). Potential systemic health risks related to the consumption of fish from Lower Leon Creek at Site 1 containing PCBs are not of public health concern.

<u>Site 2 Lower Leon Creek at U.S. 90</u>

Three of four species assayed from Site 2 contained PCB concentrations that equaled or exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4a and 6a). The *All Species* mean fish tissue PCB concentration ($\bar{x}$ = 0.050 mg/kg) exceeded the HAC_{nonca} for PCBs and a HQ of 1.0. (Tables 4a and 6a). The SALG calculated that healthy adults could consume 0.9 (8-ounce) meals per week of fish containing PCBs (Table 6a) suggesting that people should limit their consumption of fish from Lower Leon Creek at Site 2. PCB concentrations observed in fish from Site 2 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

<u>Site 3 Lower Leon Creek at KAFB</u>

The mean concentration of PCBs ($\bar{x}$ = 0.175 mg/kg) in fish from Site 3 exceeded the HAC_{nonca} for PCBs (Table 4a). The HQ for PCBs in fish from Site 3 was 3.8 (Table 6a). HQs for three of four fish species (common carp, largemouth bass, and spotted gar) collected from Site 3 exceeded 1.0. The SALG calculated that healthy adults could consume 0.2 (8-ounce) meals per week of fish containing PCBs (Table 6a) suggesting that people should not consume fish from Lower Leon Creek at Site 3. PCB concentrations observed in fish from Site 3 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

<u>Site 4 Lower Leon Creek at Ruiz Ranch</u>

The mean concentration of PCBs ($\bar{x}$ = 0.296 mg/kg) in fish from Site 4 exceeded the HAC_{nonca} for PCBs (Table 4b). The HQ for PCBs in fish from Site 4 was 6.3 (Table 6a). HQs for four of five fish species (channel catfish, common carp, largemouth bass, and spotted gar) collected from Site 4 exceeded 1.0. The SALG calculated that healthy adults could consume 0.1 (8-ounce) meals per week of fish containing PCBs (Table 6a) suggesting that people should not consume fish from Lower Leon Creek at Site 4. PCB concentrations observed in fish from Site 4 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

<u>Site 5 Lower Leon Creek at I.H. 35</u>

At Site 5, the *All Species* mean fish tissue PCB concentration ($\bar{x}$ = 0.079 mg/kg) exceeded the HAC_{nonca} for PCBs and a HQ of 1.0 (Tables 4b and 6b). HQs for three of five fish species (channel catfish, common carp, and largemouth bass) collected from Site 5 exceeded 1.0. The SALG calculated that healthy adults could consume 0.5 (8-ounce) meals per week of fish containing PCBs (Table 6a) suggesting that people should limit consumption of fish from Lower Leon Creek at Site 5. PCB concentrations observed in fish from Site 5 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

Characterization of Theoretical Lifetime Excess Cancer Risk from Consumption of Fish from Lower Leon Creek

The USEPA classifies 4,4′-DDE, chlordane, PCBs, and PCDFs/PCDDs as probable human carcinogens (B2) based upon increases in the incidence of benign and cancerous tumors in animals in experimental studies.[24] Although PCDFs/PCDDs and chlorinated pesticides were present in samples from Lower Leon Creek, none were observed at concentrations that would be likely to substantially increase the risk of cancer (Tables 3, 5a and 9). PCBs contribute the majority of the calculated increase in the theoretical probability of cancer associated with consumption of fish from Lower Leon Creek. The risk of cancer from consuming PCBs in fish (all fish combined) or any individual species of fish from Lower Leon Creek (all sites combined) did not cause the theoretical lifetime risk of cancer to exceed the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals (Tables 8 and 9). Because calculated cancer risks associated with consumption of PCB-contaminated fish from Lower Leon Creek varied by collection site, this report also discussed findings for each site.

<u>Site 1 Lower Leon Creek at Commerce St. and Rodriguez Park</u>

No species of fish collected from Site 1 contained PCBs at concentrations that would be likely to cause the theoretical lifetime risk of cancer to exceed the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals who consume fish from Lower Leon Creek. At Site 1, potential cancer risks related to consumption of fish from Lower Leon Creek are not of public health concern (Table 8a).

<u>Site 2 Lower Leon Creek at U.S. 90</u>

No species of fish collected from Site 2 contained PCBs at concentrations that would be likely to cause the theoretical lifetime risk of cancer to exceed the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals who consume fish from Lower Leon Creek. At Site 2, potential cancer risks related to consumption of fish from Lower Leon Creek are not of public health concern (Table 8a).

<u>Site 3 Lower Leon Creek at KAFB</u>

The mean concentration of PCBs in common carp and spotted gar from Site 3 exceeded the HAC_{ca} for PCBs (Table 4a). The excess cancer risk for those consuming PCB-contaminated common carp or spotted gar from Site 3 was approximately 1 in 9,972 equally exposed individuals and 1 in 7,625, respectively (Table 8a). Based on these cancer risk estimates, the SALG risk assessors calculated that healthy adults could consume 0.9 (8-ounce) meals per week of common carp or 0.7 (8-ounce) meals per week of spotted gar containing PCBs (Table 8a) suggesting that people should limit consumption of these species of fish from Lower Leon Creek at Site 3. The mean concentration of PCBs ($\bar{x}$ = 0.175 mg/kg) in fish from Site 3 did not exceed the HAC_{ca} for PCBs or the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals who consume fish from Lower Leon Creek (Table 4a). PCBs concentrations observed in common carp and spotted gar from Site 3 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

Site 4 Lower Leon Creek at Ruiz Ranch

The mean concentration of PCBs in common carp from Site 4 exceeded the HAC_{ca} for PCBs (Table 4b). The excess cancer risk for those consuming PCB-contaminated common carp from Site 3 was approximately 1 in 4,349 equally exposed individuals (Table 8b). Based on this cancer risk estimate, the SALG risk assessors calculated that healthy adults could consume 0.4 (8-ounce) meals per week of common carp (Table 8b) suggesting that people should limit consumption of common carp from Lower Leon Creek at Site 3. The mean concentration of PCBs ($\bar{x}$ = 0.296 mg/kg) in fish from Site 3 also exceeded the HAC_{ca} for PCBs or the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals who consume fish from Lower Leon Creek (Table 4b). The SALG risk assessors calculated that healthy adults could consume 0.8 (8-ounce) meals per week of fish (Table 8b) suggesting that people should limit consumption of fish from Lower Leon Creek at Site 3. PCB concentrations observed in fish from Site 3 exceed DSHS guidelines for protection of human health and may pose potential risk to human health.

Site 5 Lower Leon Creek at I.H. 35

No species of fish collected from Site 5 contained PCBs at concentrations that would be likely to cause the theoretical lifetime risk of cancer to exceed the DSHS guideline of 1 excess cancer in 10,000 equally exposed individuals who consume fish from Lower Leon Creek. At Site 5, potential cancer risks related to consumption of fish from Lower Leon Creek are not of public health concern (Table 8b).

Characterization of Calculated Cumulative Systemic Health Effects and of Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Lower Leon Creek

No species of fish collected from Lower Leon Creek contained any combination of multiple inorganic or organic contaminants at concentrations that significantly increased systemic risk to human health or the theoretical lifetime risk of cancer above that of the potential health risks associated with PCB-contaminated fish (Tables 2a–9). Potential cumulative systemic health effects or cumulative cancer risk related to consumption of fish from Lower Leon Creek are not of public health concern.

CONCLUSIONS

SALG risk assessors prepare risk characterizations to determine public health hazards from consumption of fish and shellfish harvested from Texas water bodies by recreational or subsistence fishers. If necessary, SALG may suggest strategies for reducing risk to the health of those who may eat contaminated fish or seafood to risk managers at DSHS, including the Texas Commissioner of Health.

This study addressed the public health implications of consuming fish from Lower Leon Creek, located in Bexar County, Texas. Risk assessors from the SALG conclude:

1. That the sunfish species (i.e. bluegill, redbreast sunfish, and redear sunfish) and Rio Grande cichlid do not contain PCB concentrations exceeding the HAC_{nonca} for PCBs. Therefore, consumption of these fish species **poses no apparent risk to human health**.

2. That fish from Lower Leon Creek upstream of Rodriguez Park do not contain PCBs at concentrations exceeding DSHS guidelines for protection of human health. Therefore, consumption of fish from Lower Leon Creek upstream of Rodriguez Park **poses no apparent risk to human health.**

3. That fish excluding the sunfish species from Lower Leon Creek downstream of Rodriguez Park contained PCBs at concentrations exceeding DSHS guidelines for protection of human health. Regular or long-term consumption of fish by children, women of childbearing age, women past childbearing age, and adult men from Lower Leon Creek downstream of Rodriguez Park may result in adverse health effects. Therefore, consumption of fish from Lower Leon Creek downstream of Rodriguez Park **poses an apparent risk to human health**.

4. That consumption of multiple inorganic or organic contaminants in fish does not significantly increase the likelihood of systemic or carcinogenic health risks above that of PCBs observed in fish from Lower Leon Creek. Therefore, SALG risk assessors conclude that consuming fish containing multiple contaminants at concentrations near those observed in fish in addition to PCBs does not significantly increase the risk of adverse health effects.

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the EPA.[16, 18, 49] Risk managers at the DSHS may decide to take some action to protect public health if a risk characterization confirms that people can eat four, or fewer meals per month (adults: eight ounces per meal; children: four ounces per meal) of fish or shellfish from a water body under investigation. Risk management recommendations may be in the form of consumption advice or a ban on possession of fish from the affected water body. Fish or shellfish possession bans are enforceable under subchapter D of the Texas Health and Safety Code, part 436.061(a).[50]. Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[50] DSHS consumption advice carries no penalty for noncompliance. Consumption advisories, instead, inform the public of potential health hazards associated with consuming contaminated fish or shellfish from Texas waters. With this information, members of the public can make informed decisions about whether and/or how much – contaminated fish or shellfish they wish to consume. The SALG concludes from this risk characterization that consuming fish from Lower Leon Creek **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend

1. That pregnant women, women who may become pregnant, women who are nursing infants, children less than 12 years of age or who weigh less than 75 pounds, women past childbearing age, and adult men should not consume any species of fish from Lower Leon Creek downstream of Rodriguez Park.

2. That as resources become available, the DSHS should continue to monitor fish from Lower Leon Creek for changes or trends in contaminants or contaminant concentrations that would necessitate a change in consumption advice.

PUBLIC HEALTH ACTION PLAN

Communication to the public of new and continuing possession bans or consumption advisories, or the removal of either, is essential to effective management of risk from consuming contaminated fish. In fulfillment of the responsibility for communication, DSHS takes several steps. The agency publishes fish consumption advisories and bans in a booklet available to the public through the SALG. To receive the booklet and/or the data, please contact the SALG at 1-512-834-6757.[51] The SALG also posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.state.tx.us/seafood. The SALG regularly updates this Web site. The DSHS also provides EPA (http://epa.gov/waterscience/fish/advisories/), the TCEQ (http://www.tceq.state.tx.us), and the TPWD (http://www.tpwd.state.tx.us) with information on all consumption advisories and possession bans. Each year, the TPWD informs the fishing and hunting public of consumption advisories and fishing bans on its Web site and in an official downloadable PDF file containing general hunting and fishing regulations booklet available at http://www.tpwd.state.tx.us/publications/nonpwdpubs/media/regulations_summary_2009_2010.pdf. [52] A booklet containing this information is available at all establishments selling Texas fishing licenses.[53] Readers may direct questions about the scientific information or recommendations in this risk characterization to the SALG at 512-834-6757 or may find the information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Branch of DSHS (512-458-7269). The EPA's IRIS Web site (http://www.epa.gov/iris/) contains information on environmental contaminants found in food and environmental media. The ATSDR, Division of Toxicology (888-42-ATSDR or 888-422-8737 or the ATSDR's Web site (http://www.atsdr.cdc.gov) supplies brief information via ToxFAQs.™ ToxFAQs™ are available on the ATSDR Web site in either English http://www.atsdr.cdc.gov/toxfaq.html) or Spanish (http://www.atsdr.cdc.gov/es/toxfaqs/es _toxfaqs.html). The ATSDR also publishes more in-depth reviews of many toxic substances in its *Toxicological Profiles* (ToxProfiles™). To request a copy of the ToxProfiles™ CD-ROM, PHS, or ToxFAQs™ call 1-800-CDC-INFO (800-232-4636) or email a request to cdcinfo@cdc.gov.

Figure 1. Lower Leon Creek Sample Sites

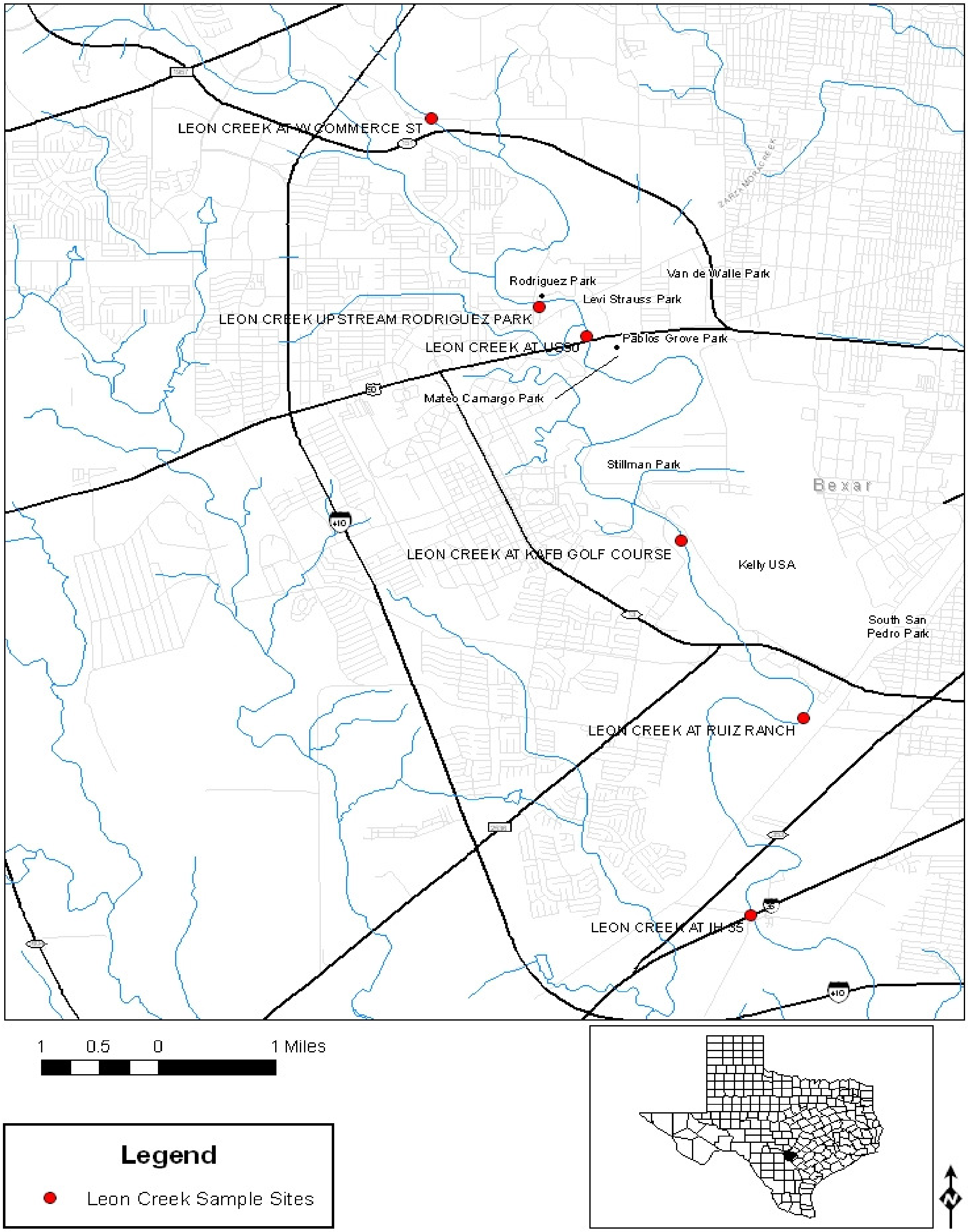


Figure 2. Mean PCB (all fish combined) concentration by sample site. Fish collected from Lower Leon Creek, November 2007.

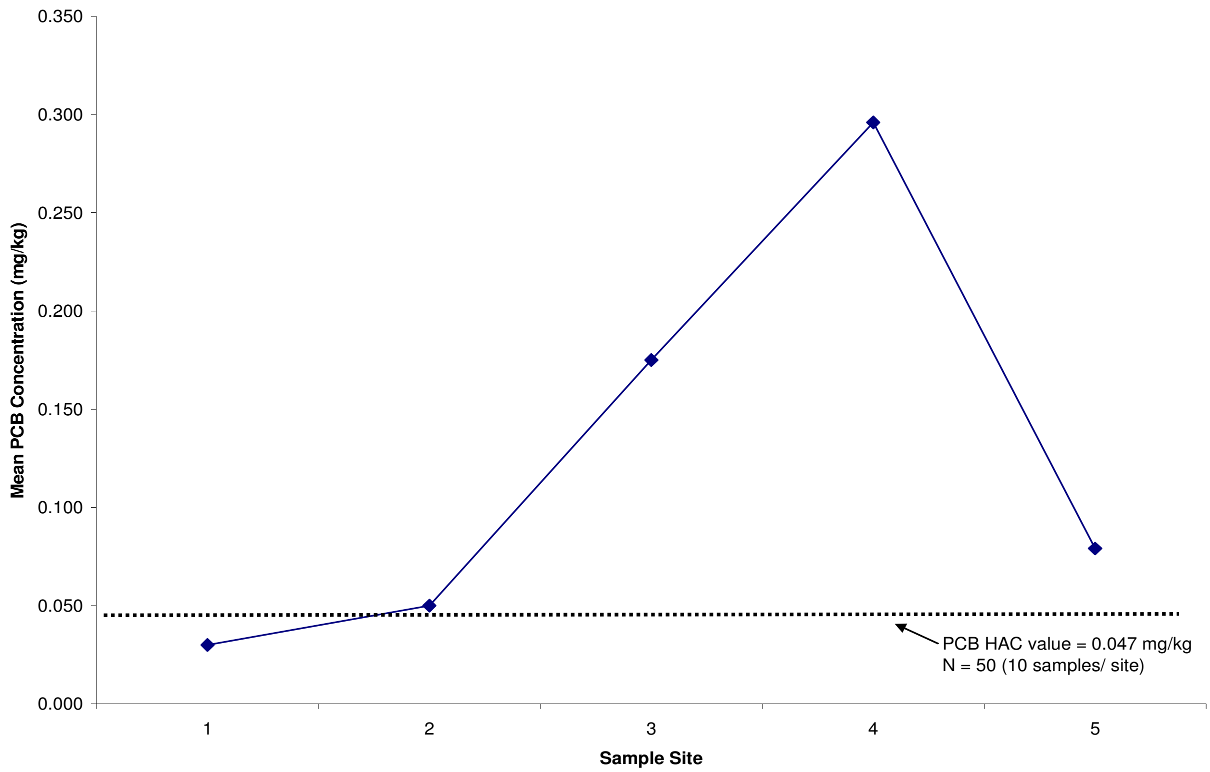


Figure 3. Common carp mean PCB concentration by sample site. Fish collected from Lower Leon Creek, November 2007.

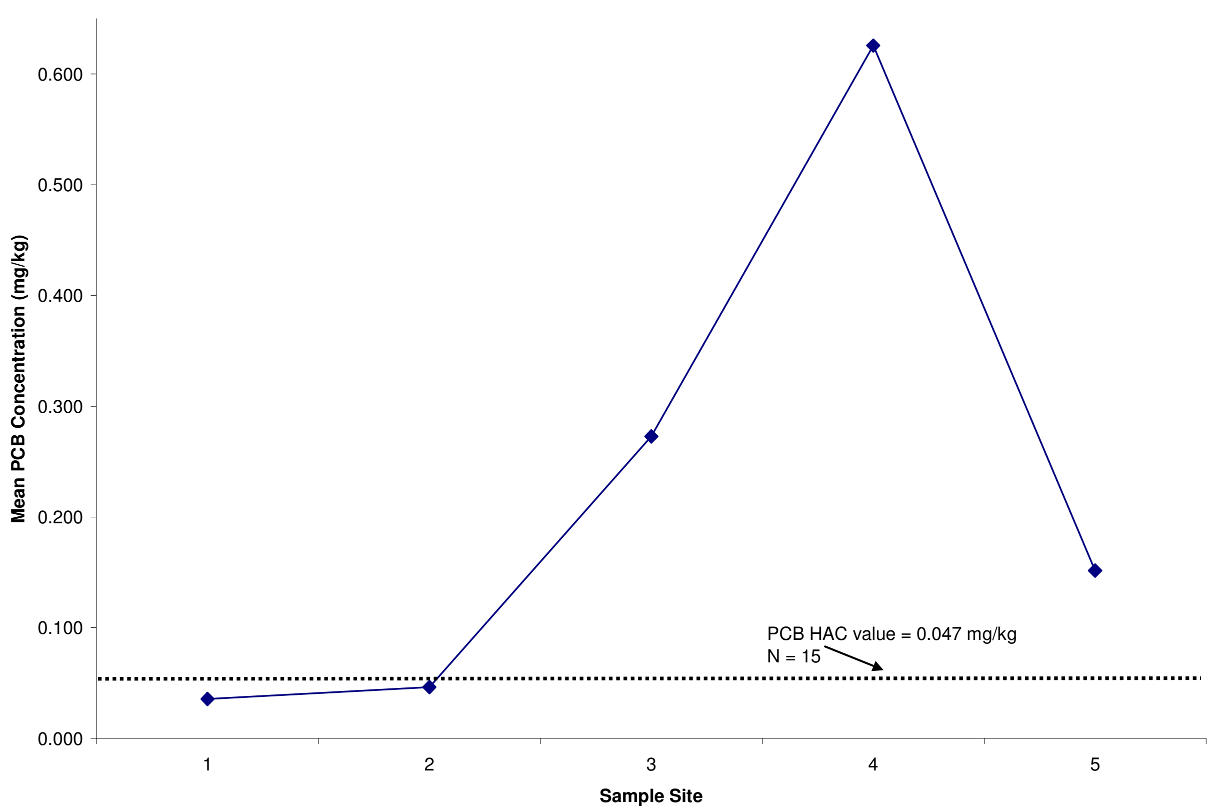
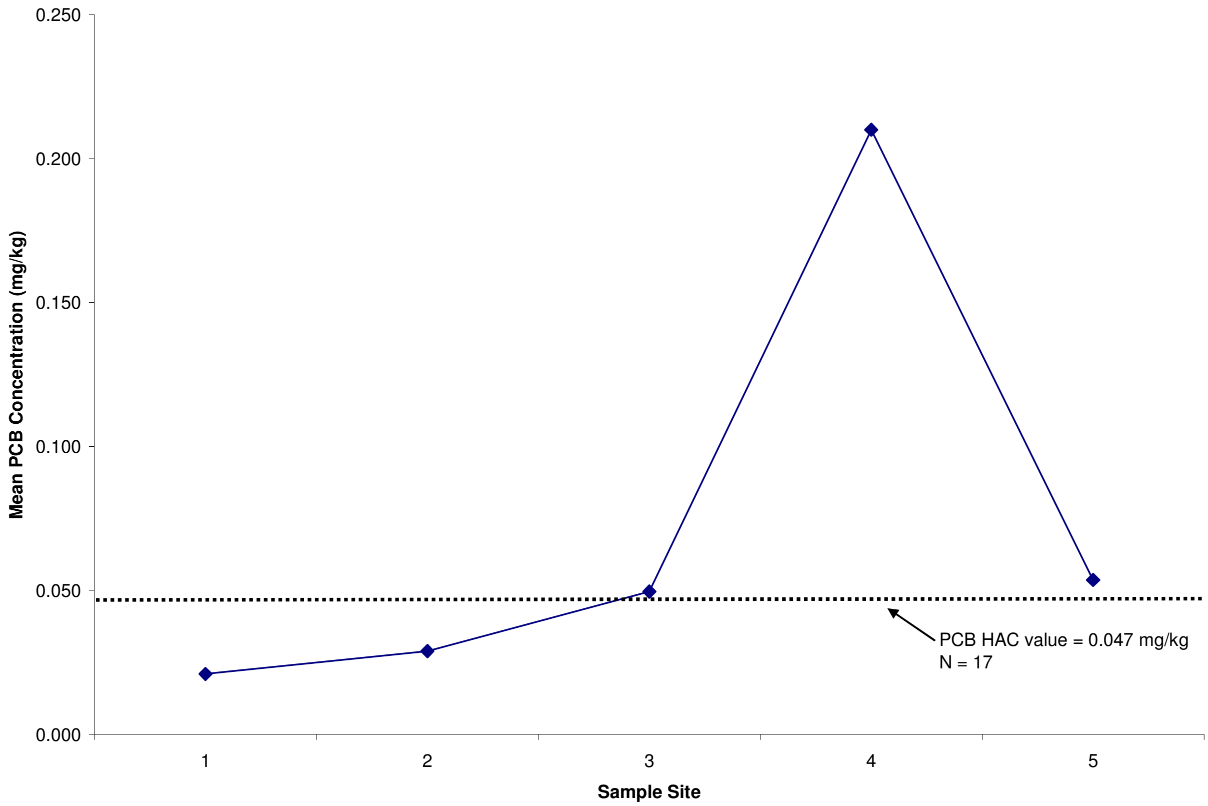


Figure 3. Largemouth bass mean PCB concentration by sample site. Fish collected from Lower Leon Creek, November 2007.



TABLES

Table 1. Fish samples collected from Lower Leon Creek on November 7 through November 9, 2007. Sample number, species, length, and weight are recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Site 1 Lower Leon Creek @ Commerce Street / Rodriguez Park			
LEC39	Largemouth bass	282	382
LEC40	Largemouth bass	257	286
LEC41	Rio Grande cichlid	189	179
LEC42	Bluegill	164	100
LEC39	Largemouth bass	282	382
LEC40	Largemouth bass	257	286
LEC41	Rio Grande cichlid	189	179
LEC42	Bluegill	164	100
LEC39	Largemouth bass	282	382
LEC40	Largemouth bass	257	286
Site 2 Lower Leon Creek @ U.S. 90			
LEC12	Common carp	584	2787
LEC13	Common carp	580	2771
LEC14	Channel catfish	560	2036
LEC15	Channel catfish	448	764
LEC16	Largemouth bass	398	1090
LEC17	Largemouth bass	382	747
LEC18	Largemouth bass	382	821
LEC19	Largemouth bass	374	688
LEC20	Spotted gar	610	942
LEC21	Spotted gar	609	906
Site 3 Lower Leon Creek @ KAFB Golf Course			
LEC1	Common carp	652	3619
LEC2	Common carp	690	4881
LEC3	Common carp	626	3271
LEC5	Largemouth bass	503	1757
LEC6	Largemouth bass	372	700
LEC7	Largemouth bass	372	700
LEC8	Largemouth bass	373	693
LEC9	Redear sunfish	192	142
LEC10	Spotted gar	678	1065
LEC11	Spotted gar	530	616

Table 1 continued. Fish samples collected from Lower Leon Creek on November 7 through November 9, 2007. Sample number, species, length, and weight are recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Site 4 Lower Leon Creek @ Ruiz Ranch			
LEC22	Common carp	715	5240
LEC23	Common carp	613	3049
LEC24	Common carp	622	2987
LEC25	Largemouth bass	412	1167
LEC26	Largemouth bass	432	1373
LEC27	Largemouth bass	445	1208
LEC28	Largemouth bass	380	842
LEC29	Channel catfish	520	1413
LEC30	Bluegill	186	119
LEC31	Spotted gar	645	1134
Site 5 Lower Leon Creek @ I.H. 35			
LEC43	Largemouth bass	425	1136
LEC44	Largemouth bass	397	874
LEC45	Largemouth bass	363	667
LEC47	Guadalupe bass	379	796
LEC48	Channel catfish	590	2357
LEC49	Channel catfish	515	1451
LEC50	Channel catfish	332	317
LEC51	Common carp	471	1397
LEC52	Common carp	437	946
LEC53	Redbreast sunfish	225	181

Table 2a. Arsenic (mg/kg) in fish collected from Lower Leon Creek, 2007.

Species	# Detected/ # Sampled	Total Arsenic Mean Concentration ± S.D. (Min-Max)	Inorganic Arsenic Mean Concentration[e]	Health Assessment Comparison Value (mg/kg)[f]	Basis for Comparison Value
Bluegill	2/3	0.010±0.0008 (ND[g]-0.011)	**0.001**	0.7 0.362	EPA chronic oral RfD for Inorganic arsenic: 0.0003 mg/kg–day EPA oral slope factor for inorganic arsenic: 1.5 per mg/kg–day
Channel catfish	2/6	0.012±0.002 (ND-0.015)	**0.001**		
Common carp	13/15	0.035±0.028 (ND-0.092)	**0.004**		
Guadalupe bass	0/1	ND	**ND**		
Largemouth bass	7/17	0.017±0.015 (ND-0.064)	**0.002**		
Redbreast sunfish	1/1	BDL[h]	**BDL**		
Redear sunfish	1/1	0.053	**0.005**		
Rio Grande cichlid	1/1	0.031	**0.003**		
Spotted gar	4/5	0.021±0.023 (ND-0.062)	**0.002**		
All fish combined	31/50	0.023±0.021 (ND-0.092)	**0.002**		

[e] *Most arsenic in fish and shellfish occurs as organic arsenic, considered virtually nontoxic. For risk assessment calculations, DSHS assumes that total arsenic is composed of 10% inorganic arsenic in fish and shellfish tissues.*
[f] *Derived from the MRL or RfD for noncarcinogens or the EPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of $1x10^{-4}$.*
[g] *ND:* "Not Detected" was used to indicate that a compound was not present in a sample at a level greater than the RL.
[h] *BDL: "Below Detection Limit" – Concentrations were reported as less than the laboratory's method detection limit ("J" values). In some instances, a "J" value was used to denote the discernable presence in a sample of a contaminant at concentrations estimated as different from the sample blank.*

Table 2b. Inorganic contaminants (mg/kg) in fish collected from Lower Leon Creek, 2007.

Species	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Cadmium				
Bluegill	2/3	BDL	0.47	ATSDR chronic oral MRL: 0.0002 mg/kg–day
Channel catfish	3/6	BDL		
Common carp	6/15	BDL		
Guadalupe bass	0/1	ND		
Largemouth bass	2/17	BDL		
Redbreast sunfish	1/1	BDL		
Redear sunfish	0/1	ND		
Rio Grande cichlid	0/1	ND		
Spotted gar	1/5	BDL		
All fish combined	15/50	BDL		
Copper				
Bluegill	3/3	0.143±0.026 (0.126-0.173)	333	National Academy of Science Upper Limit: 0.143 mg/kg–day
Channel catfish	6/6	0.248±0.052 (0.190-0.338)		
Common carp	15/15	0.585±0.173 (0.335-0.879)		
Guadalupe bass	1/1	0.153		
Largemouth bass	17/17	0.161±0.034 (0.122-0.238)		
Redbreast sunfish	1/1	0.122		
Redear sunfish	1/1	0.153		
Rio Grande cichlid	1/1	0.283		
Spotted gar	5/5	0.136±0.019 (0.106-0.156)		
All fish combined	50/50	0.296±0.217 (0.106-0.879)		

Table 2c. Inorganic contaminants (mg/kg) in fish collected from Lower Leon Creek, 2007.

Species	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Lead				
Bluegill	3/3	BDL	NA	EPA IEUBKwin32 Version 1.1 Build 9
Channel catfish	6/6	BDL		
Common carp	15/15	0.056±0.029 (BDL-0.147)		
Guadalupe bass	1/1	BDL		
Largemouth bass	17/17	0.064±0.047 (BDL-0.193)		
Redbreast sunfish	1/1	BDL		
Redear sunfish	1/1	BDL		
Rio Grande cichlid	1/1	BDL		
Spotted gar	5/5	0.054±0.026 (BDL-0.100)		
All fish combined	50/50	0.055±0.033 (BDL-0.193)		
Mercury				
Bluegill	3/3	BDL	0.7	ATSDR chronic oral MRL: 0.0003 mg/kg–day
Channel catfish	6/6	0.114±0.076 (BDL-0.250)		
Common carp	15/15	0.133±0.066 (BDL-0.257)		
Guadalupe bass	1/1	0.290		
Largemouth bass	17/17	0.316±0.105 (0.160-0.517)		
Redbreast sunfish	1/1	0.139		
Redear sunfish	1/1	0.132		
Rio Grande cichlid	1/1	BDL		
Spotted gar	5/5	0.431±0.062 (0.366-0.528)		
All fish combined	50/50	0.221±0.139 (BDL-0.528)		

Table 2d. Inorganic contaminants (mg/kg) in fish collected from Lower Leon Creek, 2007.

Species	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Selenium				
Bluegill	3/3	0.291±0.045 (0.241-0.330)	6	EPA chronic oral RfD: 0 .005 mg/kg–day ATSDR chronic oral MRL: 0.005 mg/kg–day NAS UL: 0.400 mg/day (0.005 mg/kg–day) RfD or MRL/2: (0.005 mg/kg –day/2= 0.0025 mg/kg–day) to account for other sources of selenium in the diet
Channel catfish	6/6	0.214±0.036 (0.154-0.257)		
Common carp	15/15	0.371±0.131 (0.198-0.640)		
Guadalupe bass	1/1	0.274		
Largemouth bass	17/17	0.273±0.086 (0.170-0.551)		
Redbreast sunfish	1/1	0.278		
Redear sunfish	1/1	0.299		
Rio Grande cichlid	1/1	0.290		
Spotted gar	5/5	0.223±0.058 (0.180-0.325)		
All fish combined	50/50	0.292±0.105 (0.154-0.640)		
Zinc				
Bluegill	3/3	5.523±0.139 (5.371-5.644)	700	EPA chronic oral RfD: 0.3 mg/kg–day
Channel catfish	6/6	4.717±0.891 (3.718-5.675)		
Common carp	15/15	6.442±2.964 (3.897-15.692)		
Guadalupe bass	1/1	3.079		
Largemouth bass	17/17	4.056±0.698 (3.203-5.502)		
Redbreast sunfish	1/1	6.552		
Redear sunfish	1/1	7.587		
Rio Grande cichlid	1/1	4.557		
Spotted gar	5/5	2.492±0.108 (2.396-2.658)		
All fish combined	50/50	4.894±2.149 (2.396-15.692)		

Table 3. Pesticides (mg/kg) in fish collected from Lower Leon Creek, 2007				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
4,4' DDE				
Channel catfish	3/3	0.167±0.231 (0.028-0.434)	1.167 1.599	EPA chronic oral RfD: 0.0005 mg//kg–day EPA slope factor 0.34 per mg/kg - day
Common carp	6/6	0.152±0.193 (0.017-0.440)		
Largemouth bass	1/1	0.029		
All fish combined	10/10	0.144±0.185 (0.017-0.440)		
Chlordane				
Channel catfish	3/3	0.042±0.040 (0.014-0.088)	1.167 1.553	EPA chronic oral RfD: 0.0005 mg//kg–day EPA slope factor 0.35 per mg/kg–day
Common carp	6/6	0.032±0.020 (BDL-0.055)		
Largemouth bass	1/1	BDL		
All fish combined	10/10	0.033±0.026 (BDL-0.088)		

Table 4a. PCBs (mg/kg) in fish collected in 2007 from Lower Leon Creek.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Site 1 Lower Leon Creek @ Commerce St. / Rodriguez Park				
Bluegill	2/2	0.028±0.010 (BDL- 0.035)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	5/5	0.036±0.007 (0.024-0.040)		
Largemouth bass	2/2	BDL		
Rio Grande cichlid	1/1	BDL		
All fish combined	10/10	0.030±0.009 (BDL-0.040)		
Site 2 Lower Leon Creek @ U.S. 90				
Channel catfish	2/2	**0.061**[*] ±0.020 (**0.047- 0.075**)		
Common carp	2/2	0.046±0.022 (0.031- **0.062**)		
Largemouth bass	4/4	0.029±0.009 (0.023-0.043)		
Spotted gar	2/2	**0.083**±0.021 (**0.068- 0.098**)		
All fish combined	10/10	**0.050**±0.025 (0.023-**0.098**)		
Site 3 Lower Leon Creek @ KAFB				
Common carp	3/3	**0.273**±0.142 (**0.187-0.437**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Largemouth bass	4/4	**0.050**±0.018 (0.038-**0.077**)		
Redear sunfish	1/1	0.023		
Spotted gar	2/2	**0.357**±0.230 (**0.194- 0.520**)		
All fish combined	10/10	**0.175**±0.175 (0.023-**0.520**)		

[*] Emboldened numbers denote concentrations of PCBs that exceed the HAC_{nonca} for Aroclor 1254

Table 4b. PCBs (mg/kg) in fish collected in 2007 from Lower Leon Creek.

Species	# Detected / # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Site 4 Lower Leon Creek @ Ruiz Ranch				
Bluegill	1/1	0.025		
Channel catfish	1/1	**0.167**		
Common carp	3/3	**0.626**±0.291 (**0.433-0.961**)	0.047	EPA chronic oral RfD: 0.00002 mg/kg–day
Largemouth bass	4/4	**0.210**±0.152 (**0.063-0.411**)	0.272	EPA slope factor: 2.0 per mg/kg–day
Spotted gar	1/1	**0.053**		
All fish combined	10/10	**0.296**±0.287 (0.025-**0.961**)		
Site 5 Lower Leon Creek @ I.H. 35				
Channel catfish	3/3	**0.085**±0.014 (**0.070-0.096**)		
Common carp	2/2	**0.152**±0.045 (**0.120- 0.183**)		
Guadalupe bass	1/1	0.040	0.047	EPA chronic oral RfD: 0.00002 mg/kg–day
Largemouth bass	3/3	**0.054**±0.013 (0.043-**0.069**)	0.272	EPA slope factor: 2.0 per mg/kg–day
Redbreast sunfish	1/1	0.034		
All fish combined	10/10	**0.079**±0.046 (0.034-**0.183**)		
Lower Leon Creek All Sites				
Bluegill	3/3	0.027±0.007 (BDL-0.035)		
Channel catfish	6/6	**0.091**±0.041 (**0.047-0.167**)		
Common carp	15/15	**0.218**±0.261 (0.024-**0.961**)		
Guadalupe bass	1/1	0.040		
Largemouth bass	17/17	**0.080**±0.100 (BDL-**0.411**)	0.047	EPA chronic oral RfD: 0.00002 mg/kg–day
Redbreast sunfish	1/1	0.034	0.272	EPA slope factor: 2.0 per mg/kg–day
Redear sunfish	1/1	0.023		
Rio Grande cichlid	1/1	BDL		
Spotted gar	5/5	**0.186**±0.194 (**0.053-0.520**)		
All fish combined	50/50	**0.126**±0.177 (BDL-**0.961**)		

* Emboldened numbers denote concentrations of PCBs that exceed the HAC_{nonca} for Aroclor 1254

Table 5a. PCDFs/PCDDs toxicity equivalent (TEQ) concentrations (pg/g) in fish collected in 2007 from Lower Leon Creek.

Species	# Detected / # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Site 1 Lower Leon Creek @ Commerce St. / Rodriguez Park				
Common carp	2/2	0.022±0.030 (ND-0.043)	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Site 2 Lower Leon Creek @ U.S. 90				
Channel catfish	1/1	0.155	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Common carp	0/1	ND		
All fish combined	1/2	0.078±0.110 (ND-0.155)		
Site 3 Lower Leon Creek @ KAFB				
Common carp	1/1	1.288	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Largemouth bass	0/1	ND		
All fish combined	1/2	0.644±0.911 (ND,-1.288)		
Site 4 Lower Leon Creek @ Ruiz Ranch				
Channel catfish	1/1	1.669	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Common carp	1/1	0.897		
All fish combined	2/2	1.283±0.546 (0.897-1.669)		
Site 5 Lower Leon Creek @ I.H. 35				
Channel catfish	1/1	1.551	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Common carp	1/1	0.468		
All fish combined	2/2	1.010±0.766 (0.468-1.551)		
Lower Leon Creek All Sites				
Channel catfish	3/3	1.125±0.842 (0.155-1.669)	2.33 3.49	ATSDR chronic oral MRL: 1.0×10^{-9} mg/kg/day EPA slope factor: 1.56×10^{5} per mg/kg/day
Common carp	5/6	0.449±0.543 (ND-1.288)		
Largemouth bass	0/1	ND		
All fish combined	8/10	0.607±0.684 (ND-1.669)		

Table 6a. Hazard quotients (HQ's) for PCBs in fish collected from Lower Leon Creek in 2007. Table 6b also provides suggested weekly eight-ounce meal consumption rates 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Site 1 Lower Leon Creek @ Commerce St. / Rodriguez Park			
Bluegill	2	0.6	1.5
Common carp	5	0.8	1.2
Largemouth bass	2	0.5	2.1
Rio Grande cichlid	1	0.5	2.1
All fish combined	10	0.6	1.4
Site 2 Lower Leon Creek @ U.S. 90			
Channel catfish	2	**1.3***[*]	**0.7**[†]
Common carp	2	**1.0**	**0.9**
Largemouth bass	4	0.6	1.5
Spotted gar	2	**1.8**	**0.5**
All fish combined	10	**1.1**	**0.9**
Site 3 Lower Leon Creek @ KAFB			
Common carp	3	**5.9**	**0.2**
Largemouth bass	4	**1.1**	**0.9**
Redear sunfish	1	0.5	1.9
Spotted gar	2	**7.7**	**0.1**
All fish combined	10	**3.8**	**0.2**
Site 4 Lower Leon Creek @ Ruiz Ranch			
Bluegill	1	0.5	1.7
Channel catfish	1	**3.6**	**0.3**
Common carp	3	**13.4**	**0.1**
Largemouth bass	4	**4.5**	**0.2**
Spotted gar	1	**1.1**	**0.8**
All fish combined	10/10	**6.3**	**0.1**

[*] Emboldened numbers denote the HQ for PCBs exceeds 1.0
[†] Emboldened numbers denote the calculated allowable meal consumption rate for an adult is less than one/week.

Table 6b. Hazard quotients (HQ's) for PCBs in fish collected from Lower Leon Creek in 2007. Table 6b also provides suggested weekly eight-ounce meal consumption rates 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Site 5 Lower Leon Creek @ I.H. 35			
Channel catfish	3	**1.8**	**0.5**
Common carp	2	**3.2**	**0.3**
Guadalupe bass	1	0.9	1.1
Largemouth bass	3	**1.2**	**0.8**
Redbreast sunfish	1	0.7	1.3
All fish combined	10/10	**1.7**	**0.5**
Lower Leon Creek All Sites			
Bluegill	3	0.6	1.6
Channel catfish	6	**1.9**	**0.5**
Common carp	15	**4.7**	**0.2**
Guadalupe bass	1	0.9	1.1
Largemouth bass	17	**1.7**	**0.5**
Redbreast sunfish	1	0.7	1.3
Redear sunfish	1	0.5	1.9
Rio Grande cichlid	1	0.5	2.1
Spotted gar	5	**4.0**	**0.2**
All fish combined	50/50	**2.7**	**0.3**

Table 7. Hazard quotients (HQ's) and hazard indices (HI's) for PCDFs/PCDDs and/or PCBs in fish species collected in 2007 from Lower Leon Creek. Table 6a also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[i]

Species/Contaminant	Number (N)	Hazard Quotient	Meals per Week
Channel catfish			
PCBs	6	**1.9***	**0.5**†
PCDDs/PCDFs	3	0.5	1.9
Hazard Index (meals per week)		**2.4 (0.4)**	
Common carp			
PCBs	15	**4.7**	**0.2**
PCDDs/PCDFs	6	0.2	4.8
Hazard Index (meals per week)		**4.9 (0.2)**	
Largemouth bass			
PCBs	17	**1.7**	**0.5**
PCDDs/PCDFs	1	0.0	unrestricted
Hazard Index (meals per week)		**1.7 (0.5)**	
All Fish			
PCBs	50	**2.7**	**0.3**
PCDDs/PCDFs	10	0.3	3.6
Hazard Index (meals per week)		**3.0 (0.3)**	

* Emboldened numbers denote the HQ for PCBs exceeds 1.0
† Emboldened numbers denote the calculated allowable meal consumption rate for an adult is less than one/week.

[i] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*

Table 8a. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2007 from Lower Leon Creek and suggested consumption (8-ounce meals/week) for 70 kg adults who regularly eat fish from Lower Leon Creek over a 30-year period. [j]				
Species	**Number (N)**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**1 excess cancer per number of people exposed**	
Site 1 Lower Leon Creek @ Commerce St. / Rodriguez Park				
Bluegill	2	1.0E-05	97,222	9.0
Common carp	5	1.3E-05	75,617	7.0
Largemouth bass	2	7.7E-06	129,630	12.0
Rio Grande cichlid	1	7.7E-06	129,630	12.0
All fish combined	10	1.1E-05	90,741	8.4
Site 2 Lower Leon Creek @ U.S. 90				
Channel catfish	2	2.2E-05	44,627	4.1
Common carp	2	1.7E-05	59,179	5.5
Largemouth bass	4	1.1E-05	93,870	8.7
Spotted gar	2	3.0E-05	32,798	3.0
All fish combined	10	1.8E-05	54,444	5.0
Site 3 Lower Leon Creek @ KAFB				
Common carp	3	**1.0E-04***	**9,972**	**0.9**†
Largemouth bass	4	1.8E-05	54,444	5.0
Redear sunfish	1	8.4E-06	118,357	10.9
Spotted gar	2	**1.3E-04**	**7,625**	**0.7**
All fish combined	10	6.4E-05	15,556	1.4

* Emboldened numbers denote calculated excess lifetime cancer risk after 30 years exposure is greater than 1 X 10^{-4}

† Emboldened numbers denote the calculated meal consumption rate for adults is less than one per week

[j] DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.

Table 8b. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2007 from Lower Leon Creek and suggested consumption (8-ounce meals/week) for 70 kg adults who regularly eat fish from Lower Leon Creek over a 30-year period.

Species	Number (N)	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	1 excess cancer per number of people exposed	
Site 4 Lower Leon Creek @ Ruiz Ranch				
Bluegill	1	9.2E-06	108,889	10.1
Channel catfish	1	6.1E-05	16,301	1.5
Common carp	3	**2.3E-04**	**4,349**	**0.4**
Largemouth bass	4	7.7E-05	12,963	1.2
Spotted gar	1	1.9E-05	51,363	4.7
All fish combined	10	**1.1E-04**	**9,197**	**0.8**
Site 5 Lower Leon Creek @ I.H. 35				
Channel catfish	3	3.1E-05	32,026	3.0
Common carp	2	5.5E-05	18,028	1.7
Guadalupe bass	1	1.5E-05	67,432	6.2
Largemouth bass	3	2.0E-05	50,412	4.7
Redbreast sunfish	1	1.2E-05	80,065	7.4
All fish combined	10	2.9E-05	34,459	3.2
Lower Leon Creek All Sites				
Bluegill	3	1.0E-05	100,266	9.3
Channel catfish	6	3.3E-05	29,918	2.8
Common carp	15	8.0E-05	12,487	1.2
Guadalupe bass	1	1.5E-05	67,432	6.2
Largemouth bass	17	2.9E-05	34,028	3.1
Redbreast sunfish	1	1.2E-05	80,065	7.4
Redear sunfish	1	8.4E-06	118,357	10.9
Rio Grande cichlid	1	7.7E-06	129,630	12.0
Spotted gar	5	6.8E-05	14,617	1.4
All fish combined	50	4.6E-05	21,596	2.0

Table 9. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish containing PCDFs/PCDDs and PCBs collected in 2007 from Lower Leon Creek and suggested consumption (8-ounce meals/week) for 70 kg adults who regularly eat fish from Lower Leon Creek over a 30-year period.[j]

Species/Contaminant	Number (N)	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	1 excess cancer per number of people exposed	
Channel catfish				
PCBs	6	3.3E-05	29,918	2.8
PCDDs/PCDFs	3	3.2E-05	31,022	2.9
Cumulative Cancer Risk		6.6E-05	15,230	1.4
Common carp				
PCBs	15	8.0E-05	12,487	1.2
PCDDs/PCDFs	6	1.3E-05	77,729	7.2
Cumulative Cancer Risk		9.3E-05	10,759	1.0
Largemouth bass				
PCBs	17	2.9E-05	34,028	3.1
PCDDs/PCDFs	1	0.0	------	unrestricted
Cumulative Cancer Risk		2.9E-05	34,028	3.1
All Fish				
PCBs	50	4.6E-05	21,596	2.0
PCDDs/PCDFs	10	1.7E-05	57,496	5.3
Cumulative Cancer Risk		6.4E-05	15,699	1.5

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