# Village Creek

# Hardin County, Texas

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**Department of State Health Services**
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**Policy, Standards, and Quality Assurance Unit**
**Seafood and Aquatic Life Group**

# INTRODUCTION

### *Description of Village Creek*

Village Creek is a free flowing stream arising near the Alabama-Coushatta Indian Reservation in Hardin County and meandering some 69 miles southeasterly to its confluence with the Neches River near Lumberton and Silsbee, Texas.[1] The Village Creek watershed lies entirely within the Big Thicket National Preserve – known locally as "The Big Thicket." The Big Thicket National Preserve is home to some of North America's richest biological diversity. Village Creek is composed of six tributaries draining approximately 1,113 square miles: Big Sandy Creek, Hickory Creek, Turkey Creek, Beech Creek, Beaumont Creek, and Cypress Creek. [2,3] The clear tannic waters of Village creek flow over white sand and gravel, through cypress swamps, and pine and hardwood forests. Due to its remoteness and lack of reservoirs, Village Creek retains its wild and pristine characteristics. Nonetheless, Village Creek is a popular outdoor recreation destination in southeast Texas, offering outdoor recreational activities such as canoeing, camping, and fishing. The Big Thicket National Preserve and Village Creek State Park provide access to the stream, as do a Texas Parks and Wildlife Department (TPWD) boat ramps at U.S. Highway 96 and at a few major highway crossings.[4]

### *Demographics of Hardin County near Village Creek*

In 2007, the census bureau reported the population of Hardin County to be 51,597 people.[5] Hardin County's center is located in Southeast Texas approximately 23 miles northwest of Beaumont (2007 population estimate 109,599).[6] Kountze (2007 population estimate 2,161) is the seat of county government for Hardin County, TX.[7] The Hardin County population is predominantly rural with an estimated 41% of the population residing in five towns: Lumberton, Silsbee, Kountze, Sour Lake, and Rose Hill Acres.[8]

### *Subsistence Fishing at Village Creek*

The United States Environmental Protection Agency (USEPA) suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to the rate of subsistence fishing in an area.[9] The USEPA and the Department of State Health Services for the State of Texas (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 is similar to that estimated by the USEPA.[9]

### *History of the Tier 2 Mercury in East Texas Water Bodies Project*

Three Texas agencies, the DSHS, the Texas Commission on Environmental Quality (TCEQ), and the TPWD, have critical interests in – and responsibilities for – evaluating and remediating contaminants in the waters of Texas, their sediments, and the fish and shellfish that inhabit those waters. The Seafood and Aquatic Life Group (SALG) at DSHS determines whether chemical contaminants in fish or shellfish pose a health risk to those who would consume those fish or shellfish and – if so – is responsible for issuing health advisories or prohibiting possession of contaminated fish or shellfish from public water bodies in Texas.[10] Among its other duties, the TCEQ establishes and manages water quality standards for the state and addresses pollution in Texas' public waters. The TPWD manages state fish and wildlife resources, addresses pollution that may adversely affect these resources, and enforces closures or bans issued by DSHS. These, and several other state and federal agencies, coordinate oversight of contaminant monitoring of Texas waters – and their flora and fauna – through regular meetings of the Toxic Substances Coordinating Committee (TSCC), a legislatively mandated interagency committee.[11]

The *Tier 2 Mercury in East Texas Water Bodies Project* is a two-stage project that accesses the expertise and resources of the TCEQ, the TPWD, and the DSHS.[12] The TCEQ administered an USEPA grant that funded the project through fiscal year 2008. The major portion of those funds was used to fund analyses of fish tissues for chemical contaminants that – when regularly eaten to excess – could adversely affect an individual's health. The TPWD Inland Fisheries Division[a] Contaminants Assessment Team conducted Tier 1 assessments as part of a special three-year study of 60 reservoirs in 57 East Texas counties. The primary objectives of the study were to delineate the geographical extent of mercury bioaccumulation in fish and to ascertain biotic and abiotic factors resulting in mercury bioaccumulation.[13] The team selected East Texas as the study area because the Piney Woods and Oak Woodlands ecoregions of East Texas have water, soil, and terrestrial plant communities that may correlate with bioaccumulation of mercury in fish tissue. Coincidentally, the TPWD investigation identified water bodies that exceeded DSHS fish tissue mercury screening criteria. The TCEQ also performed Tier 1 assessments as a part of its normal field operations. To characterize potential human health risks from consumption of fish containing excess mercury, the DSHS selected for its Tier 2 studies water bodies surveyed by TPWD or TCEQ that yielded fish samples containing mercury at concentrations that exceeded the DSHS' mercury screening criterion (0.525 mg/kg).

From 2002-2004, the TCEQ sampled fish from Village Creek as a part of its routine monitoring operations.[12] The TCEQ collected five largemouth bass ranging in length from 14.5 to 16.0 inches, two smallmouth buffalo, and one freshwater drum. The TCEQ submitted these samples for analysis to the Lower Colorado River Authority (LCRA) Environmental Laboratory Services in Austin, Texas. To determine whether the DSHS should conduct a Tier 2 study on fish from Village Creek, the DSHS and TCEQ compared Tier 1 mercury concentrations in fish from Village Creek to the DSHS-established human health mercury screening value (SV). The average mercury concentration in largemouth bass (1.128 mg/kg) and smallmouth buffalo (0.750 mg/kg) exceeded the human health screening value for mercury (0.525 mg/kg). Mercury in the single freshwater drum sample (1.240 mg/kg) also exceeded the mercury SV. These data confirmed the necessity of a Tier 2 study of fish from Village Creek.

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[a] Formerly the TPWD Resource Protection Division

The present report summarizes the results of the 2007 Tier 2 evaluation of Village Creek fish that followed from the Tier 1 findings. The report addresses public health implications, if any, of consuming fish from Village Creek that contain mercury or other contaminants and suggests actions to prevent or mitigate potential adverse health effects from consuming such fish.

## METHODS

### *Fish Sampling, Preparation, and Analysis*

The DSHS SALG collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people who eat contaminated fish or shellfish from those waters. 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.*[14] 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.*[15] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee (TSCC) Fish Sampling Advisory Subcommittee (FSAS).*[16] 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 Village Creek 2007 Sample Set*

In April 2007 and June 2007, SALG staff collected 39 fish samples from Village Creek. The SALG selected four sites to provide spatial coverage of the study area (Figure 1). Site 1 was located near Village Creek State Park, Site 2 at the U.S. 96 crossing, Site 3 at the FM 327 crossing, and Site 4 at the U.S. 69 crossing. Species collected represent distinct ecological groups (e.g., 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 commonly consume. The 39 fish samples collected from Village Creek during the April and June 2007 sampling period represented all targeted species. Table 1 lists targeted species collected at each sampling site in descending alphabetical order of species. Species collected (total number) were freshwater drum (8), largemouth bass (8), spotted bass (8), channel catfish (6), spotted gar (4), black crappie (3), blue catfish (1), longnose gar (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 amps, 60 pulses per second [pps], high range 500-1000 volts, 80% duty cycle) 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 enhance tissue preservation.

SALG staff processed fish onsite at Village Creek**.** The SALG team weighed each sample to the nearest gram on an electronic scale and measured total length (tip of nose to tip of tail fin) to the nearest millimeter. After weighing and measuring a fish, the team used a cutting board covered with aluminum foil and a fillet knife to prepare two skin-off fillets from each fish. After processing a sample, the foil was changed and the knife cleaned with distilled water. The SALG team wrapped the fillet(s) in two layers of fresh aluminum foil, placed each sample into a clean, previously unused, pre-labeled plastic freezer bag, storing the samples on wet ice in an insulated chest until final processing. The SALG staff transported tissue samples on wet ice to the Austin, Texas, headquarters, where the samples were stored temporarily at -5° Fahrenheit (-20° Celsius) in a locked freezer. To ensure the chain of custody remains intact while samples are in the possession of agency staff, the freezer key is accessible only to authorized SALG team members. The week following each collection trip, the SALG team 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 delivery of the 2007 Village Creek fish tissue samples, GERG personnel notified the SALG of receipt of the 39 samples and recorded the sample's DSHS identification number and its condition when received.

Using established USEPA methods, the laboratory analyzed Village Creek fish fillets for many 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), 71 volatile organic compounds (VOCs), 34 pesticides, and 209 PCB congeners. The laboratory analyzed all 39 samples for mercury and three of 39 samples for pesticides, PCBs, SVOCs, VOCs, and for other metals.[17]

## ***Details and Explanatory Notes for Various Analyses***

### ***Arsenic***

The GERG laboratory analyzed each of three fish for total arsenic (total arsenic consists of both inorganic and organic arsenic compounds). Although the proportions of each form of arsenic may differ among species, under different environmental and water conditions, and, perhaps, with other variables, the literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form virtually non-toxic to humans.[18] DSHS, taking its cue from the literature, estimates 10% of the total arsenic measured in any fish is inorganic, deriving estimates of inorganic arsenic concentrations by multiplying the laboratory-reported total arsenic concentration in each fish by a factor of 0.1.[18]

### ***Mercury***

According to the literature, nearly all mercury in upper trophic level fish three years of age or older is methylmercury.[19] Thus, total mercury concentrations in upper trophic level fish of legal size for possession in Texas should serve well as surrogates 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 concentrations in fish and that – to protect human health – the states also assume that 100% of reported mercury in any fish or shellfish is methylmercury. Consequently, the GERG laboratory analyzed fish tissues for total mercury. In its risk characterizations, DSHS compares mercury in tissues to a comparison value derived from the ATSDR's minimal risk level for methylmercury.[20] In these documents, the DSHS may interchangeably utilize the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish.

### ***Polychlorinated Biphenyls (PCBs)***

For PCBs, the EPA suggests that a state measures congeners of PCBs in fish and shellfish rather than homologs or Aroclors® because congener analysis is likely the most sensitive measure of PCBs in environmental media.[17] 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 homologs of PCBs and of Aroclor® mixtures. Despite the EPA's suggestion that the states utilize PCB congeners rather than Aroclors® or homologs to estimate toxicity, the toxicology 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),[21] from McFarland and Clarke,[22] and from the EPA's guidance documents for assessing contaminants in fish and shellfish[15, 17] to address PCBs 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 were most likely – as projected from structure-activity relationships – to show assessable toxicity.[21,22] SALG risk assessors summed the 43 congeners to derive a "total" PCB concentration in each sample.[21,22] 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 study 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.[23] 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 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 purportedly devoid of dibenzofurans, in contrast to Aroclor 1254.[24] 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, and because, 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.[25]

### *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.[26] 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. [26]

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, blue crab, 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 (Beauchamp, Richard, 1999). 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 (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[27] or the ATSDR's chronic oral MRLs.[28] 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.*[29]

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.* [29]

The ATSDR uses a similar technique to derive its MRLs.[28] 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 an 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).*[30]

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, an 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. An 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 an 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 an 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 an 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. [27]

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, use of a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, and database insufficiencies.[27,29] 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 an RfD.[29, 31]

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 default procedure for calculating the HI for the exposure mixture chemicals is to add the hazard quotients (the ratio of the external exposure dose to the RfD) for all component chemicals affecting the same target organ or organ system.

The HI simulates an “HQ” for a mixture of contaminants if all chemicals in the mixture were tested simultaneously (as if a single chemical). For example, the HI for liver toxicity should approximate the degree of liver toxicity that would have been present if effects of the whole mixture were due to a single chemical. The investigators should decide which target organs the HIs for each mixture will address and should calculate a separate HI for each toxic effect of concern. The mixture components to be included in the calculation of a HI consist of all chemical components showing the effect described by the HI, regardless of the critical effect from which the RfD is derived.

Because the RfD is derived for the critical effect – the "toxic effect occurring at the lowest dose of a chemical” – the HI computed from HQs based on the chemicals’ RfDs may be overly conservative. That is, using RfDs to calculate HIs may exaggerate health risks from consumption of chemical 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 1 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 1, concern exists over potential toxicity. As more HI's for different effects exceed 1, the potential for human toxicity also increases.*

Thus,

*Concern should increase as the number of effect-specific HI's exceeding 1 increases. As a larger number of effect-specific HI's exceed 1, 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)[29] 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.[32, 33] 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) – times when toxicants can impair or alter the structure or function of susceptible systems.[34] 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.[35] 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.[27] Additionally, in accordance with the ATSDR's *Child Health Initiative*[36] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[37] 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.[38] In computing descriptive statistics, SALG risk assessors utilized ½ the detection limit for analytes designated as not detected (ND) or estimated (J)[b]. The SALG then used those descriptive statistics to generate the present report. SALG protocols do not require hypothesis testing. Nevertheless, when data are of sufficient quantity and quality, the SALG may, as needed, determine significant differences among contaminant concentrations in species and/or at collection sites. The SALG employed Microsoft Excel® spreadsheets to generate figures, to compute $HAC_{nonca}$ and $HAC_{ca}$ for contaminants, and to calculate HQs, HIs, cancer risk probabilities, and meal consumption limits for fish from Village Creek.[39] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the USEPA'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).[40, 41]

# RESULTS

The GERG laboratory completed and electronically transmitted the Village Creek sample results to the SALG in December 2008. The laboratory analyzed all 39 fish for mercury; three of the 39 Village Creek samples (VLC1-a spotted bass, VLC5-a spotted gar, and VLC11-a freshwater drum) for six other metals, 34 pesticides, 209 PCB congeners, and suites of SVOCs and VOCs.

For reference, Table 1 contains descriptive information on each of the 39 samples collected from Village Creek in April or June 2007. Tables 2a, 2b, and 2c contain summaries of metals analyses in fish collected during 2007 from Village Creek. The paper does not display summary results for pesticides, PCBs, SVOCs, or VOCs because fish from Village Creek contained contaminants from these categories at trace[c] concentrations and/or at concentration less than each toxicant's HAC values. Unless stated otherwise, tables present the number of samples containing a specific toxicant/number tested, the mean concentration ± 1 standard deviation and, in parentheses, the minimum detected- and the maximum detected concentrations. To derive the statistical range, one may subtract the minimum concentration of a toxicant from the maximum concentration. In the tables, results may be reported as "ND" (not detected), "BDL" (below detection limit), or as a mean concentration followed by the standard deviation of the mean concentration. Results noted as "BDL" rely upon the laboratory's method detection limit (MDL), defined as the minimum concentration of an analyte that can be measured and reported with 99% confidence that the concentration is greater than zero and the RL, that is, the analyte concentration that can be reliably achieved within contract-specified limits of precision and accuracy during routine analyses. Contaminant concentrations reported as below the RL are qualified as "J" concentrations in the GERG data report and appear as "BDL" in the tables of the present report.[42]

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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 an estimate, quantitation of which may not be reproducible or that may be otherwise suspect. The DSHS treats J-Values as "not detected" in its statistical analyses of sample datasets.*

### *Inorganic Contaminants*

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

The three Village Creek samples contained arsenic (VLC1 – a spotted bass; VLC5 – a spotted gar, and VLC11 – a freshwater drum; Table 2a). The mean total arsenic concentration was 0.104 mg/kg while the calculated mean inorganic arsenic concentration was approximately 0.010 mg/kg (Table 2a). The laboratory did not detect cadmium in the three fish (Table 2b). One of the three samples (spotted bass – VLC1) contained lead. In the assayed spotted bass, the laboratory reported lead as an estimated concentration. The three samples also contained copper (mean concentration 0.155 mg/kg), selenium ($\bar{x}$=0.768 mg/kg), and zinc ($\bar{x}$=2.561 mg/kg; Table 2b).

All 39 samples from Village Creek contained mercury (Table 2c). Mercury concentrations across all species and sampling sites ranged from 0.134 mg/kg to 1.231 mg/kg. The mean concentration was 0.544 mg/kg with a standard deviation of 0.288 mg/kg (Table 2c). The 95% lower and upper confidence limits (n=39) on the mean mercury concentration were 0.450 mg/kg and 0.637 mg/kg, respectively. The mean concentration of mercury in largemouth bass collected from Village Creek was 0.683±0.350 mg/kg (Table 2c) with lower and upper 95% confidence limits of 0.390 mg/kg and 0.976 mg/kg. The median concentration of mercury in largemouth bass was 0.589 mg/kg. A largemouth bass weighing 3.6 pounds and measuring 18.7 inches contained mercury at 1.231 mg/kg, the maximum mercury concentration observed in this survey. Mercury appeared to differ among species, with a low of 0.188 mg/kg in channel catfish and a high of 0.802 mg/kg in spotted gar. Channel catfish had lower mercury values than did other species.

To determine whether length or weight reliably predicted mercury concentration in largemouth bass or freshwater drum taken from Village Creek, the SALG analyzed these species from the Tier 2 Village Creek survey with several statistical techniques, including scatter plot graphs, cluster analysis, and independent t-tests. The scatter plots and trend lines showed a positive but nonlinear relationship between total length (TL) and mercury concentration in both freshwater drum and in largemouth bass. For instance, largemouth bass less than or equal to (≤)15.3 inches (n=6) contained a mean mercury concentration of 0.518 mg/kg while LMB ≥18.5 inches (n=2) contained mercury at more than double the concentration in largemouth bass between 14 and 15.5 inches in length ($\bar{x}$ = 1.180 mg/kg). In the present study, plots of body weight (BW) and mercury essentially duplicated those of TL and mercury concentration in both species, an expected finding, since BW correlated almost perfectly with TL (r >0.9) in both species. Thus, in largemouth bass and freshwater drum TL or BW was equally predictive of mercury concentration. These results suggest that larger fish of both species likely contain disproportionately higher levels of mercury than do smaller fish of these species (freshwater drum; largemouth bass).

### *Organic Contaminants*

#### ***Pesticides***

The GERG laboratory also analyzed a subsample of three of the 39 fish from Village Creek for 34 pesticides (1 spotted bass, l spotted gar, and 1 freshwater drum). The laboratory reported measurable, but low, quantities of mirex and 4,4'-DDE in two of the three fish (data not presented). One or more of the three samples contained trace[c] quantities of 2,4'-DDD, 4,4'-DDD, 2,4'-DDT, chlordane, diazinon, endosulfan II, malathion, methoxychlor, and penta-chlorobenzene. The laboratory detected no other pesticides in samples from Village Creek.

***PCBs***

The GERG laboratory analyzed the same three samples from Village Creek for PCBs as were examined for pesticides. Of the 43 congeners utilized to determine "total" PCB concentrations for SALG risk characterizations, the laboratory reported measurable concentrations of PCB 132/153/168 and PCB 138/158 (International Union of Pure and Applied Chemists [IUPAC] assigned numbers) in two of three fish (freshwater drum and spotted gar [data not presented]). The laboratory also detected trace[c] quantities (J-values) of PCBs 12, 13, 91, and 118 in one or more of the three samples (data not presented).

***SVOCs***

The GERG laboratory reported low but measurable concentrations of bis(2-ethylhexyl) phthalate in freshwater drum and spotted gar, two of the three fish examined for pesticides, PCBs, VOCs and SVOCs. The spotted bass contained only an estimated concentration of this contaminant (data not presented). The laboratory detected no other SVOCs in the three Village Creek samples analyzed for this suite of contaminants.

***VOCs***

The GERG laboratory reported measurable concentrations of carbon disulfide (ranging from 0.030 mg/kg to 0.132 mg/kg – data not tabled) in the three Village Creek samples analyzed for VOCs. The three fish contained traces[c] of acetone, bromomethane, chloromethane, methylene chloride, chloroform, 1, 2-dichloroethane, benzene, trichlorofluoromethane, dichlorodifluoromethane, toluene, and naphthalene. The procedural blanks also contained chloromethane, methylene chloride, benzene, dichlorodifluoromethane, toluene, and naphthalene, suggesting introduction during sample preparation.

## DISCUSSION

### *Risk Characterization*

Variability and uncertainty are inherent to quantitative assessment of risk. Thus, calculations that model risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below "actual" risks. Variability between calculated and 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. Many factors used to calculate comparison values come from experiments conducted in the laboratory

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[c] *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 by a "less than" (<) sign or by other standard notation.*

on nonhuman subjects. Variability and uncertainty in the estimates of toxicity might therefore arise from judgment calls by investigators or reviewers, e.g., the study chosen as the "critical" investigation, the species/strain of animal used in the critical study, the target organ observed to be the "critical organ," exposure periods, exposure route, or doses. Uncontrolled (confounding) variables or variations in other conditions could occur. Some contaminants are overtly toxic, while others have only subtle effects. Finally, available information varies by contaminant. The literature is replete with information on some toxicants while others have hardly any data.[27]Risk assessors often must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media despite these limitations. For those contaminants appearing in Village Creek fish for which enough information is given, the DSHS calculated risk parameters for systemic toxicity and for carcinogenicity in those who would consume fish from the creek. The SALG utilizes risk parameters in meal consumption calculations – integral to the SALG's risk characterizations as consumption limits are among the variables DSHS risk managers utilize to determine departmental actions to protect human health from adverse effects of consuming toxicants in fish from Texas waters. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow the discussion of the relevance of the Village Creek results to risk of human health effects.

### *Characterization of Systemic (Noncancerous) Health Effects from Consumption of Fish from Village Creek*

### *Inorganic Contaminants*

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

The three samples (spotted bass, spotted gar, and freshwater drum) collected in 2007 from Village Creek all contained arsenic. However, the concentration of total arsenic did not exceed the $HAC_{nonca}$ for inorganic arsenic, and because the concentration of inorganic arsenic in fish is unlikely to be more than 10% of the total, there is little likelihood that inorganic arsenic in fish from Village Creek would affect human health negatively.

None of the three fish analyzed for the panel of inorganic contaminants contained cadmium. Lead occurred at detectable levels in only one fish (VLC1) – and then at but a trace. These findings suggest that fish from Village Creek would be unlikely to contain arsenic, cadmium or lead at concentrations of significance to human health.

The spotted bass, spotted gar and freshwater drum each contained the essential trace elements copper, selenium, and zinc (Table 2b).[43] Although, if consumed at high concentrations, copper, selenium, and zinc may exhibit acute toxicity, these metallic elements occurred in fish from Village Creek only at concentrations far below their respective $HAC_{nonca}$ values. Calculated hazard quotients for each contaminant were well below 1.0. Thus, consumption of fish from Village Creek containing copper, selenium, and zinc at concentrations similar to those observed in the Village Creek samples would not likely cause adverse health effects.

Mercury was present in all 39 fish collected in 2007 from Village Creek. Mean mercury concentration in combined species across all sites did not exceed the $HAC_{nonca}$. Mercury in black crappie ($\bar{x}$=0.767 mg/kg) and spotted gar ($\bar{x}$=0.802) exceeded the $HAC_{nonca}$ for mercury. Mercury in largemouth bass of legal length for possession (≥14 inches) was slightly lower than the $HAC_{nonca.}$ Largemouth bass ≥15 inches in length contained mercury at a concentration slightly higher than the methylmercury $HAC_{nonca}$ (0.7 mg/kg). The overall concentration in largemouth bass was 0.683 – which rounds to 0.7; largemouth bass are, thus, likely to be problematic for sensitive subgroups. Table 3 shows the hazard quotient for mercury in each species and in combined species along with recommended consumption for adults (in 8-ounce meals/week) of each species and of all fish combined. Hazard quotients for black crappie and spotted gar exceeded 1.0. The HQ of mercury in largemouth bass of all legal sizes (≥14 inches) was exactly 1.0.

Mercury in blue catfish, channel catfish, freshwater drum, longnose gar, and spotted bass did not exceed the $HAC_{nonca}$ for mercury nor were HQs for mercury in these species greater than 1.0 (Table 3).

Despite the finding that mercury in the total sample of freshwater drum from the 2007 Village Creek survey (n=8) did not exceed the methylmercury $HAC_{nonca,}$ risk assessors noted the large variability around the sample mean. When graphed, the relationship between TL and mercury concentration appeared nonlinear. Risk assessors observed that mercury in two samples (VCL-11 and VCL-29) – both longer than 16.5 inches – exceeded the methylmercury $HAC_{nonca}$ while mercury concentrations in the remaining six freshwater drum – all of which were under 16 inches in length – did not exceed the methylmercury $HAC_{nonca}$. A scatter plot of the eight samples showed the relationship between TL and mercury in freshwater drum from Village Creek to be positively but nonlinearly related (Figure 2). Further analyses of the eight samples confirmed two populations of freshwater drum based on the ratio of TL to mercury concentration. Freshwater drum ≥17 inches contained disproportionate levels of mercury (one-tailed t =; df=, p = ). Parenthetically, Levine's test for equality of between-groups variance was not significant even though one sample contained more data points than the other. State regulations do not generally address freshwater drum. At Village Creek, freshwater drum are not subject to special regulations such as bag limits, length limits, or slot limits.[44] Freshwater drum in Texas have been observed to exceed a length of 25 inches and a weight of 10 pounds (M. Tennant, Personal Communication 5-1-09). The data from this admittedly small sample suggest that at lengths greater than approximately 17 inches, freshwater drum from Village Creek may contain mercury at levels that, upon consumption, could result in adverse effects on human health. The developing nervous system of the human fetus may be especially susceptible to these effects.

Meal consumption calculations may assist risk managers to decide whether and what consumption advice is appropriate or regulatory actions necessary to protect individuals from possible adverse health effects of consuming contaminated fish. In this assessment, SALG risk assessors calculated meal consumption limits for each species and for combined species (Table 3) at each collection site. In three of four sites, mercury in at least one species exceeded the $HAC_{nonca}$; mercury concentrations in most species from the remaining site (FM 327) approached the $HAC_{nonca}$ for methylmercury. Keeping in mind that fish are mobile and that the sampling process is a "snapshot in time," SALG risk assessors based consumption advice for mercury-containing fish on species rather than species and collection site. Risk assessors used the species-specific HQs to compute meal consumption rates for each species. Assessors also computed a composite HQ for consumption of combined species (Table 3).

***Organic Contaminants***

***Pesticides***

Of 34 pesticides analyzed in the subsample of three fish from Village Creek, the laboratory observed only trace concentrations of chlordane, mirex, and 4,4'-DDE. These data suggest that consumption of pesticides alone in Village Creek fish would likely pose no hazard to systemic health in humans.

***SVOCs***

Two of three fish analyzed for SVOCs contained measurable concentrations of the plasticizer bis (2-ethylhexyl) phthalate; the third fish contained an estimated level of this contaminant. No sample contained bis(2-ethylhexyl) phthalate at concentrations in excess of the $HAC_{nonca}$. Consumption of Village Creek fish containing bis(2-ethylhexyl) phthalate should not adversely affect systemic health in humans.

***VOCs***

The three fish from Village Creek contained measurable carbon disulfide (0.030 mg/kg – 0.132 mg/kg [data not presented]). Traces of acetone, chloromethane, methylene chloride, chloroform, 1, 2-dichloroethane, benzene, trichlorofluoromethane, dichlorodifluoromethane, toluene, and naphthalene were present in the subsample of three fish from Village Creek. The procedural blanks also contained chloromethane, methylene chloride, benzene, dichlorodifluoromethane, toluene, and naphthalene, suggesting contamination during sample preparation. These volatile organic compounds were not present at levels that should cause concern for the systemic health of those who consume fish from Village Creek.

***PCBs***

All three Village Creek fish tested for PCBs contained one or more PCB congeners, most of which were estimated values (J-values). No PCB congener or combination of congeners exceeded the $HAC_{nonca}$ for Aroclor 1254 based on immune system deficits. The HQ did not exceed 1.0. These observations suggest that consumption of Village Creek fish containing PCBs at concentrations similar to those found in samples from Village Creek is unlikely to present a risk to systemic health.

***Characterization of Theoretical of Lifetime Excess Cancer Risk from Consumption of Fish from Village Creek***

***Inorganic Contaminants***

Because the USEPA has not provided carcinogen slope factors for mercury, copper, selenium, lead, or zinc, even though some of these metals may be carcinogenic to humans, the SALG was unable to determine the probability of excess cancers from consuming fish from Village Creek that contain these metallic/metalloid contaminants. Copper, selenium, and zinc are essential trace elements necessary for health.[43]

***Organic Contaminants***

***Pesticides***

Traces of three pesticides, chlordane, mirex, and 4,4'-DDE, were observed in the three Village creek samples tested for pesticides. No pesticide occurred at a concentration exceeding its $HAC_{ca}$. The SALG concluded from these observations that consuming fish from Village Creek that contain pesticides at concentrations near those observed in the samples is unlikely to increase an individual's risk of cancer.

***SVOCs***

Two of the three Village Creek fish contained the ubiquitous plasticizer, bis (2-ethylhexyl) phthalate – also known as di (2-ethylhexyl) phthalate or DEHP at concentrations near or below the RL. The USEPA classifies DEHP as a probable human carcinogen (B2). Recent studies, however, have suggested that DEHP is not likely carcinogenic in humans. For instance, Doull and coworkers[45] concluded that the hepatocarcinogenic effect of DEHP in rodents – peroxisome proliferation – purportedly the mechanism by which DEHP causes liver cancer in rats and mice, is not relevant to human cancer risk at any anticipated exposure level because human livers do not have peroxisomes and are therefore refractory to peroxisome proliferators. Accordingly, these authors recommended that the USEPA re-classify DEHP as an unlikely human carcinogen.[46] Consequently, the EPA has undertaken to review the risk assessment for DEHP. The low concentrations of DEHP in fish from Village Creek, along with the reassessment of the CSF for DEHP suggests that consuming fish from Village Creek that contain DEHP is unlikely to increase an individual's risk of cancer even if that person eats DEHP-contaminated fish from this stream daily for up to 30 years.

***VOCs***

VOCs in the 2007 fish samples from Village Creek occurred at concentrations below the $HAC_{ca}$ for each such contaminant. Consumption of fish from Village Creek containing individual VOCs is unlikely to increase an individual's theoretical lifetime excess risk of cancer even if the person eats VOC-contaminated fish from Village Creek for up to thirty years (the period over which the SALG assumes exposure to the same source of a carcinogen occurs).

***Characterization of Cumulative Systemic (Noncancerous) and Carcinogenic Health Effects of Consumption of Fish from Village Creek***

***Cumulative Systemic Effects***

Cumulative systemic adverse health effects may be of concern when people are exposed simultaneously to more than one contaminant in a single medium (e.g., fish) or in multiple media (multiple media are not discussed in this report because the SALG has no way of knowing the types or concentrations of toxicants to which people may be exposed through other media). In the present risk characterization, risk assessors observed low concentrations of several metallic elements, traces of chlordane. 4,4' DDD, and mirex, traces of various VOCs, and a trace of bis(2-ethylhexyl) phthalate (BEHP; DEHP – an SVOC). The laboratory also reported PCBs – ranging from traces to measurable concentrations – in fish from Village Creek. Combinations of some compounds – notably organics – could potentially have cumulative effects on organs common to the toxic effects of individual components of the mixtures (for instance, many VOCs and SVOCs affect the liver, often at higher doses than the one that induces the critical effect; PCBs are among these organics). Hazard indices – estimates of systemic effects of multiple chemicals acting on the same target organ calculated by adding the HQs for the individual contaminants – were less than 1.0 in fish from Village Creek. Thus, consumption of Village Creek fish containing mixtures of organic compounds is unlikely to cause, or result in, cumulative systemic toxicity.[47 48]

***Cumulative Carcinogenicity***

When defining cancer slope factors for use in calculating excess cancer risk from exposure to chemical carcinogens, researchers compare the number of neoplasms in control groups to the number in treated groups. Statistically significant increases in numbers of neoplasms in a treated group – whether benign or cancerous, in one organ or in multiple organs – are cumulative, no matter the contaminant or the mode or mechanism by which the chemical causes cancer. In the present risk characterization, to assess cumulative carcinogenic risk, the SALG risk assessors added the carcinogenic risk calculated for individual contaminants (pesticides, PCBs, VOCs, SVOCs, and metalloids) in fish from Village Creek for which a cancer slope factor exists. Sample results indicated that consumption of multiple carcinogens in Village Creek fish would be unlikely to increase the theoretical excess cancer risk the DSHS uses to make regulatory decisions or to formulate consumption advice (1 excess cancer in 10,000 equivalently exposed people). That is, the calculated theoretical lifetime excess cancer risk from consuming multiple contaminants in fish from Village Creek for up to 30 years would not exceed one excess cancer in 10,000 equivalently exposed persons.

To reiterate, risk assessors found no additive increase in theoretical excess lifetime cancer risk from consuming a single species containing multiple carcinogens or from consuming multiple species containing one or more carcinogens. That is, neither consuming the multiple species from Village Creek that contained the same contaminant – nor consuming multiple chemicals in a single species nor consuming multiple chemicals in multiple species – increased the calculated theoretical lifetime risk of cancer.

# 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, and – if indicated – may suggest strategies for reducing risk to the health of those who 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 Village Creek. Risk assessors from the SALG conclude from the present characterization of potential adverse health effects from consuming fish from Village Creek

1. That all fish species sampled in 2007 from Village Creek contained measurable mercury.

2. That mercury in blue catfish, channel catfish, freshwater drum, and spotted bass did not exceed the $HAC_{nonca}$ for methylmercury in fish (0.7 mg/kg). Consumption of blue catfish, channel catfish, freshwater drum, and/or spotted bass from Village Creek **poses no apparent hazard to human health**.

3. That mercury in black crappie and gar species from Village Creek exceeded the mercury $HAC_{nonca}$ by approximately 10%. Consumption of black crappie or gar species from Village Creek therefore **poses an apparent hazard to human health.**

4. That largemouth bass from Village Creek contained mercury at an average concentration approximately equal to the $HAC_{nonca}$ for methylmercury; the highest concentration of mercury in a largemouth bass was almost double the $HAC_{nonca}$. The likelihood that people will consume largemouth bass containing mercury in excess of the $HAC_{nonca}$ for methylmercury is sufficient to cause concern for health. Therefore, the SALG concludes that eating largemouth bass from Village Creek **poses an apparent hazard to human health.**

5. That other contaminants observed in fish from Village Creek, including inorganic (metalloid) or organic contaminants consisting of chlorinated pesticides, PCBs, VOCs, SVOCs did not exceed their respective $HAC_{nonca}$ or $HAC_{ca}$ and therefore, eaten singly, **pose no apparent hazard to human health.**

6. That consumption of multiple organic contaminants or inorganic contaminants other than mercury in one or more species of fish from Village Creek does not increase the likelihood of noncarcinogenic or carcinogenic effects above that of the single components of mixtures of compounds observed in fish from this water body. The SALG risk assessors conclude, therefore, that consuming fish from Village Creek containing multiple organic contaminants and/or inorganic contaminants other than mercury at concentrations near those observed in fish collected in 2007 **poses no apparent hazard to human health.**

# RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[15, 17, 49] 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 the water body under investigation could, as a result, lead risk managers at DSHS to recommend consumption advice for fish or shellfish from that water body. Alternatively, the department may ban 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 fish or shellfish they wish to consume. Mercury in black crappie, gar species, and largemouth bass collected in 2007 from Village Creek exceeded the $HAC_{nonca}$ for methylmercury (0.7 mg/kg). Black crappie, gar, and largemouth bass from Village Creek contain mercury at concentrations that may **pose some hazard to public health** and especially to the health of sensitive groups. Therefore, the DSHS recommends

1. That pregnant women, women who may become pregnant, and women who are nursing an infant, should eat no crappie, gar, or largemouth bass from Village Creek.

2. That small children (those at or below 12 years of age or who weigh less than 75 pounds) should limit consumption of crappie, gar, and largemouth bass to two four-ounce meals per month from Village Creek.

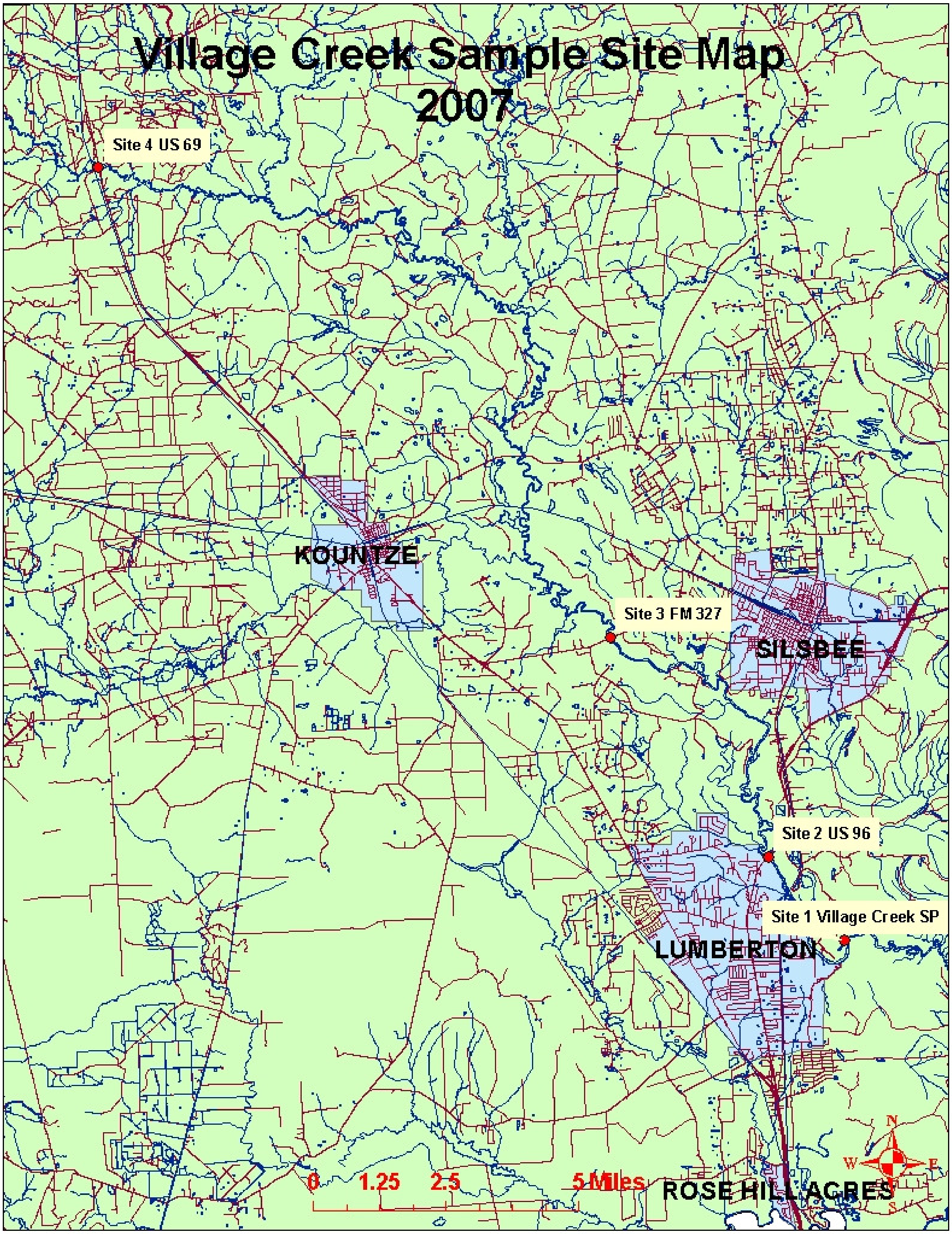
3. That adult men and women past childbearing should limit consumption of crappie, gar, and largemouth bass to two eight-ounce meal per month from Village Creek.

4. That people need not restrict their consumption of blue catfish, channel catfish, spotted bass or freshwater drum from Village Creek.

# 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, the Texas Department of State Health Services (DSHS) takes several steps. The agency publishes fish consumption advisories and bans in a booklet available to the public through the Seafood and Aquatic Life Group (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 Texas Department of State Health Services also provides the USEPA (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 available at http://www.tpwd.state.tx.us/publications/nonpwdpubs/media/outdoor_annual_2008_2009.pdf. [52] The TPWD's booklet is also 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 Seafood and Aquatic Life Group (SALG) at 512-834-6757 or may find the information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, readers may address inquiries to the Environmental and Injury Epidemiology and Toxicology Unit at the DSHS (512-458-7269). The USEPA'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.cde.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.* 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. 2007 Village Creek Sample Sites**



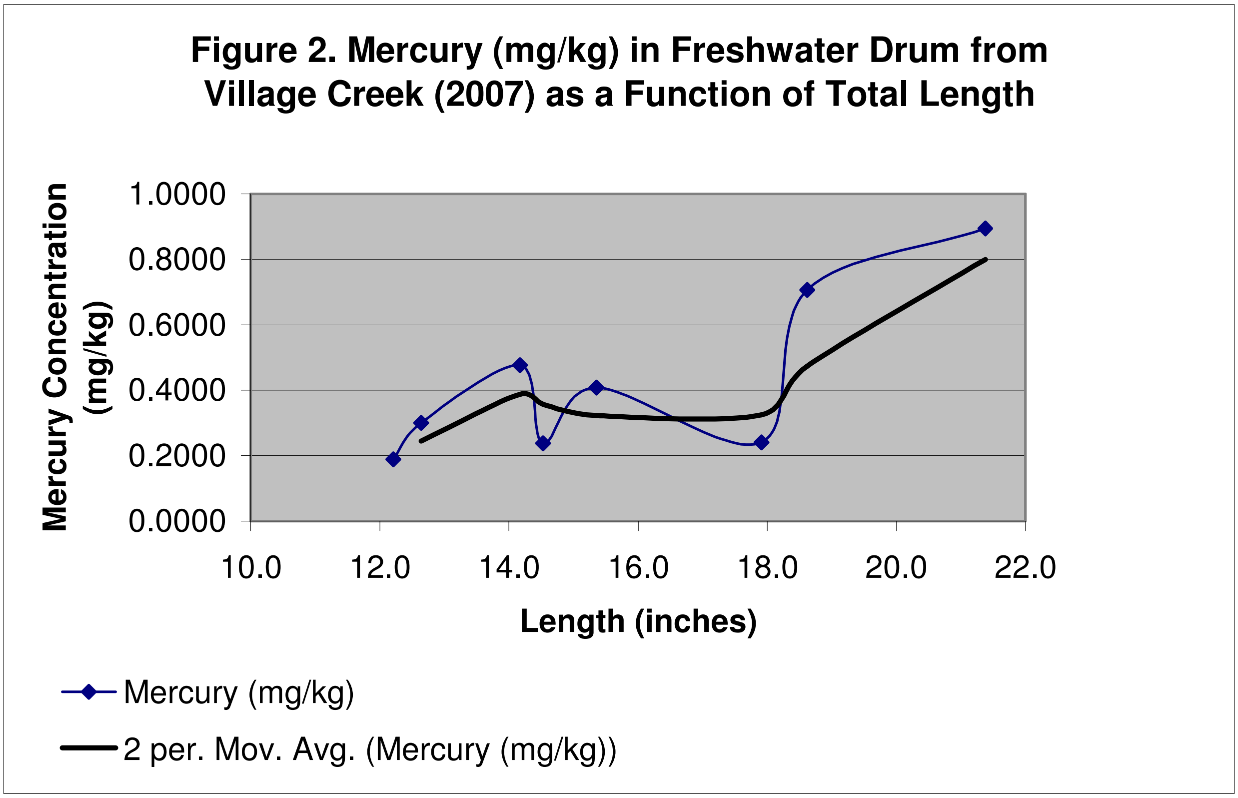


Figure 2. Mercury (mg/kg) in Freshwater Drum from Village Creek (2007) as a Function of Total Length
Mercury Concentration (mg/kg)
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
10.0
12.0
14.0
16.0
18.0
20.0
22.0
Length (inches)
Mercury (mg/kg)
2 per. Mov. Avg. (Mercury (mg/kg))

# TABLES and FIGURE

**Table 1. Fish samples collected from Village Creek April 2007 and June 2007. Sample number, species, length, and weight are shown for each sample collected.**

| Sample Number | Species | Length (mm) | Weight (g) |
|---|---|---|---|
| **Site 1 Village Creek @ Village Creek State Park** | | | |
| VLC3 | Black crappie | 319 | 505 |
| VLC2 | Black crappie | 308 | 474 |
| VLC4 | Blue catfish | 386 | 583 |
| VLC7 | Longnose gar | 575 | 303 |
| VLC1 | Spotted bass | 352 | 826 |
| VLC5 | Spotted gar | 612 | 937 |
| VLC6 | Spotted gar | 552 | 687 |
| **Site 2 Village Creek @ U.S. 96** | | | |
| VLC10 | Channel catfish | 405 | 671 |
| VLC32 | Channel catfish | 394 | 678 |
| VLC33 | Channel catfish | 387 | 558 |
| VLC9 | Channel catfish | 386 | 728 |
| VLC34 | Channel catfish | 385 | 546 |
| VLC35 | Channel catfish | 370 | 430 |
| VLC11 | Freshwater drum | 473 | 1708 |
| VLC40 | Freshwater drum | 390 | 979 |
| VLC39 | Largemouth bass | 359 | 603 |
| VLC38 | Spotted bass | 380 | 880 |
| VLC8 | Spotted bass | 315 | 458 |
| VLC37 | Spotted gar | 730 | 1842 |
| **Site 3 Village Creek @ FM 327** | | | |
| VLC14 | Black crappie | 271 | 294 |
| VLC19 | Freshwater drum | 369 | 823 |
| VLC12 | Freshwater drum | 360 | 703 |
| VLC13 | Freshwater drum | 321 | 475 |
| VLC15 | Spotted bass | 353 | 777 |
| VLC16 | Spotted bass | 331 | 528 |
| VLC18 | Spotted bass | 330 | 462 |
| VLC17 | Spotted gar | 485 | 485 |
| **Site 4 Village Creek @ U.S. 69** | | | |
| VLC29 | Freshwater drum | 543 | 2378 |
| VLC30 | Freshwater drum | 455 | 1560 |
| VLC31 | Freshwater drum | 310 | 475 |
| VLC22 | Largemouth bass | 515 | 2413 |
| VLC21 | Largemouth bass | 474 | 1647 |
| VLC20 | Largemouth bass | 388 | 979 |

| Table 1 Continued. Fish samples collected from Village Creek April 2007 and June 2007. Sample number, species, length, and weight are shown for each sample collected. | | | |
|---|---|---|---|
| **Sample Number** | **Species** | **Length (mm)** | **Weight (g)** |
| **Site 4 Village Creek @ U.S. 69 Continued** | | | |
| VLC23 | Largemouth bass | 387 | 1016 |
| VLC25 | Largemouth bass | 381 | 849 |
| VLC24 | Largemouth bass | 374 | 833 |
| VLC26 | Largemouth bass | 356 | 647 |
| VLC27 | Spotted bass | 365 | 820 |
| VLC28 | Spotted bass | 330 | 550 |

| Table 2a. Arsenic (mg/kg) in fish from Village Creek, 2007. | | | | | |
|---|---|---|---|---|---|
| **Species** | **# Detected/ # Sampled** | **Total Arsenic Mean Concentration ± S.D. (Min-Max)** | **Inorganic Arsenic Mean Concentration[d]** | **Health Assessment Comparison Value (mg/kg)[e]** | **Basis for Comparison Value** |
| Freshwater drum | 1/1 | 0.056 | 0.006 | 0.7<br>0.362 | USEPA chronic oral RfD for Inorganic arsenic: 0.0003 mg/kg–day<br><br>USEPA oral slope factor for inorganic arsenic: 1.5 per mg/kg–day |
| Spotted bass | 1/1 | 0.034 | 0.003 | | |
| Spotted gar | 1/1 | 0.222 | 0.022 | | |
| All Species | 3/3 | 0.104±0.103 (0.034-0.222) | 0.010 | | |

[d] *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.*
[e] *Derived from the MRL or RfD for noncarcinogens or the USEPA 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* $1x10^{-4}$.

**Table 2b. Inorganic contaminants (mg/kg) in largemouth bass from Village Creek, 2007.**

| Species | # Detected/ # Sampled | Mean Concentration ± S.D. (Min-Max) | Health Assessment Comparison Value (mg/kg) | Basis for Comparison Value |
|---|---|---|---|---|
| **Cadmium** | | | | |
| Freshwater drum | 0/1 | ND | 0.47 | ATSDR chronic oral MRL: 0.0002 mg/kg–day |
| Spotted bass | 0/1 | ND | | |
| Spotted gar | 0/1 | ND | | |
| All Species | 0/3 | ND | | |
| **Copper** | | | | |
| Freshwater drum | 1/1 | 0.192 | 333 | National Academy of Science Upper Limit: 0.143 mg/kg–day |
| Spotted bass | 1/1 | 0.176 | | |
| Spotted gar | 1/1 | 0.097 | | |
| All Species | 3/3 | 0.155±0.051 (0.097-0.192) | | |
| **Lead** | | | | |
| Freshwater drum | 0/1 | ND | 0.6 | USEPA IEUBKwin |
| Spotted bass | 1/1 | BDL | | |
| Spotted gar | 0/1 | ND | | |
| All Species | 1/3 | BDL | | |
| **Selenium** | | | | |
| Freshwater drum | 1/1 | 0.861 | 6 | USEPA chronic oral RfD: 0 .005 mg/kg–day<br>ATSDR chronic oral MRL: 0.005 mg/kg–day<br>NAS UL: 0.400 mg/day (0.005 mg/kg–day)<br>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 |
| Spotted bass | 1/1 | 0.744 | | |
| Spotted gar | 1/1 | 0.699 | | |
| All Species | 3/3 | 0.768±0.084 (0.699-0.861) | | |
| **Zinc** | | | | |
| Freshwater drum | 1/1 | 3.176 | 700 | USEPA chronic oral RfD: 0.3 mg/kg–day |
| Spotted bass | 1/1 | 2.816 | | |
| Spotted gar | 1/1 | 1.692 | | |
| All Species | 3/3 | 2.561±0.774 (1.692-3.176) | | |

| **Table 2c. Mercury (mg/kg) in fish from Village Creek, 2007.** | | | | |
|---|---|---|---|---|
| **Species** | **# Detected/ # Sampled** | **Mean Concentration ± S.D. (Min-Max)** | **Health Assessment Comparison Value (mg/kg)** | **Basis for Comparison Value** |
| **Site 1 Village Creek @ Village Creek State Park** | | | | |
| Black crappie | 2/2 | **0.832***±0.357 (0.579, **1.085**) | 0.7 | ATSDR chronic oral MRL: 0.0003 mg/kg–day |
| Blue catfish | 1/1 | 0.357 | | |
| Longnose gar | 1/1 | 0.599 | | |
| Spotted bass | 1/1 | 0.595 | | |
| Spotted gar | 2/2 | **0.964**±0.158 (**0.852, 1.076**) | | |
| All Species | 7/7 | **0.735**±0.276 (0.357-**1.085**) | | |
| **Site 2 Village Creek @ U.S. 96** | | | | |
| Channel catfish | 6/6 | 0.188±0.060 (0.134-0.279) | 0.7 | ATSDR chronic oral MRL: 0.0003 mg/kg–day |
| Freshwater drum | 2/2 | 0.557±0.211 (0.408, **0.706**) | | |
| Largemouth bass | 1/1 | 0.346 | | |
| Spotted bass | 2/2 | 0.597±0.191 (0.461, **0.732**) | | |
| Spotted gar | 1/1 | 0.627 | | |
| All Species | 12/12 | 0.368±0.221 (0.134-**0.732**) | | |
| **Site 3 Village Creek @ FM 327** | | | | |
| Black crappie | 1/1 | 0.635 | 0.7 | ATSDR chronic oral MRL: 0.0003 mg/kg–day |
| Freshwater drum | 3/3 | 0.338±0.0.124 (0.237-0.477) | | |
| Spotted bass | 3/3 | 0.577±0.023 (0.553-0.598) | | |
| Spotted gar | 1/1 | 0.658 | | |
| All Species | 8/8 | 0.505±0.157 (0.237-0.658) | | |
| **Site 4 Village Creek @ U.S. 69** | | | | |
| Freshwater drum | 3/3 | 0.441±0.393 (0.188-**0.894**) | 0.7 | ATSDR chronic oral MRL: 0.0003 mg/kg–day |
| Largemouth bass | 7/7 | **0.732**±0.349 (0.352-**1.231**) | | |
| Spotted bass | 2/2 | 0.582±0.158 (0.470-**0.693**) | | |
| All Species | 12/12 | 0.634±0.337 (0.188-**1.231**) | | |

*** Emboldened numbers denote concentrations that exceed the HACnonca for methylmercury (MeHg).**

| Table 2c, continued. Mercury (mg/kg) in fish from Village Creek, 2007. | | | | |
|---|---|---|---|---|
| **Species** | **# Detected/ # Sampled** | **Mean Concentration ± S.D. (Min-Max)** | **Health Assessment Comparison Value (mg/kg)** | **Basis for Comparison Value** |
| **Village Creek-All Sites** | | | | |
| Black crappie | 3/3 | **0.767**±0.277 (0.579-**1.085**) | 0.7 | ATSDR chronic oral MRL: 0.0003 mg/kg–day |
| Blue catfish | 1/1 | 0.357 | | |
| Channel catfish | 6/6 | 0.188±0.060 (0.134-0.279) | | |
| Freshwater drum | 8/8 | 0.431±0.252 (0.188-**0.894**) | | |
| Largemouth bass | 8/8 | 0.683±0.350 (0.346-**1.231**) | | |
| Longnose gar | 1/1 | 0.599 | | |
| Spotted bass | 8/8 | 0.585±0.095 (0.461-**0.732**) | | |
| Spotted gar | 4/4 | **0.802**±0.207 (0.627-**1.076**) | | |
| All Species | 39/39 | 0.544±0.288 (0.134-**1.231**) | | |

***Emboldened numerals denote concentrations that exceed the HACnonca for methylmercury (MeHg).**

**Table 3. Hazard quotients (HQ) for mercury in fish collected from Village Creek in 2007. Table 3 also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[f]**

| Species | Hazard Quotient | Meals per Week |
|---|---|---|
| Black crappie | **1.1*** | **0.8†** |
| Blue catfish | 0.5 | 1.8 |
| Channel catfish | 0.3 | 3.4 |
| Freshwater drum | 0.6 | 1.5 |
| Largemouth bass | **1.0** | **0.9** |
| Longnose gar | 0.9 | 1.1 |
| Spotted bass | 0.8 | 1.1 |
| Spotted gar | **1.1** | **0.8** |
| Spotted gar and Longnose gar combined | **1.1** | **0.8** |
| All Species (Composite HQ) | 0.8 | 1.2 |

**Emboldened numbers denote HQs that exceed 1.0.*

† *Emboldened numbers denote consumption rates that are less than one meal per week (8-ounces/meal for adults; 4 ounces/meal for young children).*

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

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