

Health Consultation

Consumption of Deer Tissue Collected at Caddo Lake National Wildlife Refuge

Karnack, Harrison County, Texas

EPA FACILITY ID: TX6213820529

JANUARY 24, 2006



Prepared by

Texas Department of State Health Services
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Purpose and Statement of Issues

The United States Fish and Wildlife Service (USFWS) asked the Texas Department of State Health Services (DSHS) to review analyses of muscle and liver samples collected from white-tailed deer (*Odocoileus virginianus*) on the Caddo Lake National Wildlife Refuge (NWR). The Caddo Lake NWR is located on part of the former Longhorn Army Ammunition Plant (LAAP), a National Priorities List (NPL) “Superfund” site. Metals, volatile and semi-volatile organic compounds, and explosives have been found in surface water, sediment, surface soil, and groundwater on the former LAAP site.

The USFWS would like to offer limited deer hunting on Caddo Lake NWR to the public. Prior to doing this, the agency asked DSHS for assistance in determining whether eating deer from Caddo Lake NWR could present a health risk to the public (Note: Appendix A lists abbreviations and acronyms used in this report).

Background

Site Description and History

Caddo Lake NWR is located in northeast Texas along the southwestern portion of Caddo Lake. The NWR is in Harrison County (population 62,110) [1] and is surrounded by the communities of Karnack (population 775) [2] and Uncertain (population 150) [1]. About 1,500 people live within a one-mile radius of the site [3].

Caddo Lake is the only naturally occurring lake in Texas. The western part of the lake is in Texas and the eastern portion is in Louisiana (Appendix B). The lake covers 26,810 acres of cypress swamp [4]. The Caddo Lake habitat supports the largest populations of several duck species and the most diverse fish fauna in Texas [5]. Studies of the refuge have listed up to 224 species of birds, 22 species of amphibians, 46 species of reptiles, and 93 fish species [3]. On November 2, 1995, the DSHS issued a fish consumption advisory (ADV-12) due to elevated levels of mercury in largemouth bass (*Micropterus salmoides*) and freshwater drum (*Aplodinotus grunniens*) from Caddo Lake. The advisory states that eating largemouth bass or freshwater drum should be limited to minimize potential exposure to mercury [6].

Caddo Lake NWR is located on property of the former LAAP. The LAAP was an 8,943 acre U.S. Department of Defense (DOD) facility that operated intermittently from 1942 to 1997. The LAAP produced 2,4,6-trinitrotoluene (TNT), pyrotechnic ammunition, rocket motors, and plastic explosives [7]. At peak production, the facility had over 2,200 employees. Metals, volatile and semi-volatile organic compounds, and explosives were previously found in on-site surface water, sediment, surface soil, and groundwater [7]. The LAAP was placed on the U.S. Environmental Protection Agency’s (EPA) NPL on August 30, 1990. The Agency for Toxic Substances and Disease Registry (ATSDR) reviewed environmental data for the site and prepared a public health assessment. In July 1999, ATSDR concluded that the LAAP site posed no apparent public health hazard because people were not likely to come into contact with site-related contaminants or because institutional controls were sufficient to protect human health [7].

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Administrative control of about 5,000 acres of the LAAP site was granted to USFWS as the Caddo Lake NWR on May 5, 2004. The DOD retains control of the remaining LAAP property until remediation is completed at several areas on the site [8]. The USFWS plans to eventually allow 300 individuals to hunt deer on the refuge property annually. The estimated hunter success rate is 30%, and about 100 deer are expected to be harvested per season. Each hunter will be allowed to harvest two deer (either sex) per season. Seasonal harvest limits may change depending on the total deer population on the refuge [9].

Environmental Sampling

The USFWS collected muscle and liver samples from 20 white-tailed deer (*Odocoileus virginianus*) during January - February 2005. Eighteen female deer (does) and two male deer (bucks) were collected from the Caddo Lake NWR area and the remaining LAAP property. They ranged from 1½ to 6½ years of age. The sampling ratio of does to bucks (9:1) was similar to harvest results of past seasons when the U.S. Army allowed deer hunting on the LAAP facility by a limited number of personnel [10].

Average live weight for the 18 does was 45-50 kilograms (kg) or approximately 100-110 pounds (lbs). Live weights of the bucks were 59 and 64 kg (130 and 140 lbs) [11]. For muscle tissue, samples of backstrap (loin) and hind quarters were pooled as one muscle tissue sample per deer. Liver samples were also collected from each deer [10].

Samples were sent to TDI - Brooks International, Inc., College Station, Texas for pesticide analyses and to Laboratory and Environmental Testing, Inc., Columbia, Missouri for metals analyses [12]. The DSHS and ATSDR relied on information provided in the referenced documents and assumed adequate quality assurance/quality control (QA/QC) procedures were followed with regard to data collection, chain-of-custody, laboratory procedures, and data reporting. Procedural blank analyses were acceptable, analyses of duplicate samples were within normal limits, and limits of detection were within laboratory contract requirements.

Data on background concentrations of metals and pesticides in white-tailed deer from other areas around Caddo Lake were not collected; thus, it was not possible to compare the risks associated with eating deer from the area of concern to those associated with eating deer from other areas.

Discussion

Health-based screening values specifically for deer tissues were not available. Therefore, for all contaminants except lead, we used ATSDR minimal risk levels (MRLs)¹ and EPA reference doses (RfDs)² to develop non-cancer screening values. We used standard assumptions for ingestion rate (4 ounces (oz) per week for children; 8 oz per week for adults) and body weight (15 kg for children; 70 kg for adults). For lead, we used the ATSDR "Framework to Guide

¹ An MRL is a contaminant specific exposure dose below those which might cause adverse health effects in the people most sensitive to such chemical-induced effects. MRLs generally are based on the most sensitive chemical-induced end point considered to be of relevance to humans.

² An RfD is an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily exposure to the human population (including sensitive groups) that is likely to be without appreciable risk of deleterious effects during a lifetime.

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Public Health Assessment Decisions at Lead Sites” to estimate probable increases in blood lead levels associated with tissue consumption [13].

For contaminants classified as human carcinogens, probable human carcinogens, or possible human carcinogens, we used EPA chemical specific cancer slope factors (CSF) and an estimated excess lifetime cancer risk of one-in-one-million persons exposed to develop cancer-screening values. Arsenic and polychlorinated biphenyls (PCBs) were the only contaminants for which CSFs were available. Concentrations of these contaminants in the liver and muscle samples were below detection limits.

Exceeding either a non-cancer or a cancer screening value does not necessarily mean that the contaminant will cause harm; however, it does suggest that potential exposure to the contaminant warrants further consideration. Factors that influence whether exposure to a contaminant could or would result in adverse health effects include: how much of the contaminant an individual is exposed to, how often and how long they are exposed, and the manner in which the contaminant enters or contacts the body. Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status all may influence how well the individual absorbs, distributes, metabolizes, and excretes the contaminant.

We assessed the public health significance of contaminants that exceeded screening values by reviewing and integrating relevant toxicological information with plausible exposure scenarios. We used a weight-of-evidence approach to determine the public health significance of the contaminants that exceeded the screening values.

Public Health Implications

For many samples, contaminant concentrations were below detection limits. We eliminated from further consideration those contaminants which were below detection limits in all samples if the respective detection limit was less than the health-based screening value. For muscle samples, this eliminated arsenic, beryllium, cadmium, mercury, molybdenum, vanadium, and all pesticides tested, except mirex and oxychlorane, as contaminants of concern. For liver samples, this eliminated arsenic, beryllium, mercury, vanadium, and most organochlorine pesticides.

For the remaining contaminants found in one or more tissue samples, we compared the maximum levels found to the respective calculated health-based screening values. For muscle samples, all contaminants were below their respective health-based screening values (Table C-1). For liver samples, all but three contaminants were below their respective health-based screening values (Table C-2). Cadmium, copper and selenium exceeded their respective health-based screening values in liver samples (Table C-3). In the absence of background samples for comparison, we cannot determine with any degree of certainty whether the presence of these contaminants in deer liver poses an excess health risk.

For lead, we used the maximum concentration found in muscle tissue, 5.2 milligrams per kilogram (mg/kg), and ATSDR’s “Framework to Guide Public Health Assessment Decisions at Lead Sites” to estimate probable increases in blood lead levels associated with tissue consumption [13]. We estimated that increased blood lead levels in children would be <1.4

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µg/dL (micrograms per deciliter) and < 0.4 µg/dL in adults. Based on these findings, lead was eliminated as a contaminant of concern.

Throughout the world, studies have been conducted to determine the risk to hunters of eating wild game contaminated with heavy metals. One metal of particular concern has been cadmium. In wild game, cadmium levels may be elevated in liver and kidney tissues but low in muscle tissues [14]. Because of this, health advisories on the consumption of liver and kidney tissues have been issued in many areas, including Maine and New Hampshire, as well as in Canada (Ontario, New Quebec, and New Brunswick) [15].

Child Health Considerations

In communities faced with air, water, or food contamination, children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. Sufficient exposure levels during critical growth stages can sustain permanent damage to the developing body systems of children. Children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

Health risks to children consuming white-tailed deer collected at Caddo Lake NWR were evaluated in this health consultation. Assuming levels of contaminants in samples of deer tissue collected at Caddo Lake NWR are representative of concentrations to which children could be exposed; children may consume deer muscle tissue collected from the site without appreciable risk of adverse health affects.

Conclusions

The conclusions reached in this report only apply to deer taken from the Caddo Lake National Wildlife Refuge (NWR). Based on the information available for this report:

1. Using a plausible exposure scenario, none of the contaminants exceeded their respective health-based screening values in muscle. We therefore conclude that if deer hunting is allowed, then eating muscle from deer taken from Caddo Lake NWR would pose **no apparent public health hazard**.
2. Selenium exceeded the health-based screening value in only one liver sample. We think it unlikely that people eating deer liver would be exposed to selenium at levels of concern on a regular basis. Given the available information, we conclude that if deer hunting is allowed, then exposure to selenium in deer liver taken from Caddo Lake NWR would pose **no apparent public health hazard**.
3. Cadmium and copper were found at levels above their respective health-based screening values in all liver samples. Because deer hunting is presently not allowed on the Caddo Lake NWR, these levels currently pose **no public health hazard**. If hunting is allowed in the future, and livers from the Caddo Lake NWR deer are not consumed, then no apparent public health hazard would likely to exist.

Recommendations

1. If deer hunting is allowed on Caddo Lake NWR, the USFWS should retain and dispose of the livers. Hunters should be informed that eating the liver of deer taken from the Caddo Lake NWR may result in adverse health effects due to elevated levels of copper and cadmium.
2. Given the previous land use for this refuge, collecting data from a suitable background area could help determine if the contaminants found in the liver pose an excess risk.
3. If other types of hunting (squirrel, turkey, and wild hog) are considered for Caddo Lake NWR, the USFWS should sample these biota to help determine whether environmental contaminant levels are a concern.

Public Health Action Plan

Actions Completed

1. The USFWS collected and analyzed tissue (muscle and liver) samples from 20 white-tailed deer inhabiting the Caddo Lake NWR.
2. The DSHS and ATSDR evaluated contaminant data from deer collected at Caddo Lake NWR.

Actions Planned

1. Based on the conclusions of this Public Health Consultation, the USFWS will decide whether to allow public hunting on the Caddo Lake NWR.
2. This health consultation will be provided to the public, the local government, and state and federal health/environmental agencies.
3. Additional wild game sampling data from Caddo Lake NWR will be evaluated by DSHS and ATSDR as it becomes available.

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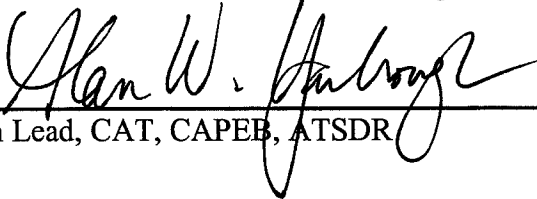
Certification

This public health consultation was prepared by the Texas Department of State Health Services (DSHS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time this public health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.



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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with its findings.



Team Lead, CAT, CAPEB, ATSDR

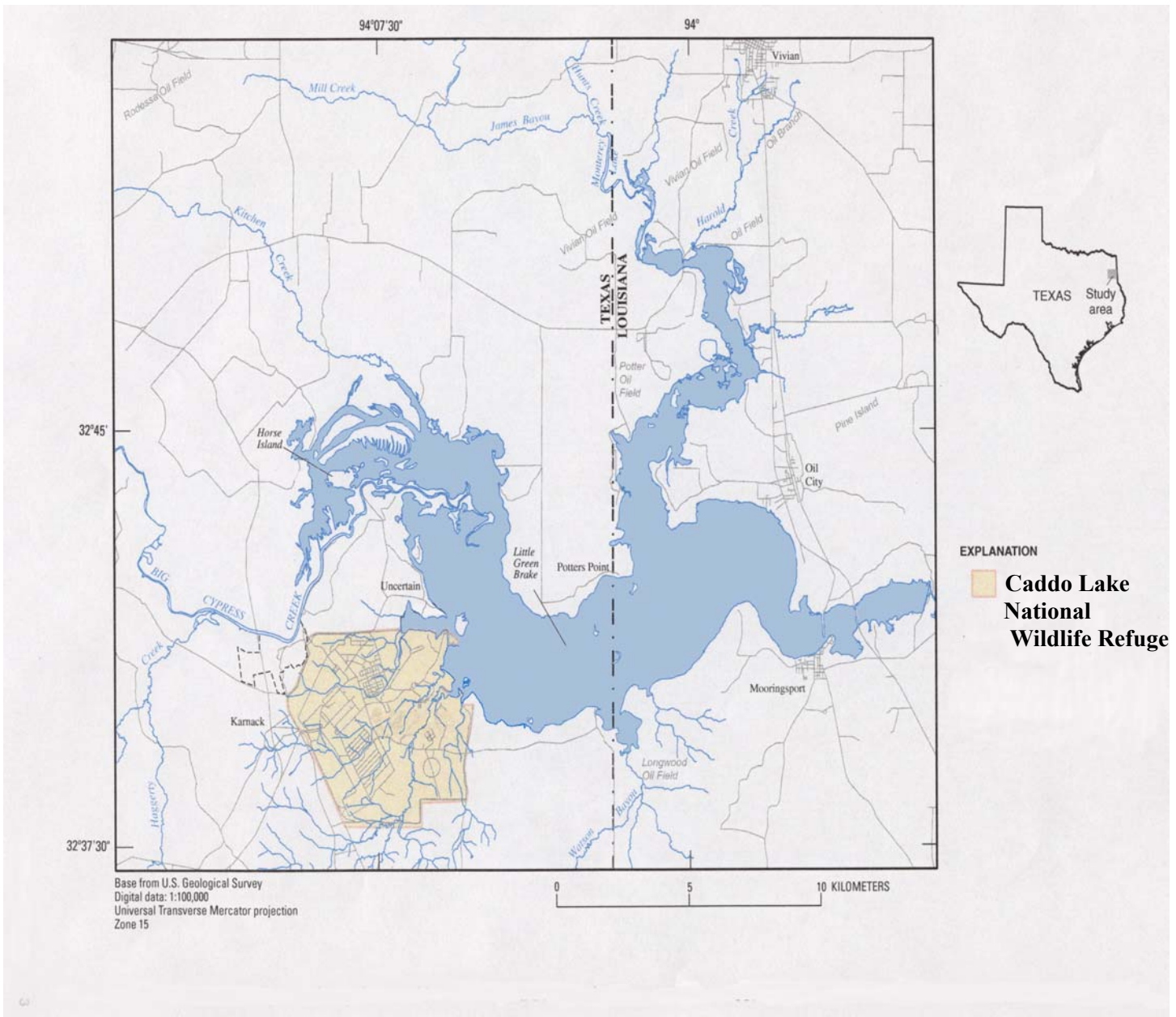
Appendix A - Acronyms and Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BHC	benzenehexachloride
CSF	Cancer Slope Factor
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DL	detection limit
DOD	Department of Defense
DSHS	Department of State Health Services
EPA	Environmental Protection Agency
kg	kilogram
LAAP	Longhorn Army Ammunition Plant
lbs	pounds
MRL	Minimal Risk Level
mg/kg	milligrams per kilogram
µg/dL	micrograms per deciliter
NA	not applicable
NPL	National Priorities List
NWR	National Wildlife Refuge
oz	ounces
PCB	polychlorinated biphenyls
QA/QC	Quality Assurance/Quality Control
RfD	Reference Dose
TNT	trinitrotoluene
USFWS	United States Fish and Wildlife Service

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Appendix B - Map

Caddo Lake and surrounding area, including Caddo Lake National Wildlife Refuge (NWR).



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Appendix C - Tables

Table C-1. Summary data for contaminants found in one or more **muscle** samples (n=20) that did not exceed health-based screening values. No contaminants of concern were identified.

Contaminant	Concentration Range	Screening Value	Screening Value
	(mg/kg) Muscle [†]	(mg/kg) [‡] Child	(mg/kg) [‡] Adult
Aluminum	<DL-12	2000	4000
Barium	<DL-0.76	200	400
Boron	<DL-2	9	20
Chromium	<DL-1.5	1000	3000
Copper	5.7-8.6	9	22
Lead	<DL-5.2	NA	NA
Manganese	0.5-0.8	50	100
Nickel	<DL-2.1	20	40
Selenium	0.6-1.4	5	10
Strontium	<DL-0.68	2000	4000
Zinc	47-74.4	300	600
Mirex	<DL-0.000212	0.7	2
Oxychlorane	<DL-0.004640	0.6	1

[†] DL = detection limit of the analytical instrument.

[‡] Derived from the MRL or RfD for non-cancerous adverse health effects using standard assumptions of body weight for children (15 kg or 33 lbs) and adults (70 kg or 154 lbs). An intake rate of 0.113 kg per week (0.25 lb) for children and 0.227 kg per week (0.5) for adults and an exposure frequency of one day per week for six months out of the year were used in this analysis.

NA = Not applicable, no MRL or RfD was available for lead, thus a screening value could not be determined. We estimated a < 1.4 µg/dL increase in blood lead levels for children and < 0.4 µg/dL blood lead increase for adults, thus lead is not a contaminant of concern.

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Table C-2. Summary data for contaminants found in one or more **liver** samples (n=18[#]) that did not exceed health-based screening values.

Contaminant	Concentration Range	Screening Value	Screening Value
	(mg/kg) Liver [†]	(mg/kg) [‡] Child	(mg/kg) [‡] Adult
Aluminum	<DL-2	2000	4000
Barium	<DL-1	200	400
Boron	<DL-3	9	20
Chromium	<DL-1	1000	3000
Lead	<DL-1.9	NA	NA
Manganese	11-19	50	100
Molybdenum	<DL-2	5	10
Nickel	<DL-3	20	40
Strontium	<DL-0.62	2000	4000
Zinc	86.9-162	300	600
γ-BHC [*]	<DL-0.003720	0.009	0.02
o,p'-DDE [*]	<DL-0.001770	0.5	1
Oxychlorane	0.000964-0.022300	0.6	1
Total-BHC	<DL-0.003720	0.009	0.02
Total-DDTs [*]	<DL-0.001770	0.5	1

[#] During one of the sampling events, the livers were not collected from two does, thus only 18 liver samples were analyzed [16].

[†] DL = detection limit of the analytical instrument.

[‡] Derived from the MRL or RfD for non-cancerous adverse health effects using standard assumptions of body weight for children (15 kg or 33 lbs) and adults (70 kg or 154 lbs). An intake rate of 0.113 kg per week (0.25 lb) for children and 0.227 kg per week (0.5) for adults and an exposure frequency of one day per week for six months out of the year were used in this analysis.

NA = Not applicable, no MRL or RfD was available for lead, thus a screening value could not be determined. We estimated a < 1.4 µg/dL increase in blood lead levels for children and < 0.4 µg/dL blood lead increase for adults, thus lead is not a contaminant of concern.

^{*}BHC=benzenehexachloride, DDE=dichlorodiphenyldichloroethylene, and DDT=dichlorodiphenyltrichloroethane.

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Table C-3. Summary data for contaminants of concern in white-tailed deer **liver** tissues taken from Caddo Lake NWR. There were no contaminants of concern in **muscle** tissues.

Contaminant	Concentration Range (mg/kg)	Screening Value (mg/kg) [‡]		# Samples Exceeded [§]
		Child	Adult	
Cadmium	0.34 – 7.7	0.2		18
		0.4		17
Copper	22 – 949	9		18
		22		18
Selenium	0.89 – 20.10	5		1
		10		1

[‡] Derived from the MRL or RfD for non-cancerous adverse health effects using standard assumptions of body weight for children (15 kg or 33 lbs) and adults (70 kg or 154 lbs). An intake rate of 0.113 kg per week (0.25 lb) for children and 0.227 kg per week (0.5) for adults and an exposure frequency of one day per week for six months out of the year were used in this analysis.

[§] Number of samples that exceeded the screening value.