EMGT 835 FIELD PROJECT:

Evaluating Mercury Concentrations in Midwest Fish in Relationship to Mercury Emission Sources

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Executive Summary

Mercury serves as one of the most visible forms of inorganic pollution in the public eye and is most commonly associated with contaminated fish. For many years pregnant women and women of child-bearing age have been instructed by both the Food and Drug Administration and the Environmental Protection Agency to limit their intake of fish due to concerns with mercury.

Atmospheric deposition of mercury is the primary route of uptake in fish. In recent years there has been significant discussion regarding the influence of local and global sources of mercury concentrations in fish. Few studies exist that attempt to sufficiently evaluate the relationship between mercury concentrations in fish and their proximity to mercury sources (most notably coal-fired power plants). To remedy this, mercury concentrations in fish tissue collected from over 250 locations throughout four states in the Midwest were spatially analyzed using Geographic Information Systems (GIS) technology to determine whether there appeared a relationship between the locations of mercury emission sources and concentrations of mercury in fish.

It proved difficult to portray the relationship based on a simple linear analysis of distance between the location of a sample and the concentration. However, when sources were buffered based on an approximation of watersheds within the commonly accepted area of localized deposition, there appeared a clear relationship for large mouth bass, the most prominent predatory species in the Midwest (the relationship did not hold true for bottom-feeders as expected since they do not bioaccumulate mercury at the same rate as predators).

Table of Contents

Table of Contents (cont.)

Table of Contents (cont.)

List of Figures

1.0 Introduction

Although numerous types of environmental contamination are attributable to humans, mercury contamination has been long cited as a problem facing both man and animal because of the adverse health effects it causes especially on sensitive populations, such as pregnant woman. Humans can be exposed to mercury via old tooth fillings, broken thermostats, or broken thermometers; however, the most prevalent route of exposure for uptake in humans is via contaminated fish. According to the Food and Drug Administration (FDA), a surveillance sampling for methyl mercury in fish from October 1992 through September 1994 found concentrations that ranged from non-detect in several species to 1.68 parts per million (ppm) in swordfish (Foulke, 1994). Fish accumulate mercury through diet and as water passes over their gills. Mercury[1] reaches waterbodies through a number of sources including geological formations, wastewater discharges, and mining; however, deposition of mercury from the air serves as the primary source of mercury. This mercury comes from both natural and man-made sources. Natural sources such as volcanic eruptions and forest fires contribute a quarter to half of atmospheric mercury while man-made sources make up the remaining half to three quarters (EPA, 1997c). The apportionment of anthropogenic mercury (US sources vs. global sources) varies depending on the organization conducting the research and the particular geographic section of the country but appears to range from 30% to 80%, with 59% presented in the Environmental Protection Agency's (EPA) 1997 *Mercury Study*

[1] Throughout this document the word mercury is used, but in reality mercury is commonly discussed in terms of total mercury and methyl mercury, an organic form of mercury that is created when mercury combines with carbon. Within the aquatic setting inorganic mercury is converted to organic methylmercury, which is the form of mercury that accumulates in the food chain. Within fish (especially predators) methylmercury generally constitutes 95% of the total mercury. Accordingly, the two are sometimes used interchangeably and total mercury is often analyzed for rather than methylmercury because it is typcially cheaper and easier analysis to perform.

Report to Congress (total deposition inside the US of 87 tons, with 52 tons from US sources).

Unfortunately, any estimates of mercury contributions are unlikely to be valid or stable in the future given the rapidity with which changes in the energy sector have occurred and will occur given the exploding world-wide energy demand. The Department of Energy's 2008 *International Energy Outlook* estimates that world usage of coal will grow from 132 quadrillion British Thermal Units (BTU) in 2008 to over 202 quadrillion BTU in 2030 (USDOE, 2008). Even with improved mercury controls on power plants, this increase will result in additional tons of mercury being released into the environment. The 2005 *International Energy Outlook* (USDOE, 2005) estimated that United States mercury emissions from the electric generating industry would grow 12% from 2003 to 2025.[2]

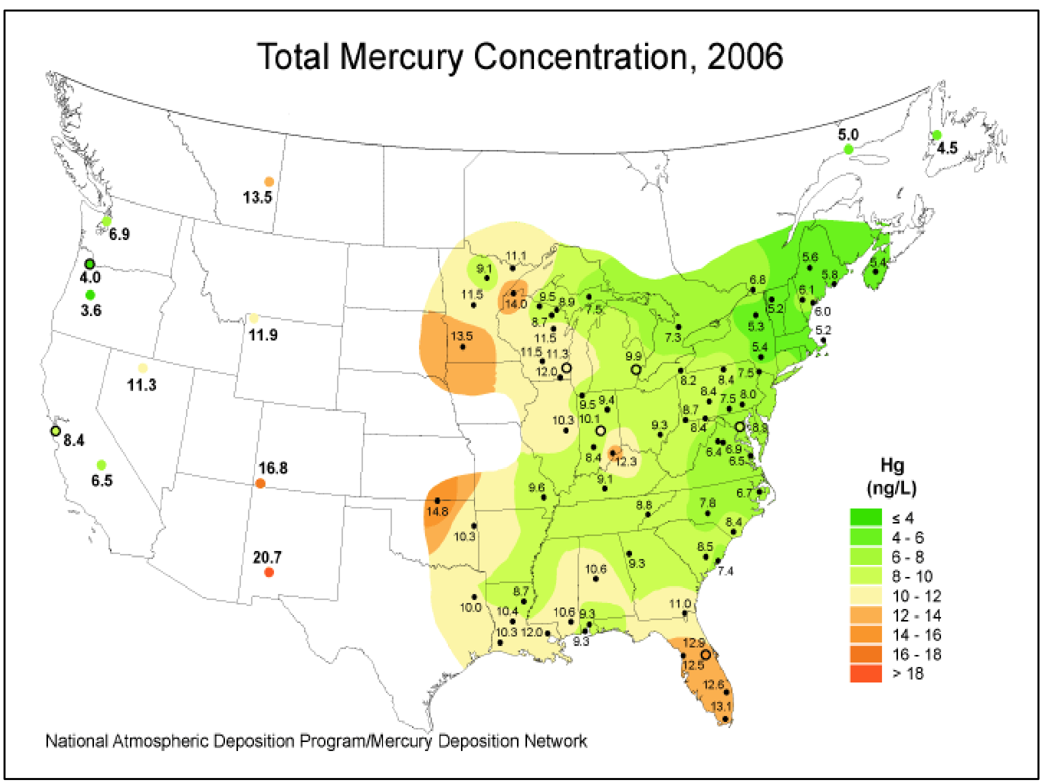
Given that: (1) coal use worldwide is increasing, (2) the US has abundant coal reserves (USDOE, 2007) and appears poised to embrace numerous energy sources including increased coal as a means to supplant foreign oil consumption, and (3) coal represents the largest current energy source in the Midwest plains region (USDOE 2008b, 2008c); increased mercury deposition appears an inevitability, as is further elevated levels in fish.

[2] The 2007 and 2008 *International Energy Outlook* from the US Department of Energy's Energy Information Administration, contained estimates that depict reduced mercury emissions based on EPA's 2005 *Clean Air Mercury Rule* (CAMR). However, this rule was vacated by the United States Court of Appeals, so it is more appropriate to forecast emissions in the absence of CAMR, hence the use of the 2005 Outlook.

This future reality may especially hold true for the Midwest. Data from the National Atmospheric Deposition Program (NADP) Network appear to show elevated levels across the States of the lower Missouri River (a lack of monitoring stations prohibits a more robust extrapolation) as depicted in Figure 1.

With this likely future scenario, it is worthwhile to further examine the relationships between local sources of mercury and elevated concentrations of mercury in fish since these relationships may better inform control strategies, siting concerns, and overall energy policies. The author's research proposes to evaluate such relationships in the four States of Iowa, Kansas, Missouri, and Nebraska.

Figure 1 - Concentrations of Total Mercury Deposition Throughout the United States[3]



[3] Obtained from the NADP at http://nadp.sws.uiuc.edu/mdn/maps/map.asp?imgFile=2006/06MDNconc.gif

2.0 Background

The issues surrounding mercury deposition and contamination are sufficiently complex as to require some minimal discussion in order to provide adequate background to describe the study design and illustrate why particular assumptions were adopted for the analysis. Salient information can be grouped into three categories:

- Risks of mercury for fish and humans;
- Mercury in emissions from coal-fired power plants; and
- Mercury transport.

2.1 Risks of Mercury

Mercury is an element that at normal temperatures exists in a liquid form as silver beads. In nature it is found in a number of rocks (such as coal) and minerals (cinnabar), and is rarely found in free elemental form. Mercury has been used by man in a number of products and processes over the years from tooth fillings and thermometers to thermostats and compact fluorescent light bulbs. Although an element and therefore natural, mercury exhibits properties which can be harmful to humans and wildlife alike.

2.1.1 Effects in Humans

Numerous studies have provided ample evidence that mercury is harmful to humans (ATSDR, 1999). Acute exposure (typically short duration and high level), particularly to vapors, may cause lung damage, tremors, or convulsions, and victims are likely to experience eye and skin irritation, nausea, and vomiting. Longer term exposure can damage the brain, kidneys, and numerous organs within a developing fetus. (ATSDR 1999)

Though not entirely understood effects in fetuses are especially pronounced because blood with elevated levels of mercury is passed to the fetus from the mother and disturbs rapidly developing organs such as the brain. Children exposed to high levels of mercury in-utero have been shown to exhibit a wide array of problems including cerebral palsy, development delays, and lower neurological test scores. (ATSDR, 1999).

2.1.2 Effects in Fish and other Animals

Mercury also poses a risk to wildlife. Aquatic species are obviously at an increased risk due to deposition of mercury since waterbodies act as a sink for the runoff of deposits. Behavioral effects in fish have been noted at levels of 5-10 ppb (parts per billion) (Wiener and Spry 1996, Wiener et al., 2002), while reproductive effects have been noted including suppressed hormone concentrations and inhibited gonad development (Fjeld et., al . 1998, and Wiener et al., 2002). In 1984, EPA authored an *Ambient Water Quality Criteria Document for Mercury* that provides a fairly detailed discussion of acute and chronic toxicity studies which provide LC50s, the concentration of water that causes 50 percent mortality in a species (USEPA, 1984). Recent studies have shown levels of mercury in fish that exceed these toxicity thresholds throughout the United States (Schmitt et al., 2005, Hinck et al., 2006, and 2007). Numerous birds and mammals that consume fish also are at risk of mercury. Studies have found elevated concentrations of mercury in mink, otters, kingfishers, and other predators (Scheuhammer 2007, Baron 1997, Halbrook et al., 2004). A 2007 study found that, “Loon Hg exposure, measured either as Hg levels in female loon blood or in fish prey, appeared to impose an upper limit on loon productivity,” and, “Loon productivity decreased as Hg exposure increased.” (Burgess, 2008)

2.1.3 Risk Levels

An important point in understanding the risks associated with mercury is knowing the levels at which adverse health effects occur, namely the level at which humans may consume fish without an appreciable increase in the risk of adverse health effects due to mercury contamination. The FDA continues to maintain an “action level” for mercury in fish of 1 ppm (1 mg/kg) which was established in 1979. This level applies primarily to purchased seafood, and is a revision of an earlier value of 0.5 ppm established in 1969 in response to hundreds of deaths in Japan due to mercury contamination in fish. (Bolger, 2005) In 2001, the EPA established a screening level of 0.3 ppm (a fish tissue residue criterion for methylmercury based on a total fish consumption rate of 0.0175 kg/day and a reference dose of 0.1 µg/kg per day). In 2000, the National Academy of Science (NAS) found, “On the basis of its evaluation, the committee's consensus is that the value of EPA's current RfD for MeHg, 0.1 µg/kg per day, is a scientifically justifiable level for the protection of public health,” (NAS, 2000) bolstering support for a public health protection screening level of 0.3 ppm.

EPA established the 0.3 ppm criteria using a daily fish consumption rate of 0.0175 kg/day (17 grams).[4] EPA conducted a study to look at consumption rates (EPA, 2002). These ranged from 0.11 - 2.3 g/kg of body weight per day (or 7-161 grams per day assuming a default body weight of 70 kg). Higher daily intakes result in lower or more protective screening values. For instance, a 75 gram per day consumption of fish correlates to a screening level of 0.093 ppm using the human health criteria equations from EPA's *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (USEPA, 2000). This may be a more reasonable assumption for many subsistence fishers as it is roughly half of the highest value reported in the EPA consumption study and would result in derivation of a screening value roughly 3 times more protective than the 0.3 ppm screening level. A more statistically valid value could be derived using the 95% Upper Confidence Limit (UCL) of the dataset; however, the raw data from this study was not evaluated. These concepts will be important considerations when evaluating the data from the author's research.

2.2 Mercury from Coal-fired Power Plants

Coal is one of the most plentiful fossil fuels found in the United States, and is made up primarily of carbon, hydrogen, oxygen, nitrogen, and sulphur. The three primary types of coal (bituminous, anthracite, and lignite) all have various energy contents and mixtures of elements (World Coal Institute, 2005). In addition to the primary constituents of coal, numerous other elements exist in minute concentrations,

[4] For perspective, a small 3 ounce can of tuna constitutes 85 grams

among them mercury. Each type of coal contains different mean concentrations of mercury (as due the same types of coal mined from different geographic regions).

The vast majority of plants in the Midwest use sub-bituminous coal from Wyoming fields (NETL, 2007). Although this coal has less mercury overall than mercury from the eastern part of the country, it contains a greater percentage of elemental mercury in insoluble form because of its lower chlorine content (Hatch et al. 2006). Do to this insolubility, scrubbers are less efficient at removing mercury, resulting in lower mercury capture and correspondingly higher emissions per ton of coal burned (Senior and Adams, 2006). For purposes of studying effects of coal-fired power plant mercury emissions on fish, these are important considerations since it means that more mercury is likely to be emitted per plant in the Midwest compared to other areas of the country.

Coal has been burned in the United States since the 1880's and there are over 600 coal-fired power plants currently operating in the United States (USDOE, 2008d). Coal-fired power plants produce electricity by burning coal in a boiler, which in turn heats water to produce steam. The steam, then flows through a turbine that spins a generator producing electricity. The process of burning the coal results in emissions that leave the plant via stacks. These emissions contain numerous constituents including carbon dioxide, sulphur dioxide, and mercury. Various control devices are installed to remove harmful constituents including mercury. In terms of understanding emissions and deposition, key pieces of information include stack height (the higher the stack the farther the plume travels prior to deposition occurring), emissions rates, and concentrations of constituents in emissions. For purposes of this study, simplifying assumptions have been made to disregard all three of these key parameters. On the macro scale that is being investigated it would prove difficult to collect information at all of the plants in the Midwest and model emissions. Accordingly all plants were assumed to be roughly similar. This assumption sacrifices the ability to interpret specific correlations based on plant size, emissions, and stack height, but should still provide robust data to allow for coarse correlations between the locations of plants and levels of mercury in fish.

2.3 Mercury Transport

Particulate matter and other constituents such as mercury that leave stacks are carried by the wind and deposited back to earth, through a process commonly referred to as mercury transport. The location where mercury is deposited varies depending on the

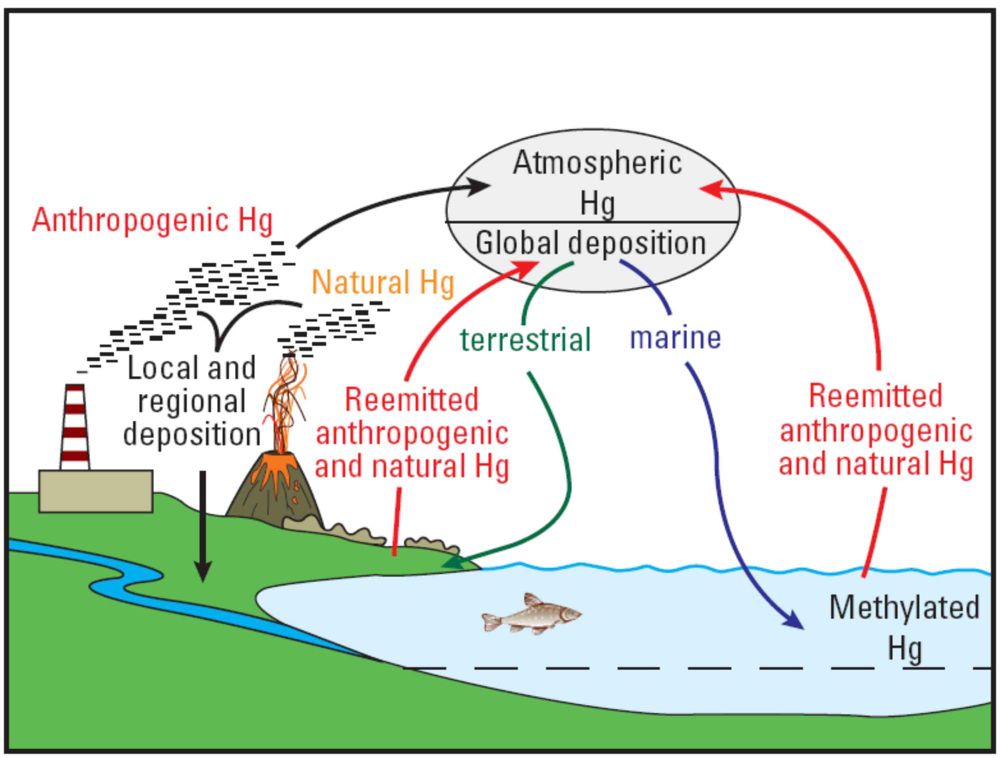


Figure 2 – Simplified Geochemical cycle of mercury (Taken from *Mercury in US Coal – Abundance, Distribution and Modes of Occurrence, USGS, and September 2001*)

height of stacks, the type of mercury emitted, and the weather patterns at the time it is emitted. Some mercury is deposited locally, while other mercury can be deposited across the globe. EPA's 1997 *Mercury Report to Congress* estimates that a third of the mercury emissions from the United States are in fact deposited in the United States, representing 70-75 percent of the total deposition in the U.S. This percent varies by Region depending on the presence and types of local sources. The Electric Power Research Institute indicates that this ranges from 10-80 percent based on Regions. (EPRI, 2006)

Once mercury enters water via deposition (or runoff containing deposited mercury), mercury will either volatize into the atmosphere, settle into sediments or enter the food chain. It enters the food chain via bacteria which convert inorganic mercury into methylmercury. Bacteria with methylmercury can either be consumed by macroinvertebrates and other organisms further up the food chain or can excrete the methylmercury which can adsorb to phytoplankton which are also eaten by other organisms. Through this process, mercury bioaccumulates in fish with top predators (such as large mouth bass) accumulating more mercury than bottom-feeding fish (catfish, carp).

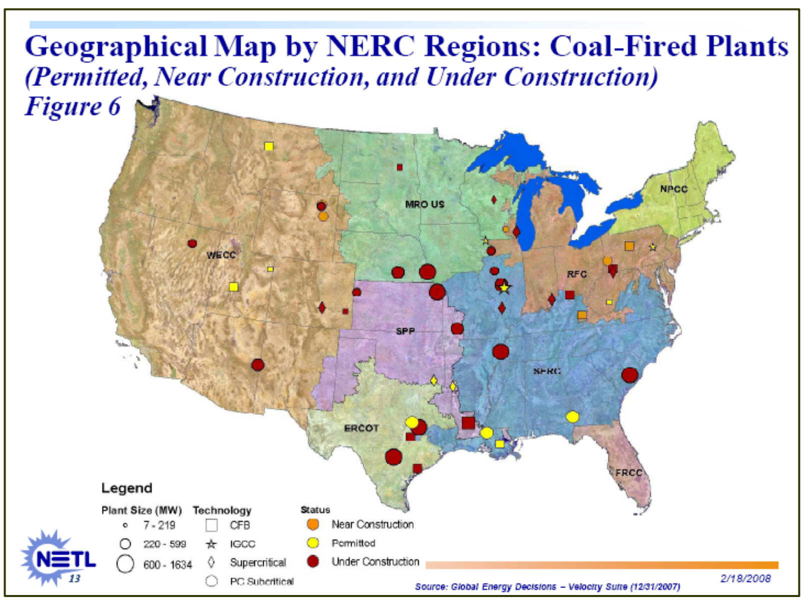
Similar to how mercury emissions were addressed from point sources, rather simple assumptions were necessary to deal with mercury transport for this project. Numerous studies have attempted to model the amounts of local, regional, and global deposition and apportion deposition to each of these three sources based on transport. Such an approach with this study would prove exceedingly complex because of the number of plants being evaluated and the absence of a sufficient number of active mercury deposition monitors in the Midwest to calibrate modeled deposition (refer to Figure 1.)

These complexities and others prohibit consideration of full mercury transport. Fortunately this study does not require an evaluation of mercury transport, since in effect, it seeks to identify if there is another contributor (local mercury deposition from coal-fired power plants) beyond long-range mercury deposition that affects mercury contributions in fish. The study area also consists of many sites and homogenous spatial distribution across the entire four states of Iowa, Kansas, Missouri, and Nebraska, minimizing the likelihood that any other site specific anomalies associated with atmospheric deposition would affect the outcome (sites close to power plants would be equally as likely to be affected as those far from plants).

3.0 Problem Description

Coal-fired power plants are the major anthropogenic sources of mercury in the United States. As previously discussed, some of this mercury finds its way into waterbodies via deposition, which can bioaccumulate within fish. To the extent that mercury finds its way into waterbodies from local sources, it may pose a unique challenge in the Midwest. According to the Department of Energy, 78% of the power in Iowa, Missouri, Kansas, and Nebraska is derived from coal-fired power plants, a much greater percentage than any other Region in the country (USDOE, 2008b and 2008c). This is expected to remain consistent, if not increase, given issues of energy generation and the expected growth in coal-fired power plants in coming years (see Figure 3).[5]

Figure 3 – Coal-Fired Plants, Permitted, Near Construction, & Under Construction



[5] This figure was taken from a power point presentation entitled, *Tracking New Coal-fired Power Plants*, and is attributed to Erik Shuster of the Office of Systems and Analysis Planning at the Department of Energy's National Energy Technology Laboratory, however, it is unclear at what conference or meeting the presentation was given although it is dated June 30, 2008. Additionally, the presentation contains a notation that the DOE does not warrant the accuracy or suitability of the information contained therein.

Several studies conclude that local sources of mercury emissions do not appreciably contribute to local deposition (Sullivan et al., 2006, Constantinou et al., 1995, Seigneur et al., 2006). However, this seems counter-intuitive especially given the elevated levels of mercury deposition in the Missouri River valley (see Figure 1). In fact, other studies have indicated that local sources may in fact contribute significant amounts to local deposition (Dvonch, et al., 1997, Lindberg and Stratton, 1998, and Cohen et al., 2004). Harris et al., 2007, found that, "an increase in mercury loading at rates relevant to atmospheric deposition resulted in an increase in methylmercury production and concentrations in aquatic biota in only 3 years." Accordingly it is reasonable to expect that an increased loading due to local emissions might result in increased mercury concentrations in fish above that which would be expected from atmospheric deposition due to global transport. This is precisely what this project seeks to evaluate.

3.1 Literature Review

There have been many studies that have evaluated mercury concentrations in fish, however, most focus on a single or number of waterbodies specific to a narrow geographic area, and few have any information regarding the distance to sources of mercury. Most provide a simple narrative discussion noting that mercury emissions from power plants are one of the sources of contamination found in fish. Only a few studies seek to evaluate mercury concentrations in local settings related to mercury emission sources. Three peer reviewed studies figured most prominently, while one more recent Masters Thesis also attempted to evaluate the phenomenon.

The earliest study attempting to quantify effects of power plant emissions on mercury concentrations in fish was developed by Anderson and Smith in 1977. They studied the Kincaid Power Plant near Springfield, IL. The study evaluated mercury concentration within the cooling water lake adjacent to the power plant. The authors found that the mean concentration of mercury in largemouth bass in the lake was 0.07 ppm, as compared to mean concentrations of 0.16-0.56 ppm for bass from three other IL lakes. This study has been cited by others as demonstrating that local emissions do not appreciably contribute to mercury concentrations in fish; however, the authors contend that some unidentified factor at Lake Sangchris had suppressed mercury accumulation in fish.[6] They go on to note:

> *In this regard, we emphasize that concentrations in the fishes were not merely normal for central Illinois, but were atypically low. Until the reason-the environmental factor-for this phenomenon can be explained, the findings for fishes in Lake Sangchris should not be applied to other fisheries located near large coal-burning facilities. (Anderson and Smith, 1977)*

Unfortunately, this study does not provide sufficient data to draw broad conclusions since it only focuses on a single mercury source and compares mercury concentrations in fish in the adjacent lake to concentrations in three other lakes. Additionally, since no additional information is available regarding potential sources of mercury proximal to these three lakes it is unclear if the source of mercury would be

[6] Recent studies have evaluated the relationship between mercury and selenium, namely the ability for selenium to reduce toxicity since selenium can bind with and sequester mercury preventing it from moving into the food chain in its methylated form. The author's research does not address this evolving issue.

expected to be solely atmospheric deposition, or whether other sources resulted in the elevated levels.

Somewhat similar to the Kincaid study, an additional study (Pinkney et al 1996) evaluated mercury concentrations in fish relative to a single plant. The researchers evaluated twenty-three ponds located around a power plant in Dickerson, Maryland. Ponds were probabilistically sampled within several zones surrounding the plant at fixed distances. Fish within each of the ponds were analyzed for mercury. Only sunfish or largemouth bass (found at 14 of the 23 ponds) were caught and sampled. Concentrations in the ponds ranged from 0.01 to 0.43 ppm. The researchers' primary conclusion was that the pattern of bioaccumulation was not consistent with the pattern expected from wet deposition models.

This study again does not broadly address the question on the macro-scale of whether proximity to mercury emission sources results in higher mercury concentrations within fish. As indicated this study looked at concentrations surrounding a single plant. All of the data points contained in the sample would be considered as "near" a mercury source as described in the methodology described in Section 4.0, so a more appropriate way to view this work with respect to the problem description above would be to evaluate the concentrations of fish (large mouth bass) at 14 sites (mean concentration of 0.2 ppm) with other fish data from around the Region taken during the same time period. Other studies providing information on mercury concentrations in fish in Maryland (Gilmour and Riedel, 2000 and Castro et al., 2002) do not contain data from the same year and use different sampling methodologies, laboratory analysis, and do not contain geographic information sufficient to easily draw comparisons. The author's concluded:

> *Examination of average mercury tissue concentrations in sunfish…and largemouth bass… for each pond (overlaid on the depositional isopleths at each pond location) does not suggest a clear relationship between mercury concentrations and predicted wet deposition.*

This conclusion is not incongruent with the idea that concentrations should not be viewed in light of a discrete proximal distance to a mercury source, but rather that they are viewed as either within or outside a "sphere of influence" surrounding an emission source. This also seems to be confirmed by noting that the lowest mean concentration in large mouth bass was found in the farthest concentric ring located between 10 and 15 km from the power plant, a distance which may be considered outside the area of local deposition. This fact proved important as additional support for establishing the design of this project. As indicated in Section 4.0, a buffer of 20 miles was selected as a proxy for watersheds at the Hydrologic Unit Code (HUC) 12 level that have a portion of their surface area that lies within 15km of a power plant.

The final peer reviewed work was conducted by researchers with the Brookhaven National Laboratory (Sullivan et al., 2006). This work appears to be the most oft cited research relating to local impacts of mercury contamination from power plants. This effort examined mercury concentrations in soil and vegetation within 10 miles of a coal-fired power plant in Monticello, Texas. The study concluded that only a few percent of the mercury emitted from a power plant deposited within 10 miles of a power plant. Additionally, they refer to a previous work (Lipfert et al., 2004) which indicates that mercury levels of are proportional to the square root of wet deposition (after controlling for water chemistry), and then state that because of this mercury levels are only expected to be elevated by 5-6 percent. Unfortunately, the endnotes to the Sullivan work do not contain a Lipfert et al., 2004 citation, nor could one be located that contained any reference to this correlation. Regardless this seems to be at odds with the previous study which indicates that there was not a clear relationship between mercury concentrations and wet deposition.

This study is not entirely germane to the problem at hand since it only evaluates soil and vegetation and extrapolates to fish from that data which may or may not serve as an adequate proxy for bioaccumulation in fish. Similar to the Maryland study previously mentioned, measured results did not match expected modeled deposition. If this was the case, it is unclear why the researchers felt compelled to indicate that deposition modeling was sufficient to predict only minimal increases in concentrations of mercury in fish. Notwithstanding this contradiction, issues regarding deposition modeling may be bypassed because the problem statement posed by this project does not seek to establish correlations between modeled depositions and field data. As indicated in the previous Section, it is assumed that local deposition is roughly similar from all plants. This assumption sacrifices the ability to interpret correlations based on plant size, emissions, and stack-heights, but should provide data to allow for coarse correlations between the locations of plants and levels of mercury in fish found near power plants.

Several statements in this study also cast a peculiar shadow over its purposes since they appear at odds with established health statements and are presented rather matter-of-factly as if to indicate that regardless of the results there is no health risk. The study indicates that, “In order for a local Hg deposit to pose a risk to a developing fetus, its mother must routinely consume high-Hg fish from an affected water body for several months, probably at the rate of 2 or 3 meals per day.” (Sullivan et al., 2006) This directly contradicts data, findings, and recommendations provided by the FDA, EPA, the NAS World Health Organization, and numerous other researchers. The study also presents this comment without providing data to support this conclusion. Accordingly the study findings were not employed to guide sample design for the author’s research.

One final study, a Masters Thesis by Chad Furl (Baylor University) entitled, *A Baseline Assessment of Local Mercury Deposition from Coal-Fired Power Plants in Central Texas*, also evaluated mercury and attempted to characterize deposition near several plants. Similar to the Brookhaven study, no fish tissue data was collected, however, water column and soil data were collected. Additionally, and similar to both the Brookhaven and Maryland studies, no correlation was found between modeled deposition and field results. However, this study indicates that one possible cause for the discrepancy might be bioaccumulation of mercury in vegetation and organisms.

These four studies only provided glimpses at the problem described in Section 3.0. To fully address this problem, it has been more fully defined below and serves as the basis for data collection and analysis activities for the author's research.

3.2 Problem Statement

In summary, the author's research seeks to address the issue of the lack of knowledge between a possible correlation between elevated levels of mercury in fish and their general proximity to local sources of mercury emissions. The project will seek to bin samples as either within a potential "area of influence" of an emissions source, or outside the presumed potential "area of influence" of an emissions source. Mercury results will be compiled via these geographic distinctions, with mean concentrations compared for the two bins.

3.3 Data Needs

In order to evaluate the effects of mercury in the Midwest, several sets of data are necessary. The first set of information is the location of coal-fired power plants in the Midwest. For this project, the primary focus area is the four State Region of Iowa, Kansas, Missouri, and Nebraska, however, data for surrounding states (Colorado, Oklahoma, etc.) are also necessary, to account for effects of plants located near state borders.

The second data set of importance is concentrations of mercury in fish tissue. This data has been collected by the States of Iowa, Kansas, Missouri, and Nebraska

(Region 7) as well as the United States EPA since the early eighties. Numerous other data exist throughout the United States both temporally and spatially however, all of the data collected in Region 7 was collected using the same Standard Operating Procedures (SOP) and following and similar Quality Assurance Project Plans which should allow the data to be comparable. Although data exists from numerous years, only the most recent data sets will be utilized since this data contained information collected from a number of lakes and rivers of different sizes across the Midwest, whereas older data focused more on rivers.

Another set of data that was necessary for this project was water quality information. EPA's Storage and Retrieval (STORET) system and the United States Geological Survey's (USGS) National Water Information System (NWIS) provide information on ambient conditions in waterbodies throughout the United States. This data serves to supplement the fish tissue data by providing water quality data conterminous with that of fish tissue (where available). Correlations will not be drawn between fish tissue and water column concentrations of mercury, rather the data will be used to evaluate anomalies within the fish tissue data set which may have elevated levels of mercury from sources other than air emissions.

The third major type of data was collected from EPA's Toxic Release Information (TRI) system which provides information on releases of toxic chemicals from facilities when such releases exceed a particular threshold. The locations of non-power plant facilities which released mercury into the environment were also included in the analysis to account for additional sources of mercury. These additional facilities typically consist of cement kilns and incinerators.

4.0 Methodology & Procedures

Several activities were undertaken to develop a methodology and process that would seek to answer the problem outlined in Section 3.0. These activities break down into four general areas; data collection, spatial analysis, outlier analysis, and statistical analysis.

4.1 Collecting Data

The data described in the previous section was collected primarily through data mining efforts, although the author did assist with several of the field collection activities. None of the data that were mined resided within the same systems so numerous manipulations were required to allow the sets to be used together. Where such processing was required it has been noted.

4.1.1 – Fish Tissue Data

For over twenty years the EPA and the States of Iowa, Kansas, Missouri, and Nebraska have participated in the Regional Ambient Fish Tissue (RAFT) program as described in Appendix A[7]. The purpose of the program is to:

> *…measure contaminant levels in the environment (specifically, in fish tissue) and, to gather the data needed to assess the risk to humans from consuming contaminated fish from all waterbody classes that are significant fishing resources in EPA Region 7 and protected by the Clean Water Act.*

[7] The RAFT Program Document has been included because it contains important information regarding the design of the study (particularly with respect to probabilistic design), and the document itself is not readily available as a reference.

One of the difficulties in analyzing concentrations of contaminants in fish at broad geographic scales is that many different organizations collect and analyze the fish using numerous protocols that differ considerably. The RAFT program utilizes a common SOP for fish collection which is found in Appendix B. Accordingly data can be compared across broad geographic areas with some degree of confidence. This comparability is one of the key factors that make this analysis possible.

While numerous years of data were available, it was decided to evaluate only the 2006 sampling results since it was the first year that included probabilistic sampling of lakes throughout the Midwest (early years only focused on fixed trend sites, and those sites that States sampled due to citizen complaints or because of particular interest which likely bias sampling).[8] As such this data set has a rather broad geographic distribution, where previous years tended to cluster around population centers, not surprisingly which often have mercury emission sources. Sampling was completed in the Fall/Winter of 2006, with analytical work completed during 2007. Samples were analyzed for mercury using SW-846 method 747.

The data was obtained from EPA's Storage STORET system and verified against Region 7's Regional Science and Technology Center's Laboratory Information Management System. For purposes of this analysis, the data pull only consisted of specific data fields that were germane to this study including such items as mercury

[8] Probabilistic monitoring is the sampling of randomly selected locations selected through an unbiased manner by a computer program. Each site has an equal probability or chance of being selected for monitoring.

concentration, length and weight (where available, although disregarded later), location, type of fish, etc.

Unfortunately, not all of the data sheets contained geographic (ie., lat long) information, and instead were coded with some other method of identifying the geographic location (ie., Big River south of town next to the bridge). Where possible based on narrative descriptions, those data points without lat longs were evaluated using Google Earth or other means to identify specific locational coordinates that corresponded to the narrative descriptions. For lakes this was rather easy since named lakes were easily identified via a review of State Department of Conservation web sites which provide information on publicly accessible fishing lakes. For rivers, identifiable points were situated close to the nearest means of ingress/egress since this would likely be the entry point for field staff entering with either boat or backpack mounted electroshockers. If ambiguity existed, or where narrative descriptions were insufficient to provide accurate locations, the data were removed from the analysis.

Another aspect of the data that became apparent was the different types of species collected. The RAFT program sampling plan calls for the collection of two separate species of fish, one a predator the other a bottom feeder. However, there is no specific requirement for a particular species; rather field staff members collect whatever bottom feeders and predators they can that meet the RAFT protocol requirements of 3 to 5 fish of the same species, all of which are within 75% of each other in length. Twenty-eight different species of fish were collected during the 2006 season. By far the greatest number of similar fish were carp (80), followed by large mouth bass (57), and channel catfish (29). Large mouth bass are predators while channel catfish and carp are bottom feeders. All other species of fish were caught in much lower numbers and were not as geographically representative as large mouth bass, channel catfish, and carp. Accordingly, only these three were retained for further analysis. Fish Tissue Data is found in Appendix C.

4.1.2 – TRI Data

The second key factor in conducting the analysis is identifying sources of mercury releases to the environment. EPA maintains a database called the TRI. It was created by the 1986 Emergency Planning and Community Right to Know Act (EPCRA) and holds data regarding releases and transfers of certain toxic chemicals from industrial facilities. The data can be accessed via a website called TRI Explorer (http://www.epa.gov/triexplorer/). Coal-fired power plants are a subset of the universe of facilities that report releases under TRI.

TRI Explorer was queried four separate times (once for each of the four States) using the chemical report module, with the year "2006," "all industries," and "mercury and mercury compounds," as query criteria. Each of the four queries yielded a set of facilities which had released mercury to the environment. Of these facilities only those that had either on-site air emissions; fugitive air emissions; on-site surface water discharges; or a combination of the above three releases were retained for the analyses. The other releases of mercury typically refer to landfilling, underground injection control, or off-site waste transfers. The data reports found in Appendix D contain a number of fields, but most importantly, latitude and longitude as well as pounds of mercury emitted during 2006. An additional constraint was placed on the data by only retaining those facilities that that emitted greater than 1 pound of mercury. This universe contained primarily coal-fired power plants with a handful of additional facilities that emitted smaller amounts. All data were combined in a single database.

4.1.3 – NETL and HSIP Data

The TRI data was expected to provide robust information regarding the sources of mercury in the Midwest as well as the locations of sources (especially power plants). However, two additional data sets containing information identifying power plant locations were evaluated to ensure that the TRI database contained all currently operating power plants (since TRI data is generated by emitters and sent to the State prior to upload into the TRI system there existed the chance that several sources might be excluded). The Homeland Security Infrastructure Program (HSIP) Gold (2005) is a geospatial data inventory assembled by the National Geospatial Intelligence Agency (NGA) with the help of other federal partners. HSIP contains numerous layers including one that provides locations of electricity generating stations. The geospatial data layer containing generating stations was opened in ArcGIS and a selection of all coal-fired plants was undertaken using the second data set, the 2007 *National Energy Technology Laboratory Coal Database* (NETL, 2007). Those facilities that were in both data sets were clipped into a new ArcGis shapefile. This shapefile was compared visually against a shapefile created from the TRI data to identify any anomalies between the two sets. Minor discrepancies existed, so both sets of data (TRI and NETL) were carried forward for use in the analyses. Similar to TRI geographic locations were the most important data field in this set. NETL data is found in Appendix E.

4.1.4 – Water Quality Data

It is infrequent occurrence to find mercury in the water column above method detection limits, however, in order to account for waterbodies that have elevated levels of mercury which may be caused by sources other than air emissions, water quality databases were evaluated to identify waterbodies that might contain high levels of mercury. This information constitutes the third and smallest factor for this analysis (which was used exclusively as part of the outlier analysis described in Section 4.3) . The two largest sources of data available to the public are the USGS's NWIS and USEPA's STORET system.

The interface for the NWIS data system is difficult to use when attempting to run a query on a particular chemical parameter at a large scale. Accordingly no queries were run in advance of analysis. However, NWIS was used after the analysis was conducted to evaluate the status of outliers. Namely, the HUC where an outlier was identified was used as a geographic query within NWIS to identify any possible mercury water quality data. Ultimately, no detectable concentrations of mercury were found using this approach, for the specific locations where fish tissue data was collected.

Water quality information from EPA's STORET database was downloaded in comma-delimited files from the web from June 1 – 30th of 2008. A query was run of the modernized STORET data (which only dates back to 2000) limiting the query to mercury found in lakes, streams, or rivers within the four States of interest. The text files were then modified in Excel before being placed in a database. Of the over 6,000 mercury samples found in STORET, only 92 had concentrations in water above the method detection limits. This subset of sample locations where Mercury was detected in the water column was carried forward into the outlier analysis. The raw data is found in Appendix F.

4.2 Spatial Data Analysis

In order to evaluate the effects of coal-fired power plants on fish as described in the problem statement, the first two data sets (fish collection sites and emissions source locations must be evaluated spatially. This can be accomplished using ArcGIS software and the data sets described in Section 4.1. The maps produced to conduct the analysis have been included in the entirety in Appendix G.[9]

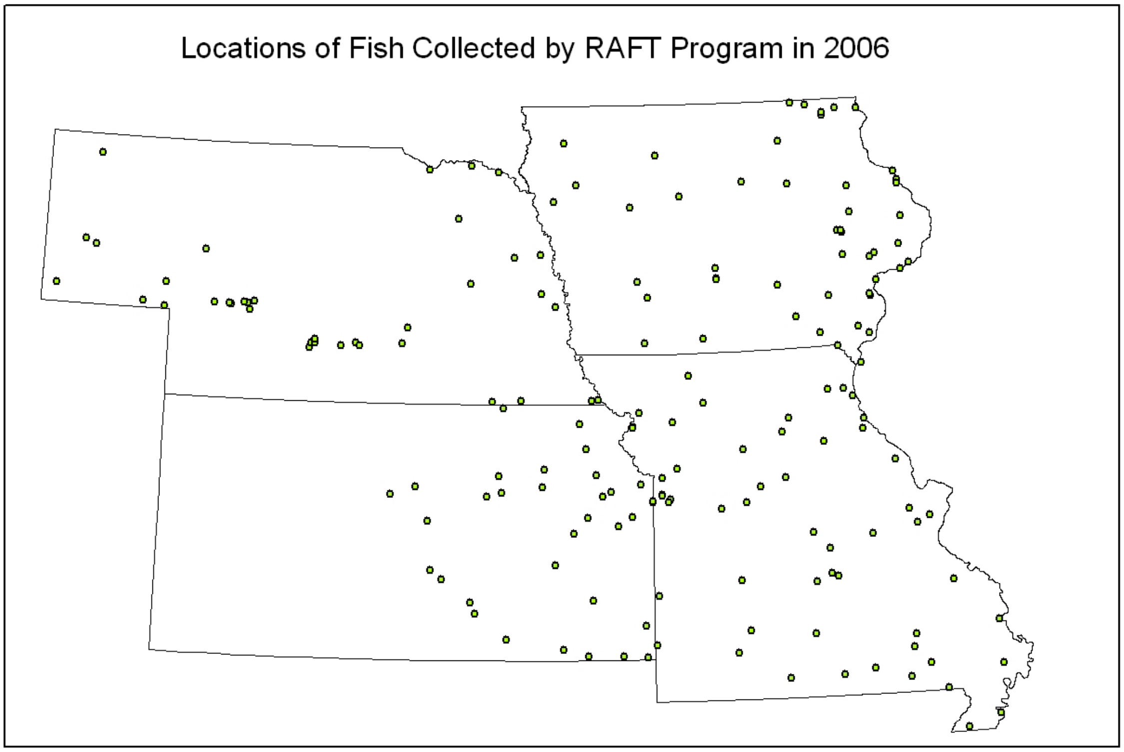
First the RAFT dataset was separated into four separate databases, one each for carp, channel catfish, large mouth bass, and other.[10] Only the first three were retained for further analysis since the other category contained numerous different types of fish (gar, small mouth bass, suckers, etc.) that were found in such lower counts and in such specific

[9] Some smaller versions of particular maps are included in this section to aid in the discussion of the analysis.

[10] In reality most work was completed using spreadsheets that were saved as databases prior to import into the GIS environment. However, so as not to add confusion I use the term "database" to mean both databases and interim spreadsheets.

locations of the Region as not to provide a meaningful and robust analysis.   Next these databases were converted into ArcGIS shapefiles(points) and added to the GIS project as shown in the map depicted in Figure 4.

Figure 4 - Locations of Fish Collected by the Raft Program in 2006



In order to ensure that these points actually fell on waterbodies, the National Hydrography Dataset (NHD) was added as a Quality Assurance (QA) step. This QA was completed visually, as depicted in Figures 5 and 6.

Figure 5 – RAFT Sampling Locations with NHD as Base Layer

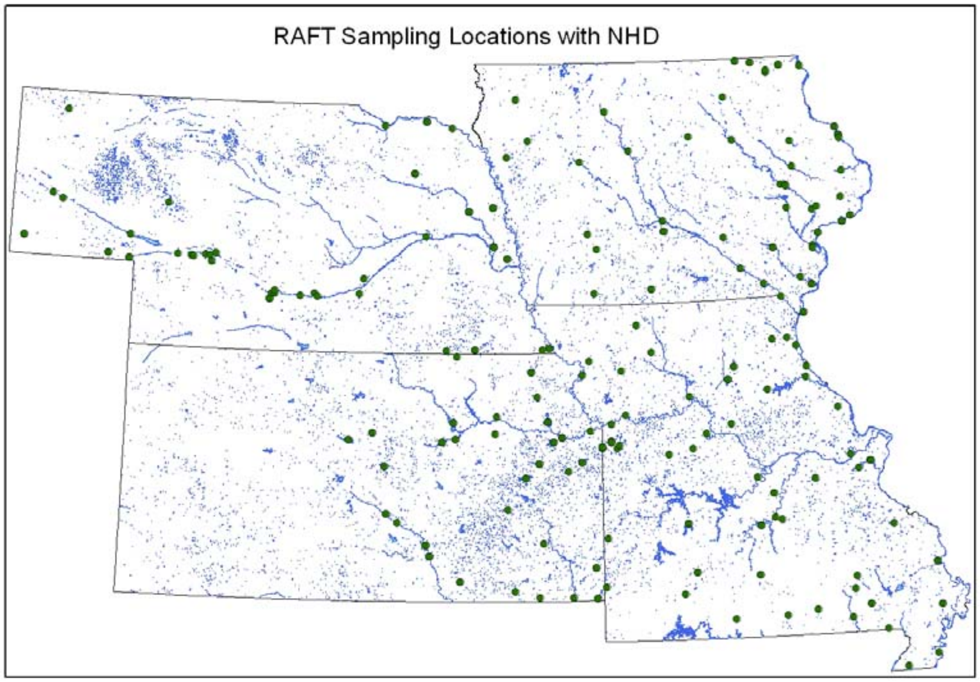
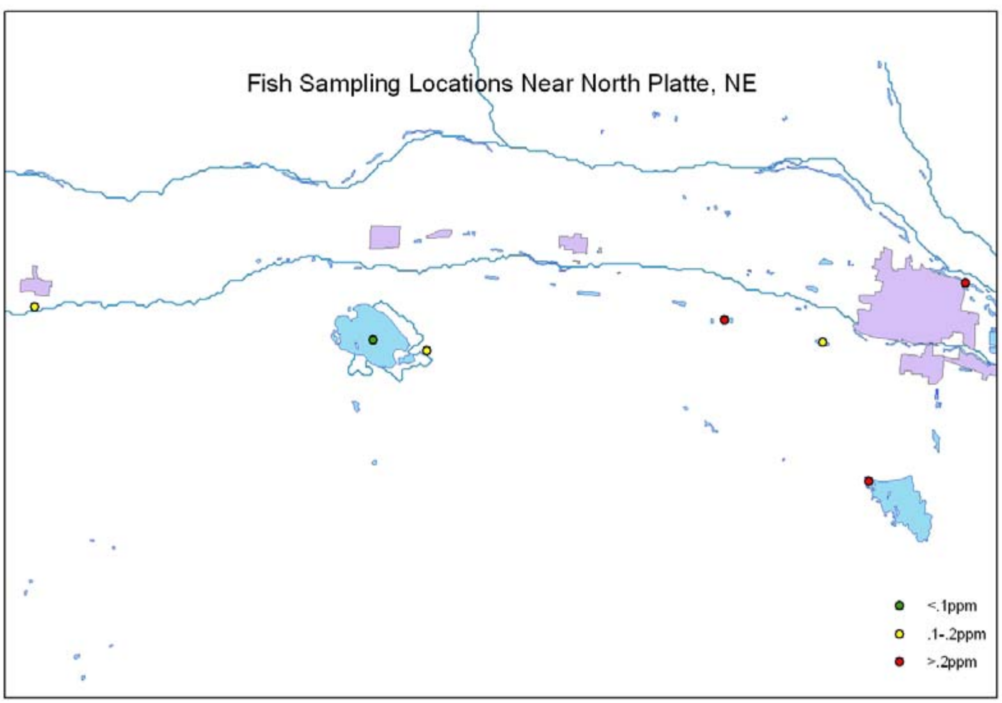


Figure 6 – Close-up of RAFT Sampling Locations near North Platte Nebraska with NHD as Base Layer



Next, the coal-fired power plant data layers from TRI and NETL were added to the project. Using the buffer tool, a new layer was created that established a buffer of 20 miles around each of the coal-fired power plants and emission sources. Next the select by geography tool found in ArcGIS was utilized to select those RAFT locations that fell within the buffers surrounding emissions sources. A separate layer was established using this selection, as was the inverse (those RAFT sampling locations outside the buffers). This effort was undertaken separately for large mouth bass, carp, and channel catfish, resulting in six separate data layers which were migrated back to database as described in Section 4.4.

After this spatial analysis was completed, the resulting layers were exported back into the database to develop the final results provided in Section 5.0 and to perform the basic statistical analysis using tools available within the Microsoft Office Suite, as discussed in Section 4.4.

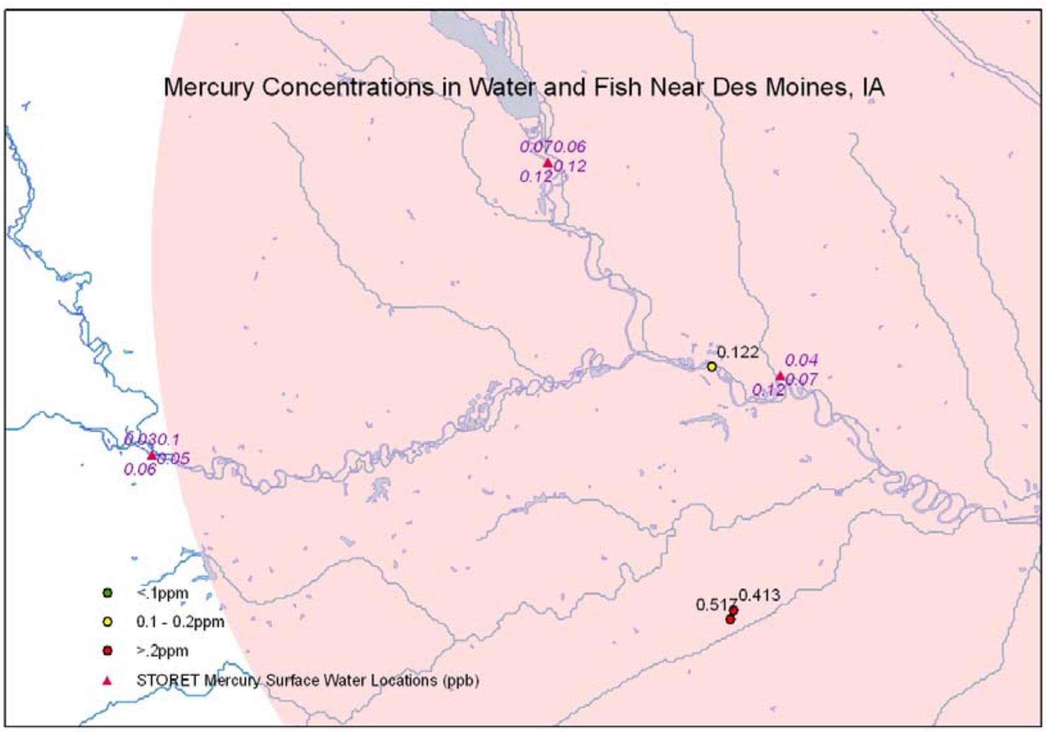
4.3 Outlier Analysis

In order to evaluate the potential that elevated water concentrations from a source other than deposition were contributing to elevated levels of mercury in fish two separate analysis were undertaken. First, USGS's NWIS database was queried based on the HUCs in which individual fish collection sites were located. This yielded no correlation between locations.[11] Next, the 92 data points from the STORET database were added to the project. Those that appeared within the buffers developed for the TRI were visually

[11] This was essentially true with one small caveat namely there a few locations where sites were co-located in the same HUC but which were not truly hydraulically linked (for example a lake in the upper part of a watershed and a 2nd order stream in the bottom part of a watershed).

investigated to see if their might be potential links between surface water concentrations and fish concentrations. This was not found to be the case, as is depicted in Figure 7, which contains a close-up of Des Moines area. As depicted there are two locations where fish were collected. The highest readings were taken from a lake in the southeast section of the map, separated from the surface water sample sites by both distance and other waterbodies. The other location where fish were collected is on the main stem of the river while the closest surface water values are from a tributary that enters further downstream.

Figure 7 – Mercury Concentrations in Water and Fish Near Des Moines, IA



The same effort was undertaken to evaluate water concentrations and fish concentrations in areas outside buffers surrounding mercury emission sources, with similar results. Practically speaking this analysis did not provide much support to the author's research, but it did seek to rule out a potential confounding factor which might have been the source of potential outlier data.

4.4 Statistical Analysis

Because of the numerous assumptions and the rather simplified question that was constructed around the problem statement (namely are mercury concentrations in fish close to mercury emission sources higher than those that are farther away), the type of statistical analyses appropriate to apply to the resulting data sets are also necessarily of the simple variety.

Box and Whisker Plots

Box and whisker plots are a visually appealing way to provide basic statistics (quartiles, means, medians, etc) when data is comprised of two variables. In this case the variables are comprised of the fish concentrations in parts per million and the location of the sample, expressed as either within the buffer of an emissions source or outside the buffer. As indicated in Section 4.2, the attribute tables from the shape files were exported from ArcGIS back into a database. Next, a box and whisker plot add-in tool called PTS charts was applied to the data to create the plots[12]. The plots and associated data are found in Appendix H.

[12] http://peltiertech.com/Excel/Charts/BoxWhisker.html

Standard Deviaition

For each of the paired data sets (inside and outside buffers) a comparison was also made regarding the standard deviation associated with the data. Since the locations of the data were for the most part randomly chosen because of the probabilistic design, it was assumed that the standard deviations might be expected to be somewhat similar for both sets of data (not the same values but the same relative order of magnitude rather both really high, low or moderate). Vastly different standard deviations might indicate that the two sets of data may not be appropriately compared in the simple box and whisker comparison as noted above, and that numerous other variables beyond the simple proximity to a mercury emissions source could possibly be at play.

5.0 Conclusion

The above described analysis provided different results based on the type of fish that was sampled, and while not overwhelmingly convincing from either a methodological perspective or statistical perspective, tend to support at least further analysis of this phenomenon.

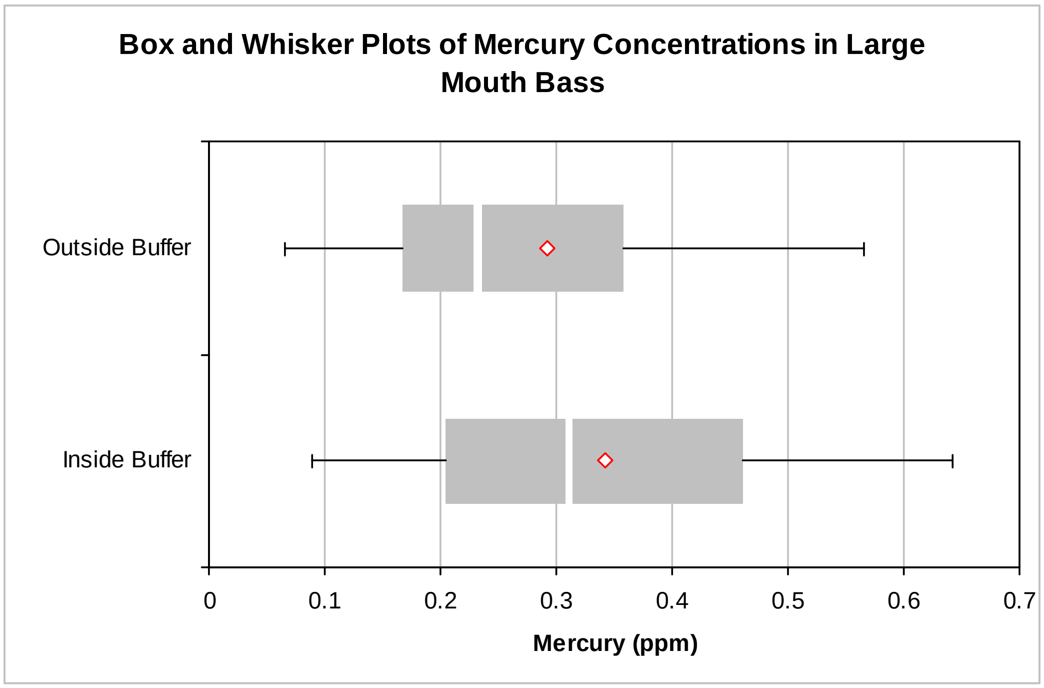
5.1 Results

The results of the spatial analysis appear to indicate a marked difference between large mouth bass caught within 20 miles of a mercury emissions source versus those caught outside. However, this relationship does not appear to hold true for channel catfish or carp. Mean concentrations are shown below:

Fish Species	Mean Concentrations within 20 miles (ppm Mercury)	Mean Concentrations of Fish Outside 20 miles (ppm Mercury)	Δ
Large Mouth Bass	0.343	0.293	.05
Carp	.185	.189	-.004
Catfish	0.132	0.149	.017

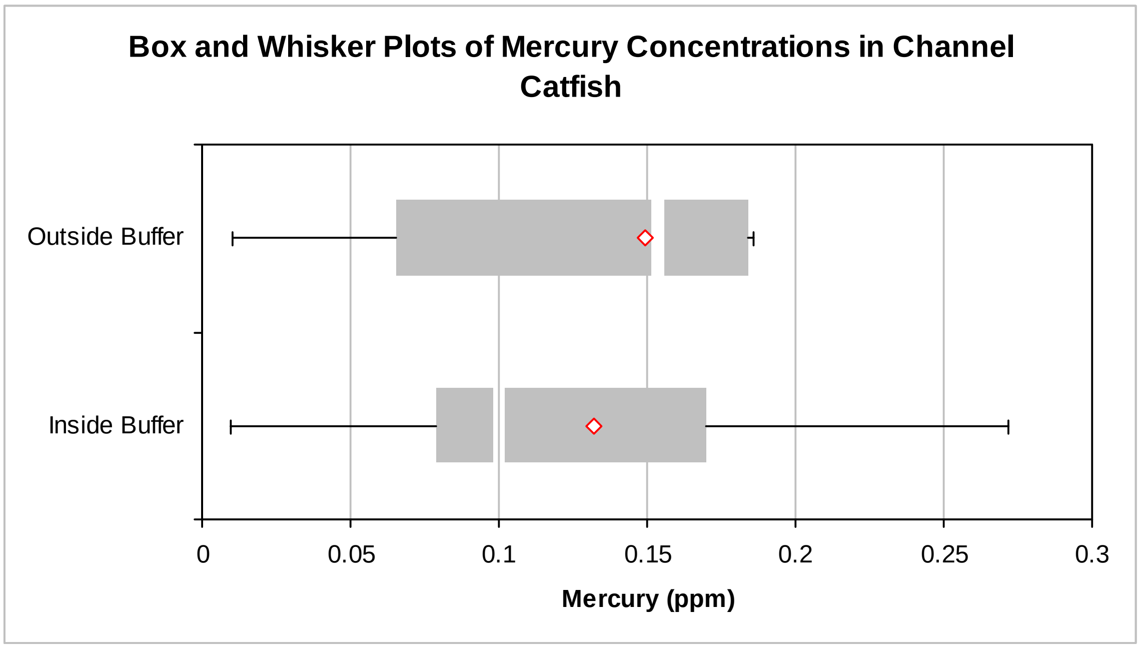
When the differences (Δ) for each of these fish types is viewed as a function of the action levels described in Section 2.1.3, we see that for both carp and catfish the percent of difference only translates to 1-6 percent of the action level, where as for large mouth bass, the difference translates to 17% of the action level. In other words it is unlikely that the location of a bottom-feeding fish will significantly affect its chance that it will meet action levels when concentrations are near the action level. For predator species however, the location does matter as the difference in location can mean almost as much a 20% increase, which is significant at levels near the action level. This is conveniently depicted in the results since the mean for large mouth bass caught outside buffers meets the action level, while the mean for those caught inside exceeds. These relationships are more evident when looking at the box and whisker plots for each of the fish types.

For large mouth bass, the box and whisker plot provides a clear way to see the relationship described above.

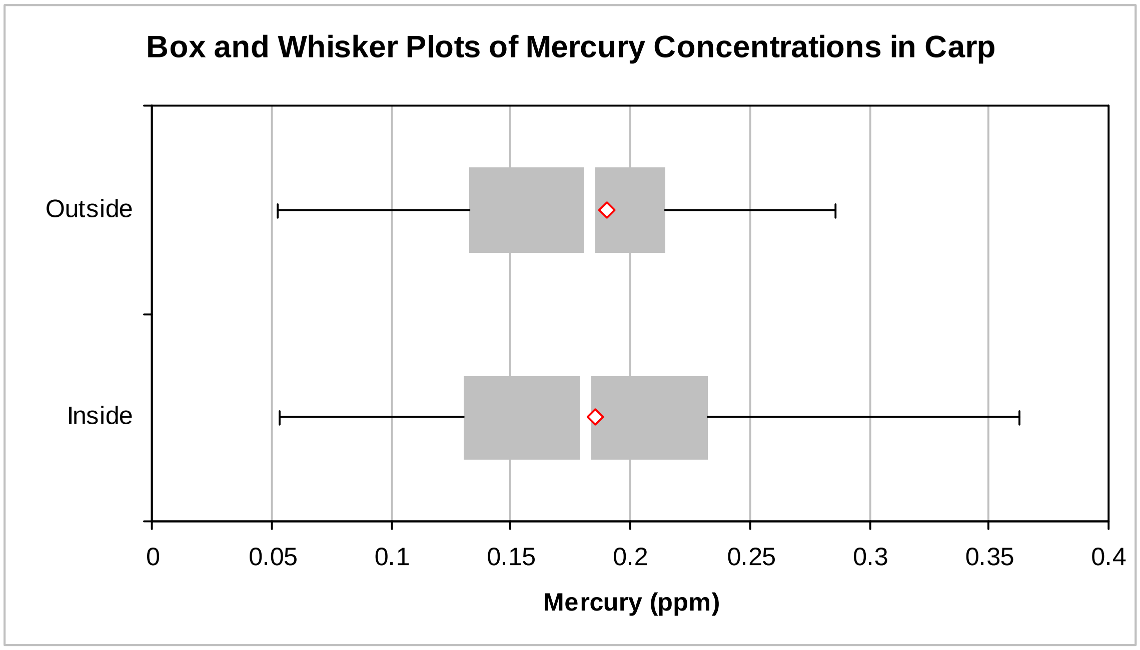


The mean, median, quartiles, and fences were all higher for the set representing those fish caught inside the buffer than for the set representing those caught outside. These results seem to indicate that a statistically significant relationship exists between presence or absence within the buffered areas and concentrations of mercury. Additionally, the standard deviations for both sets of data are relatively similar (0.18 vs. 0.16) indicating that the distribution of concentrations in each of the data sets are similar indicating comparable levels of uncertainty about the average.

Unlike the data sets for large mouth bass the dataset for catfish shows a higher mean for fish outside buffers than within although the two values were relatively close (a difference of .017).



The 25th percentile is lower and the 75th percentile higher for the outside the buffer data set as compared to the inside the buffer data. This may be the result of the data sets for catfish being smaller (only 9 and 10 values respectively). The similar means and low levels of mercury seems to confirm the many studies which indicate that bottom-feeding fish such as catfish have much lower levels of mercury in their systems than predators such as large mouth bass. This data also seems to indicate that local deposition of mercury may not play an important part in bioaccumulation in bottom feeders. This could be due to the fact that the levels of mercury moving all the way through the water column and depositing in sediments are similar regardless of location, whereas where local deposition is high this additional mercury is removed as it passes through the water column and converted into methylmercury and move into the foodchain.



Carp, seemed to behave very much like catfish and exhibited even closer means (only a difference of .004). Evaluating this data their appeared to truly be no significant difference between the two data sets (similar medians, standard deviations, and quartiles), also reaffirming the conclusion noted with regard to catfish, namely that mercury contamination in bottom feeders does not seem to be an issue in the United States. As shown the data indicates that this holds true regardless of whether a fish resides in a closer proximity to a mercury source or not, leading again to the potential conclusion that local deposition of mercury may not play an important part in bioaccumulation in bottom feeders.

5.2 Sources of Error

There are numerous sources of potential overestimation, underestimation, and error. Many of these were already hinted at throughout this document as assumptions were discussed in the above sections. Several of the most prevalent and obvious are discussed below.

A number of fish sampling sites were excluded from the analysis because of poor locational data. While there is no reason to expect that these data would be biased in either direction, their exclusion may have affected the results of the analysis. Additionally, the sample size for one of the types of fish (catfish) was particularly small in part because of poor locational data. Often rather crude directions were given regarding the location of a sampling on larger rivers. As discussed earlier in this section, the small sample size limits the ability to draw as definitive of conclusions regarding the data.

Further complicating any analysis within this Region is the presence of mercury from non-point sources particularly farming practices. Up until the late 1969, mercury was commonly used fungicides, mildewcides, and pesticides, and not until 1995 were registrations for pesticides using mercury cancelled. Although banned, their use has resulted in ill-defined levels throughout agriculture areas. These levels may be only perceptively above normal background concentrations, but little information exists attempting to characterize these levels. An early attempt in the author's research sought to help control for potential impacts by incorporating land cover into the analysis, however, it quickly became too complicated. Accordingly, any source from agriculture might affect levels in fish, and therefore skew the analysis.

Numerous studies have clearly shown a correlation between the age and/or size of fish and concentrations of mercury. This is not surprising since mercury bioaccumulates and the older a fish is, the longer it is likely to be, and correspondingly the more mercury it may have consumed. Several studies have attempted to age or length correct mercury concentrations. Since age data was absent and length data was missing for much of the data, all fish were assumed to be roughly the same. This assumption could serve to over or under-estimate the results (if younger/smaller fish were caught closer to power plants and older longer fish away from plants any correlation would be underestimated and therefore overestimated for the converse).

5.3 Recommendations

Obviously additional work that sought to remove or address any of the biases, assumptions, or sources of error described above might prove useful in either adding support or calling into question the results of the author's research. However, there are a number of additional activities that could be completed in the short term to build onto this project.

<u>Evaluate the Correlation between Concentrations and Actual Distance</u>

With the existing data and using some additional tools from the ArcGIS software, distances could be calculated from the location of fish sample collection to the nearest emissions source. The resulting distance and concentration could be plotted to determine if there is a correlation between distance and concentration. This might more appropriately be completed on the set of fish data found within buffers of the emissions sources since local deposition is the phenomenon of interest.

Evaluate additional Years of Data

The author's research only evaluated data collected from 2006. Additional years of data will be available in the near future. It would be worthwhile to discover whether the relationship noted for large mouth bass holds true in additional years or does the data more closely approximate that for carp and catfish where no correlation was evident.

Evaluate additional Predators

The RAFT data set does not contain as much information regarding predator species as for bottom feeders. All major studies concerning mercury concentrations in fish have indicated much higher levels of mercury in predators than in bottom feeders. It would be useful to collect additional data for other predators to verify the conclusion that local deposition in the Midwest may be a cause for concern for predators but not bottom feeders.

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Appendix A

Regional Ambient Fish Tissue Program

EPA Region 7
Regional Ambient Fish Tissue Monitoring Program (RAFTMP)

Program Rationale, Design and Implementation Plans for 2006 - 2010

February 2006

USEPA Region 7
Environmental Services Division
and the Regional Fish Tissue Monitoring Workgroup

TABLE OF CONTENTS

Page

INTRODUCTION

The absence of detectable concentrations of toxic substances in samples of water and sediments from a given water body, year after year, is not always an indication that the water body is free of those substances. On the other hand, fish who reside in those waters can bio-accumulate quantities of toxicants in greater concentrations than observed in the water column. In light of this, EPA Headquarters issued in 1976, a recommendation that the EPA Regions support the ambient water quality monitoring programs of the states by analyzing fish the states collect from some of their strategically located trend stations. In 1977 in response to this recommendation, the states and EPA Region VII began the Regional Ambient Fish Tissue Monitoring Program (RAFTMP)[13]. The program established a network of stations from which samples of whole fish were collected and analyzed for toxicants. Whole fish analysis was selected because 1) whole fish have a higher percentage of lipids and therefore, have greater potential to store lipophylic toxicants, and 2) wildlife eat whole fish. In the 1980s, the RAFTM program evolved into a function more useful to the states. Emphasis shifted from whole fish analysis and began to include the edible portion (filets), since FDA human consumption guidelines were available. While monitoring whole fish from core stations for trend purposes continued, the states began to also look at other (non-core) waterbodies.

Although detection of trends for contaminants and protection of human health continue to be the main objectives of the program, in 2004 EPA Region 7 and its states began the process of examining the program to look for opportunities to maximize its utility and value. The purpose of this document is to provide the rationale, objectives (including monitoring design) and implementation plans for the redesigned RAFTM program for the period of 2006 to 2010. The redesigned program is continuous and consistent with the past program. However, it has also been improved to fill monitoring gaps identified in the existing program and to make better use of the program data. The redesigned program is also consistent with and supportive of the EPA's overall strategic water monitoring plan as well as those of the state water monitoring strategies. The RAFTM program and the state strategies are intended to improve water quality monitoring, the amount and quality of data to assess all our waters, and ultimately, to protect human health and the environment.

This document was developed through a broad multi-agency collaborative effort which included state water quality and conservation agencies, state departments of public health, EPA, USGS, FWS, Army Corps of Engineers and university personnel. These agencies and organizations came together to form a Region 7 Fish Tissue Monitoring Workgroup (refer to Attachment 1, Workgroup Participants List) which held a series of meetings and conference calls between Dec. 2004 and Dec. 2005. The purpose of these meetings was to examine and then redesign the Region 7 RAFTM program. The workgroup provided a wide range of Regional expertise and perspectives and functioned in a truly collaborative manner to accomplish that work.

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[13] Information of the program's background, methods and standard operating procedures can be obtained from Lorenzo Sena or Lyle Cowles, EPA Region 7 (contact information is included in Attachment 1).

PROGRAM GOALS

The primary goals of this program are to measure contaminant levels in the environment (specifically, in fish tissue) and, to gather the data needed to assess the risk to humans from consuming contaminated fish from all waterbody classes that are significant fishing resources in EPA Region 7 and protected by the Clean Water Act. A secondary goal of this program is to identify possible risks to piscivorous wildlife from consuming contaminated fish.

PROGRAM RATIONALE

Section 305(b) of the Clean Water Act (CWA) requires the states to do a number of activities related to monitoring and assessment of their waters including providing a comprehensive assessment of water quality to the EPA Administrator every two years. Section 303(d) also requires that the states develop a comprehensive listing of all impaired waters. This requirement includes listing of those waters impaired by the presence of contaminated fish tissue which poses an undue risk to human health. The RAFTM program is designed to support these CWA requirements by directly supporting the states' monitoring programs relative to these objectives as well as to assess, communicate and manage health risks in their waters by posting fish consumption advisories (FCAs). The redesigned RAFTM program will continue to support these CWA programs but in addition, address the following issues and concerns the Regional workgroup expressed regarding the old RAFTM program.

1) ***Although levels of a number of contaminants have declined over the history of the program, contaminants are still present at many Regional sampling sites in concentrations of concern to both humans and/or wildlife*. *Therefore, the program will continue to monitor for the traditional suite of pesticides and metals.***

2) ***The program's limited analytical resources, along with the states' procedural need for multiple-years data from some of the same sites, act to severely limit sampling/ geographic coverage. This limitation prohibits achieving some program objectives such as comprehensive sampling coverage of all the waterbody classes as well as investigation and assessment of risk to sensitive and/or subsistence fishing populations***.

3) ***Both targeted and probability-based (or other representative-type) monitoring designs should be used simultaneously to ensure all program objectives are achieved***.

4) ***Risk to piscivorous wildlife should be considered in assessing the program data***.

5) ***We need to understand more regarding the broad scale geographic distribution and concentration of emerging pollutants such as PBDEs as well as dioxins/furans.***

6) ***We must produce and provide consistent, timely and value-added information to the public and resource managers. That information must be consistently communicated***

across state lines regarding the risks of eating contaminated fish as well as the general benefits of eating fish.

Program Objectives

The redesigned RAFTM program will meet its goals and address the issues identified with the existing program by achieving the objectives stated below. Implementation plans for each objective are provided in the final section of this document.

Program Objective 1; Build Multiple Monitoring Design Layers to Support Multiple Monitoring and Assessment Objectives:
The program will build and support the necessary number of monitoring designs and monitoring stations to achieve the monitoring and assessment objectives listed below. In addition, the program will seek to integrate these designs and the sample collection process into a coordinated, systematic state / Regional fish tissue monitoring and assessment network. The primary objectives of this network would be to provide better 305(b) and 303(d) sampling coverage to the states as well as assist the states with their fish consumption advisories and risk assessment activities.

Monitoring and Assessment Objectives:

a) Comprehensive monitoring and assessment of all waterbody classes which are used to a significant degree by humans for fishing (for state 305b and 303d).
b) Support both site specific and broad scale geographic monitoring and assessment for existing and emerging contaminants of concern (for state 305b and 303d).
c) Monitor and assess long-term trends in state/Regional contaminant levels.
d) Support monitoring and assessment of risk to sensitive and subsistence fishing populations as well as to populations consuming other aquatic organisms such as shellfish.

Other Assessment Objectives:

Assess potential risk to piscivorous wildlife from contaminated fish tissue.

Program Objective 2; Provide Adequate Resources to Operate the Program
The program will estimate and then provide all the resources (analytical, sampling, operating) needed to implement the redesigned program in order to meet its goals and objectives. If additional resources are needed, they will be provided by both maximizing the efficiency of the current program and by investing some new resources.

As part of the process for redesigning the program, the workgroup estimated the analytical and the sampling resources needed to meet all the monitoring objectives for the redesigned program (refer to Program Monitoring Objectives). An estimate was made for both an improved base program and, for additional monitoring needed to support new sampling components (waterbody classes) of the redesigned program. These estimates showed that the annual analytical resource dedicated to the existing program (Region-wide, 150 samples providing coverage to approx. 75 sites) was not adequate to meet either the existing or redesigned program's needs. Therefore, the resources will be increased by both maximizing the efficiency of the current program and by investing some new resources.

Program Objective 3; Examine and Adjust Parameter Coverage and Methods: For 2006 - 2010, continue to monitor for the program's current and historical suite of pesticides and metals, but add additional parameters of interest such as dioxin/furans, PBDEs as well as other emerging pollutants.

As part of the program redesign and workgroup process, historical data from RAFTM as well as almost all other fish tissue monitoring programs in the Region (and nation), were examined to derive overall findings and conclusions regarding the status of pollutants in fish tissue in the Region. These data and the conclusions drawn by the workgroup influenced the program's redesign. Although all these data have been preserved as part of the process notes referenced earlier, some of the more interesting and conclusive data (depicted graphically) have been included with this document as Attachment 3 to support the redesign rationale.

The data in Attachment 3, Graph 1 show that in general, pesticide levels have decreased significantly over the last twenty years especially for historical pesticides such as chlordane, DDT, dieldrin and, for PCBs. In addition, the data in Graph 2 shows mercury levels have exhibited moderate fluctuation over the history of the program. Despite the overall decrease in the levels of most pesticides, the data also shows that contaminants are still present in Regional fish tissue at levels to be of concern to both humans and piscivorous wildlife. Therefore, the program will continue to monitor for the traditional list of contaminants in order to track trends.

The program will also adapt in order to monitor and assess threats from both new compounds (such as PBDE) and legacy pollutants (such as dioxins/furans). Through monitoring efforts such as EPA's National Lake Fish Tissue monitoring program, these two classes of compounds have been shown to be widespread throughout the country and Region 7. In fact, the levels of PBDEs in the environment have been shown to be doubling approximately every two to five years (personal communication with L. Birnbaum, USEPA). Therefore, the program will also seek to better understand the spatial distribution and concentration levels of these compounds at the state and Regional spatial scales. Although the assessment levels of concern for some of these compounds need to be carefully examined, the workgroup agreed the program should gather the background data needed to some day assess the risk from these compounds as well as track trends.

Program Objective 4; Develop Consistency in Assessments and Message: Develop consistent fish tissue assessment procedures among Region 7 states relative to preparing the 303(d) list, the 305(b) report and in posting fish consumption advisories. In addition, develop a more uniform and less confusing message (across state lines) in order to communicate more consistently to the public regarding both the risks as well as the benefits from eating fish.

Early in the process of redesigning the program, the Regional workgroup agreed that inconsistencies between the states in assessment methods create confusion in the public. This confusion detracts from achieving the objectives of the program. Therefore, the Regional workgroup identified most of the issues contributing to the inconsistencies (see list provided in Implementation Plans for Objective 4). The workgroup also identified the need for a consistent state/Regional message regarding the risks as well as the benefits to consuming fish to address the often conflicting and confusing array of both state and federally produced information on the subject.

Program Objective 5; Provide Information Products for Improving Resource Management and to Inform the Public:
Develop and provide highly useful and consistent assessment information products to both resource managers and the public. The information would be relevant to conveying the condition and trends of the environment as well as potential risks to humans and piscivorous wildlife from eating contaminated fish by comparison of the data to appropriate levels of concern.

Although states produce summary reports of their annual RAFTM program monitoring, the workgroup discussed and agreed that we are not making the fullest use of, and therefore deriving the fullest value and benefits from, the current and historical program data. To address this, the workgroup discussed producing several informational products geared toward better educating both the public and resource managers. These products (or a single product) could potentially include a wide array of information such as: 305(b) information on the general condition of state/Regional fish tissue relative to contaminant concentration levels and for several different waterbody classes (for example, urban lakes, big rivers, sensitive and subsistence populations, etc.); 303(d) information on the locations of contaminated fish; assessment of risks to piscivorous wildlife; background material on contaminants. This information, when taken together would be designed to provide clear and more complete assessments of the resources.

Among the products discussed was a Region 7 "Fish Contaminants" report similar to the report produced by EPA Region 5 for the Great Lakes (available at: www.epa.gov/region5). The workgroup agreed there were merits and potential benefits to producing a similar style fish tissue report either for the Region or for each state. Potential benefits include better utilization of the data and assistance in working through at least some of the inconsistency issues (especially relative to message). In addition, it provides an opportunity to tell a "good news" fish tissue story in Region 7 as opposed to a bad news, 303(d) story. The workgroup also agreed that public information products should be 'reader-friendly' (non-scientific) periodic publications intended to convey basic information such as current status, historical trends, risk, etc.

General Program Operating Procedures and Definitions

The redesigned program will be operated through active management by EPA Region 7 and its states in cooperation with the Regional Fish Tissue Monitoring Workgroup. The program will conduct at least one regularly scheduled annual meeting of the Regional workgroup (timing TBD but probably in the early spring, Jan., Feb) to accomplish the tasks described below. Other meetings will be scheduled as needed with coordination of sampling (includes distributing field sheets, tags and other sampling supplies) handled through EPA contact with each state individually.

<u>Agenda for annual program meeting</u>:

-Review implementation plans for the coming year. Refine and add the necessary operational details to the program.

-Finish monitoring design and site selection work for the coming year and begin work on monitoring design and inventory of resources for next year.

-Review data, findings and assessment results from previous years.

-Work on program objective 4 (achieving consistency among the states in fish consumption advisory protocols and 303(d) listing procedures) and objective 5 (production of improved and value-added information products for resource managers and the public).

Tracking Program Science and Coverage

The RAFTM program will track the site selection rationale and sample coverage for each waterbody class and sub-class for both the new and old parts of the program. To do this the states will determine the type of sampling site (site selection rationale) for each site (see definitions below) and report this information to EPA on the field sheet for each site. These definitions can also be discussed and clarified by the workgroup as needed. In addition, the program will continue to track information for each site on the species composition of the samples and well as weight and length data for each specimen within each sample.

C = Census: all sites sampled
P = Probability: sites selected by random design
TR = Targeted Representative: sites selected to represent a population or an area
T = Targeted: special study sites selected for investigating suspected problems

Sample timing:

Per EPA National guidance on fish sampling and analysis (Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories, Volume 1: Fish Sampling and Analysis. Third Edition. November 2000. EPA-823-B-00-007.), samples will preferably be collected during the period from summer to early fall (i.e. July to November) as the lipid content of most species is normally highest at this time. It is best to avoid the spawning period of the targeted species in order to achieve the most representative sample and to avoid disturbing spawning grounds.

Sample Types: The trends portion of the program will remain as whole fish.

For all other components of this program, fillet samples will be collected and submitted as “skin-off”.

Definitions:
- Status Sites: Sites selected by the states for investigation of either suspected contamination or to document current contamination levels.
- Follow-up Sites: Status sites previously sampled and found to have concentrations above state levels of concern.
- Trend Sites: Fixed station sites selected for the purpose of detecting long-term trends in ambient concentrations of pollutants from bottom feeding whole fish.

Lake Classes: The following definitions of the lake classes are general program guidelines. Each state can refine these definitions for its own uses. The definitions were primarily established to convey the level of sampling coverage the states required for each class. Lake size is a secondary but relevant consideration in the definition.

- Class A: Usually (but not exclusively) large public lakes (estimated to be less than 100 per state), listed within state water quality standards and with high public use, value and interest. **These are lakes for which the state determines it needs census style data** (i.e., data on each lake at some frequency to be determined by each state). Examples of these lakes are, Lake of the Ozarks (MO), Okoboji (IA), McConaughy (NE), Perry (KS).

- Class B: Generally medium-size public lakes, (estimated to be several hundred per state) with significant public value and interest which may or may not be listed in state standards but which might be listed in the future. These lakes do not require census type sampling but still, need good sampling coverage (meaning a significant percentage of representative lakes sampled). Representative sampling can be provided by either a probability-based or other representative type sampling design.

- Class C: Small public lakes or private lakes with public access (estimated to be several thousand per state) which are not, and have little chance of being listed in state water quality standards. These lakes are however, easily distinguishable as ‘waters of the U.S.’ under the Clean Water Act. The information need for this class of lakes is to represent the population using a Regional scale probability-based sampling design.

‘Waters of the U.S.’: Waters which have a hydrologic connection, either by groundwater or surface water pathways, to the navigable waters of the United States and/or their tributaries.

*Sampling Designs***:**
Targeted monitoring approaches dominate current monitoring designs especially for 303(d) purposes. However, targeted monitoring should be guided and prioritized using science-based estimates of the likelihood of impaired conditions and the key stresses contributing to impairment. Targeted monitoring can confirm estimated condition (or

impairment status), identify causes and sources, and support planning and implementation of control measures.

Probability-based monitoring designs utilize statistically unbiased random samples of a population of waters. They provide a cost effective and scientifically valid approach to estimate the fraction of impaired waters and the distribution of the condition of all waters and provide an excellent design for 305(b) purposes. They can also provide estimates of the proportion of waters impacted by predominant stresses such as sediment, nutrients, urban runoff, mining, or exotic/invasive species.

Targeted - Representative monitoring approaches attempt to select water bodies which are representative of populations and/or geographic areas. This in normally done by BPJ or using various types of data such as remotely sensed land use, land cover, etc.

Census-style monitoring achieves comprehensive coverage by sampling all members of a population. Census serves well as a design for both 305(b) and 303(d) but is impractical, especially for large populations and limited budget programs.

Rationale for Sampling Coverage of Waterbody Classes

The rationale and data for the program design decisions made as part of this program redesign and workgroup process as summarized below. All data and rationale have been preserved as part of the group decision record in the form of meeting notes which were produced after each meeting and ratified thereafter by the workgroup. The meeting notes are maintained as part of the program documentation. In addition, a summary of the monitoring design, rationale and implementation schedule for the program is provided in Attachment 2, Table 1, RAFTM Program Design 2006-2010.

For purposes of designing a comprehensive monitoring program, each of the broad waterbody classes (lakes, rivers, etc.) was divided into distinct sub-classes based on factors such as natural functional differences, population size differences and sampling considerations (refer to Attachment 2, Table 1, RAFTM Program Design 2006-2010). The decision to monitor or not monitor each waterbody class and sub-class was made by the workgroup based upon two factors:

1) The first factor was the importance and/or public profile of the waterbody class. For example, the workgroup asked, "Is the waterbody or class significant such that the states must have data on that water body or on each water body in the class (such as large public reservoirs)?"

2) Since the goal of the program is to protect human health, the second factor considered was the amount of fishing pressure (either perceived or real) on the waterbody. For the larger water bodies (big lakes and rivers) the group consensus was that there was sufficient public profile and fishing use to merit monitoring. However, for some of the smaller classes of water bodies such as the Class C lakes (small public lakes or private lakes with public access) and ponds, creel survey and fishing license data was evaluated to determine if "significant use" was occurring on these water bodies. Waterbody classes or sub-classes that were evaluated by the workgroup as 'yes' for either of these two factors were included in the program monitoring design.

Special Note:
Small streams (including small urban streams) and wetlands were eliminated from the program design because they are not considered significant fishing resources by the Regional Workgroup.

In addition, urban wadeable streams were also eliminated as a discrete design sub-class by the workgroup through consideration and agreement with the following rationale:

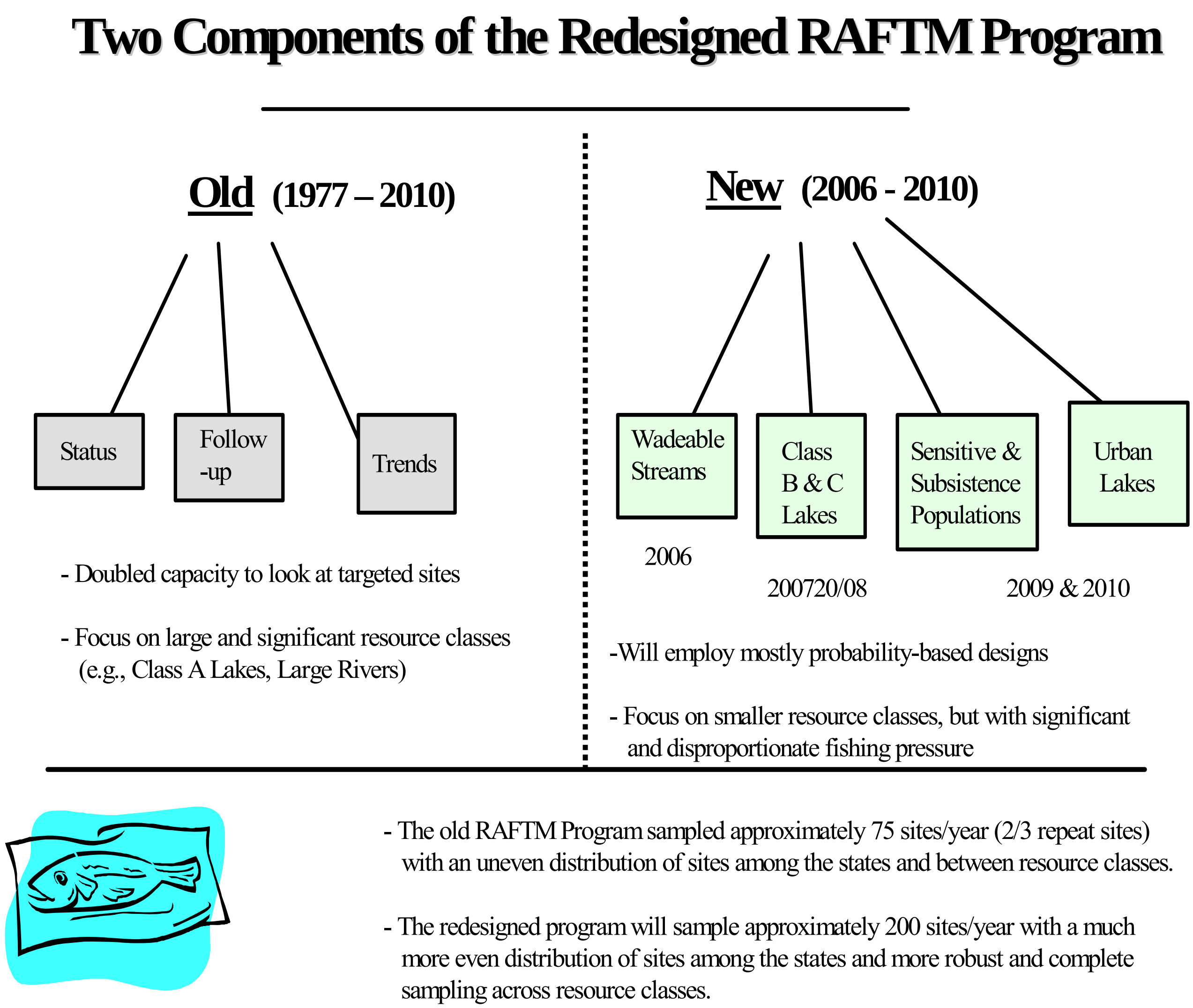
1) Most urban areas in Region 7 are either near or on big or non-wadeable rivers/streams.
2) Most urban areas have numerous lakes and ponds.
3) Large rivers and urban lakes/ponds are generally more accessible and, present a more attractive and much more frequented fishing venue than urban wadeable streams.

4) Fish collected from the larger streams in urban areas are just as likely (and perhaps more likely) to represent worst-case urban contamination scenarios than wadeable streams (i.e., urban rivers and urban lakes represent conditions in the urban areas).

Program Sampling Components

The redesigned RAFTM program for 2006 - 2010 will consist of two components, the old program with status, trends, and follow up sites and a new component that was created to monitor un-assessed and/or under-assessed waterbody classes that were identified by the workgroup (see Figure 1). The redesigned program components are described below and their application to waterbody classes are summarized in Attachment 2, Table 1, RAFTM Program Design, 2006 to 2010.

Figure 1



Improved (old) RAFTMP: The old RAFTM program will function as it did in the past which was to provide the states with resources to sample their status, follow-up and trend sites. But, it will be improved by providing more samples which will allow the states to investigate more targeted sites (status and follow up) and, to have more Regional trend sites (increased from 23 to 40). The existing program component will also be improved by tracking the waterbody coverage and sampling design science per procedures described previously.

The old program component will also be improved by using it to target and increase the sample coverage for the waterbody classes that are the highest profile and/or receive the most use, such as big rivers (Missouri and Mississippi), non-wadeable rivers and large public lakes. The site rationale, sampling design science and waterbody coverage for all the classes will be tracked (refer to Table 1), evaluated as the program is implemented and the coverage increased if not found sufficient to represent each class.

Although trend sites will be collected only in the even numbered years, this should have minimal impact on our ability to detect long-term trends. This is because the primary purpose of the trends program is not to detect trends on an annual basis. In addition, the parameter base coverage will remain the same so our ability to look at the long-term trends in individual contaminants will not change.

New RAFTM Program Component: The new component of the redesigned RAFTM program is a series of various probability-based and targeted-representative type monitoring designs that will be implemented across several different waterbodies classes or populations (both waterbody and human) over the next five years. These waterbody classes and populations of interest are described below and are those that were identified by the Regional workgroup as either un-assessed or under-assessed. These are waterbodies such as the Class B and C lakes, urban lakes and sensitive and subsistence fishing populations. The rationale for selecting an appropriate monitoring design for each of these waterbodies or populations was made by the workgroup primarily based on the size of the waterbody or population and the sampling coverage needed (census or representative) for the class.

a) *Wadeable Streams*: In 2006 the program will use the existing state probability-based sampling programs (RAM in Missouri, R-EMAP in the others) to collect fish tissue (bottom feeder for organics and a predator for mercury) from 60 wadeable stream sites in Region 7 (approx. 15 per state). We will attempt to maximize the geographic area covered by these samples in order to gain more insight into mercury distribution. This will provide Regional level comprehensive coverage of this waterbody class with a measurable degree of statistical confidence. It will also allow possible trend analysis on this class as it will be comparable to some of the past R-EMAP data in the states.

b) *Class B and C Lakes*: In 2007/2008 the program will focus in on improving coverage in Class B lakes (population estimated to be several hundred per state) and the C lakes (population estimated to be several thousand per state). This will be done by collecting

120 samples from the Class B lakes (30 per state, using a targeted representative design) and 40 from the Class C lakes (10 per state, using a probability-based design). In regard to sampling objectives for these classes, the states expressed the desire to do representative sampling across the entire state for characterizing mercury contamination levels and geographic distribution. To devise both a representative and geographically broad sampling design for the B lakes, the states will produce a complete inventory of these lakes for their state. This inventory will be divided into appropriate geographic areas (also to be determined by the state) in order to draw a spatially stratified random sample (process to be determined). In addition, EPA will attempt to develop an inventory of the Class C lakes from the National Hydrographic Dataset (NHD) with assistance from the states to enhance the inventory, draw samples and categorize the urban lakes.

c) *Urban Lakes*:

The program will focus on urban lakes in 2009 /2010 but treat that time period as one sampling design period which will include the sensitive and subsistence populations (see description below). Both these populations will be sampled during that time period using some combination of up to 160 samples (60 in 2009 and 100 in 2010).

Regarding the urban lakes, both the 303(d) and 305(b) questions will be considered in the program design because the workgroup and program representatives did not feel that urban lakes are being adequately addressed through the existing state 303(d) programs. In addition, the definition of urban includes cities of 25,000 population and greater but the states have the option to add some cities that may be slightly under 25,000.

In regard to the questions about urban lakes, the program will focus on comparing the "relative risk" between urban and rural lakes as well as attempt to identify impaired lakes. This could be done by first answering the primary questions (see below) for urban lakes in phase 1 of the program (2006 - 2010) and then answering the secondary questions in phase 2 (after 2010). However, the workgroup will re-examine the implementation plan (including the questions) for this component beginning in 2007 and make final decisions in 2008.

Primary questions for the "urban" lakes:

1) What is the condition of all urban lakes (i.e., what percent is impaired by contaminated fish tissue)?

2) Is the condition of urban lakes different than non-urban (rural) lakes (i.e., are the percentages of lakes impaired by contaminated fish tissue significantly different)? Answering this question could tell us if we have an "urban lakes problem."

3) Is the condition of lakes in small cities (25K) different than lakes in large cities (100K) (i.e., are the percentages of lakes impaired by contaminated fish tissue significantly different in these two populations)?

4) Can we determine the factors that drive / contribute to impaired lake condition from unimpaired condition (such as land use & land cover, proximity to industry, point and non-point source contributions, etc.)?

Secondary questions for urban lakes:

5) Can we use our knowledge of the most critical driving/contributing factors of impairment (ascertained from the work done as part of primary question 4), to develop effective and efficient targeting methods for identifying all the impaired lakes (urban and rural)?
6) Can we implement a targeted urban lakes study to test these targeting methods and identify the impaired urban lakes?

d) *Sensitive and Subsistence Populations*:
This portion of the program addresses monitoring to protect the health and evaluate risk to subsistence anglers (including low-income and urban anglers) as well as different ethnic groups (such as Asians and Native Americans). In general, these are groups of people who either consume more fish than others, consume different parts of fish or other aquatic organisms (such as freshwater mussels), who may fish more contaminated waters or, who may be more sensitive to contamination (such as children and the elderly).

For many of these groups, food is an important part of their culture and serves economic, social, aesthetic, ceremonial, and religious functions. Fish, as an important cultural resource, may contribute to community well-being and cohesiveness. Fish may hold a prominent place in religious and social ceremonies and rituals. Fishing activity often involves the intergenerational transfer of knowledge, and may contribute to sharing and social bonding within the family and community. For some, the consumption of self-caught fish is an important means of augmenting family food supplies; it has important economic impacts. In isolated, rural communities, alternate food sources may not be readily available. In poorer communities, families may lack sufficient income to purchase alternate foods.

Program Implementation Plans for 2005/2006

2005/2006 Program Implementation Plans for Program Objective 1; Build Multiple Monitoring Layers to Support Multiple Monitoring and Assessment Objectives:

Implementation plans for the program's **monitoring objectives** are provided below. The implementation plans for the program's **assessment objectives** are included with the Program Objective 5, "Provide Information Products".

Monitoring and Assessment Objectives:

a) Comprehensive monitoring and assessment of all waterbody classes which are used to a significant degree by humans for fishing (for state 305b and 303d).
b) Support both site specific and broad scale geographic monitoring and assessment for existing and emerging contaminants of concern (for state 305b and 303d).
c) Monitor and assess long-term trends in state/Regional contaminant levels.
d) Support monitoring and assessment of risk to sensitive and subsistence fishing populations as well as to populations consuming other aquatic organisms such as shellfish**.**
e) Assess potential risk to piscivorous wildlife from fish consumption.

1. Conduct a workgroup meeting In Oct. 2005, to review the draft program design document and develop the basic operational details needed for implementation such as:
    a) Sample collection collaborations, and responsibilities
    b) Program science tracking
    c) Sampling design for some analytical parameters (PBDEs, dioxin, etc.)
    d) Begin the process to develop waterbody class inventories for B and C lakes
    f) Workgroup coordination processes (meeting frequency and timing) for:
        1) Coordination of annual logistical program operations
        2) Work on 'parking lot' issues: consistency in assessment, reporting & message, data analysis, wildlife assessment, etc.

2. Conduct the annual program meeting in early calendar year 2006 (Jan. - Feb.) to finalize both the base program operating procedures and the program document. In addition, begin to discuss operational and logistical details needed to implement the program in 2006 to 2008 such as:

a) Field sheets and tags (including field duplicates for 5 to 10% of 200 sites
b) Sampling responsibilities
c) Sample prep and/or special sample handling procedures (e.g., for mercury)
d) Selection of sample sites for the 2006 program components and waterbody classes:
    1) Status & follow-up sites (states choose 100 sites total, 25 per state),
    2) Trend sites; states and EPA use all historical sites (approx. 40),
    3) Wadeable streams: 60 sites (probability-based)

In regard to the wadeable streams, EPA will coordinate sample collection with the existing state probability-based sample networks (R-EMAP or otherwise) and crews to sample 60 total sites (15 per state). The sites should be geographically spread out to allow spatial characterization of mercury and PBDEs. The stream sites should also be stratified by size to exclude the smaller wadeable streams that would not be significant fishing waterbodies for humans. In regard to stratifying by larger streams, EPA could provide some assistance to the states (at least to KS, NE, MO) by looking at data from the 94/95 R-EMAP database and identifying streams with the desired species and size. In addition, the crews will be asked to submit fillet samples and select species according to the preference list of the EPA National Lakes Study.

In regard to allocating the 50 annual dioxin/furan samples, the workgroup decided to allocate all 50 in 2006 on big and non-wadeable rivers. Therefore, each state must choose 13 big and non-wadeable rivers sites (from the status, follow-up and trends components) and designate them as dioxin/furan sites. These sites should be selected to optimize geographic coverage of the state.

To prepare for sampling the Class B and C lakes in 2007/2008, the states will develop inventories (lists) of both their Class A and Class B lakes and bring them to the Jan. 2006 meeting. EPA Region 7 will work with ORD to develop an inventory of the Class C lakes. The workgroup will need to determine how urban lakes are selected (for 2010).

3. Final selection of sampling sites and coordination of sampling will be accomplished by late March – early April through individual coordination between EPA and each state via conference calls and/or meetings.

4. Summer and fall 2006; implement the sampling designs and sampling plans by collecting all the program samples including duplicates (5 to 10%). This includes 140 samples for the status, follow-up and trends portions of the program on the high profile water bodies and, 60 samples on wadeable streams.

5. December 2006; finish the sampling design work for the Class B and C lakes. States either select 120 targeted representative Class B lake sites to represent all geographic regions of each state (30 lakes per state) or, draw a spatially stratified random sample.

6. Continue to work with the Environmental Justice (EJ) program within EPA Region 7 to first identify sensitive and subsistence populations. The objective of the monitoring will be to assess the risks associated with the fish being caught and consumed from the areas where these groups are located and/or for discrete water bodies being fished by these groups.

7. The workgroup will periodically use the data from the program's science tracking to check if the desired coverage is being achieved for each waterbody class.

2005/2006 Implementation Plans for Program Objective 2; Provide Adequate Resources to Operate the Redesigned Program:

Part 1, Analytical Resources:
In order to both increase and maximize the utility of the analytical resources for meeting the redesigned program's monitoring objectives, the workgroup agreed that the program will take the following steps:

a) The status and follow-up portions of the program will be changed to utilize only one type of sample (generally a bottom feeder) per site for organics with a predator used for mercury (and other metals). The states will retain the option to utilize two samples (or more) for organics at a few sites. However, any additional samples needed for a site would be subtracted from that state's annual allotment of status and follow-up samples. **This step effectively doubled the states' capacity to look at new status sites.**

b) The trends portion of the program will increase the number of sites from 23 to 40. However, the sampling frequency will be reduced to every other year.

c) The annual Regional analytical budget for the status and follow-up portions of the RAFTM program (approx. 100 samples) will now be equally divided among the states (25 each).

d) The program will receive an additional 55 samples per year in analytical support (for a total of 205) from the EPA Region 7 lab. Five of these samples will be for field duplicates which will be assigned by EPA.

e) In 2006, the Region 7 lab will begin analyzing mercury using a new analytical instrument. This instrument will greatly reduce the time needed to prepare and analyze tissue samples for mercury. This will greatly increase the lab's capacity to do mercury samples for the RAFTM program.

f) In regard to resources needed for PBDEs analyses, (see Program Objective 3, "Parameters"), the workgroup (with EPA as lead) will begin to write a proposal to purchase a significant number of analyses at a contract lab. The proposal will capture the program's monitoring and assessment objectives for PBDEs as well as the rationale, design and number of samples needed.

g) EPA Region 7 will discuss with the Army Corps of Engineers (COE) assistance in paying for analytical services for samples collected at COE lakes in Region 7.

h) The number of pesticides samples is the limiting factor in achieving the redesigned program's goal and objectives. The group explored some possible opportunities to increase the pesticide analyses from 200 to 300. This included exploring Regional grants (such as RGI, R-EMAP, TMDL, EJ Program and state 106) to purchase 100 sample analyses (cost estimated to be between $20,000 and $35,000). Although 200 samples will be adequate to implement the redesigned program, this option will remain open if additional program needs arise such as purchasing PBDE analyses (see objective 3).

2005/2006 Implementation Plans for Program Objective 2, Part 2; Increase and Maximize the Efficiency of the Sample Collection Resources:
The redesigned program have the additional sample collection resources needed to fully implement the program through increased sample collection efforts by both the states and EPA Region 7 Environmental Services Division which will assemble at least two field sampling crews. In states where these efforts are not sufficient, the workgroup seek additional monitoring partnerships with local, state and/or federal agencies.

Sampling resources to meet the program's annual operational plans will be estimated on a state by state basis at the beginning of each year at the program's annual meeting and coordinated thereafter. This should provide adequate lead time to seek additional sampling collaborators if needed.

Other Activities Investigated for Achieving Program Objective 2:
The workgroup investigated a number of possible activities for further stretching the program's analytical resources. These activities and their outcomes are summarized below.

Develop 'conversion factors' (one per species) for converting concentrations of contaminants found in whole fish to concentrations expected in fillets and vise versa. This would permit using only one sample type (fillet or whole) per site rather than two. This option was explored but dismissed by the group due to the potential variability between sites and species (see Feb. 2005 meeting notes).

Eliminate and/or alleviate some of the process bottle-necks for analyzing fish tissue at the Region 7 lab (such as grinding and extraction of fish tissue samples). This was later rejected by the lab as an insignificant time and cost savings as well as an additional potential source of variability.

2005/2006 Implementation Plan for Program Objective 3; Periodically Examine and Adjust Parameter Coverage and Methods:

Monitoring Objectives for Dioxins/ Furans and PBDEs:
Region 7 and its states have very limited data on the occurrence of dioxins/furans and PBDEs in Regional fish tissue. Therefore, the Regional fish tissue monitoring workgroup determined more data is needed for these compounds. The initial program monitoring objectives for dioxins/furans and PBDEs are to provide a base understanding of both the concentration range and the overall spatial distribution of these compounds. Optimally, a sample for dioxin/furans and PBDEs would be collected and analyzed at each of the 200 annual pesticide sampling sites. However, these objectives can be met (albeit less robustly) with fewer samples so implementation will be planned for both scenarios.

For dioxins/furans, this objective will be initially met by maximizing the spatial distribution of the 50 samples (provided by the EPA Region 7 lab) within the most significant target resource class identified for each year (for example, in 2006 the big and non-wadeable rivers). However, if more dioxin/furan samples become available (either through obtaining additional analytical services or acquiring H4IIE screening) the distribution of sample sites for dioxin/furans will be broadened.

In regard to achieving the monitoring objectives for PBDEs, since no sample analyses are currently in cue for PBDEs, as an interim step an additional tissue aliquot from each pesticide sample site (for all components of the redesigned program) will be collected and preserved. This will provide a bank of potential PBDE samples with both wide geographic coverage and resource class types from which to draw when PBDE analyses become available.

Analyses for Dioxins / Furans:
The EPA Region 7 lab will provide a minimum of 50 dioxin analyses by GC/MS each year. EPA is also negotiating with USGS and the EPA Region 7 lab regarding the possibility of USGS screening all 205 pesticide samples collected in 2006 by H4IIE bioassay method. Analytical results of the screening (samples over criteria) would then be used to target follow up sample analyses of samples by GC/MS.

Analyses for PBDEs**:**
In regard to PBDEs, the Region is investigating a number of options for obtaining analyses for PBDE samples. These options include development and use of low resolution GC/MS methods at the EPA Region 7 lab as well as purchasing analyses through a commercial contract lab.

2005/2006 Implementation Plan for Program Objective 4; Develop Consistency in Fish Consumption Assessments and Message:

None: See 20072008 Implementation Plans for Objective 4.

2005/2006 Implementation Plans for Program Objective 5; Provide Information Products for Improving Resource Management and to Inform the Public:

Monitoring and Assessment Objectives:

a) Comprehensive monitoring and assessment of all waterbody classes which are used to a significant degree by humans for fishing (for state 305b and 303d).
b) Support both site specific and broad scale geographic monitoring and assessment for existing and emerging contaminants of concern (for state 305b and 303d).
c) Monitor and assess long-term trends in state/Regional contaminant levels.
d) Support monitoring and assessment of risk to sensitive and subsistence fishing populations as well as to populations consuming other aquatic organisms such as shellfish**.**
e) Assess potential risk to piscivorous wildlife from fish consumption.

Special Note: Program Assessment Objectives a, b and c will be achieved periodically throughout the course of implementing the program because the states will use the program data as they have in the past for state-level assessments related to 303(d), 305(b), (including trends) and, for risk assessment relative to posting consumption advisories. However, this does not preclude the workgroup, states, or EPA from using the data to produce other types of assessments or reports.

In fact, the Regional workgroup will attempt to maximize the value and the utility of the Regional fish tissue data (both past and present) by first defining and then developing and delivering a set of highly useful and value added information products such as for sub-classes of special of interest (for example, urban lakes), for sensitive or subsistence populations or, for Regional scale assessments (especially those involving the probability-based sampling designs). These products could be geared toward both the public and resource managers and, could potentially deliver a consistent understandable message about the risks as well as benefits of eating fish.

In regard to achieving this assessment objective, EPA will take the lead on drafting a prototype Regional fish tissue report (possibly in collaboration with USGS). This report could be similar in style to the Region 5 "Fish Contaminants" report but, possibly more robust in scope and scale including assessment of the data relative to risks to piscivorous wildlife. In addition, EPA will take the lead in assessing the data from probability-based designs. However, all data, results and draft reports will be developed (in collaboration if possible) and reviewed with the Regional fish tissue workgroup prior to publication.

Program Implementation Plans for 2007/2008

2007/2008 Implementation Plans for Program Objective 1; Build Multiple Monitoring Layers to Support Multiple Monitoring and Assessment Objectives

1. Conduct the annual Program meeting in Jan. 2007 to accomplish the following:
   a) Finish the design for the B and C lakes. States either select 120 targeted representative Class B lake sites to represent all geographic regions of each state (30 lakes per state) or, draw a spatially stratified random sample (similar to Class C lakes) of this population.
   b) Select sites for the 100 dioxin/furan samples (two years of sites) on the Class A and B lakes (**50 per class, 25 per state**?). These lakes should also be selected by the states to optimize geographic coverage of each state.
   c) Coordinate sample collection activities.
   d) Work on parking lot issues including consistency (if still an objective).

2. By March 2007, EPA will produce an inventory of all the Class C lakes and EPA will draw 40 probability-based random samples to represent that Class. The Class C lake samples will also be spatially stratified to represent most if not all of the geographic regions of Region 7. A subset of this work will be identifying the urban lakes.

3. In summer and fall 2007 and 2008, implement collection of samples from the B and C lakes design as well as the normal status, follow-up and trends sites.

4. Fall 2007, the workgroup will continue to work with the EPA Region 7 EJ program on identifying sensitive and subsistence populations and begin to ground-truth the GIS-based data used to do so. Update the workgroup on progress and begin targeting water bodies for sampling in 2009/2010.

5. Fall 2007, begin assessment work on the 2006 data if these data are available.

2007/2008 Implementation Plans for Program Objective 2; Provide Adequate Resources to Operate the Redesigned Program:
Finish and/or implement funding proposals for analysis of PBDEs.

2007/2008 Implementation Plan for Program Objective 3; Periodically Examine and Adjust Parameter Coverage and Methods:
At the annual program meeting, use the workgroup's expertise to discuss emerging contaminants. Adjust the program if additional contaminants of concern are identified.

2007/2008 Implementation Plan for Program Objective 4; Develop Consistency in Fish Consumption Assessments and Message:

For 2007, the workgroup will focus short-term efforts on developing more consistency in the public message portion of this objective. The workgroup may attempt in the long-term to address the most important issues relating to inconsistency in assessments between the states such as, risk assessment procedures, 303(d) listing procedures and procedures for posting advisories (especially, relative to interstate waters). This will be accomplished by continuing to meet and periodically exploring and discussing the issues around consistent assessments.

Issues for Consideration in Developing Consistent State Assessments:

1) Data handling and analysis
2) 303(d) listing protocol
3) Fish consumption advisory protocols
4) EPA risk assessment methods vs. others (e.g., FDA action levels or Great Lakes protocols)
5) Assumptions for determining risk (daily intake, life expectancy, etc.)
6) Risk level assumed (1 in 100K, 1 in 10K, etc.)
7) Comparison of data to criteria for piscivorous wildlife
8) Use of data for 305(b) assessments (especially, use of probability-based data)
9) Message relative to communicating to the public the risks of consuming contaminated fish as well as the overall benefits of eating fish.

In light of the limited success of the Upper Mississippi River Basin Association's Water Quality Taskforce (UMRBA) to achieve a similar objective (develop consistency in state assessments), the workgroup will re-examine this objective at the 2006 annual program meeting to determine if it needs to be deleted, modified and/or clarified.

If the workgroup retains the objective for developing consistency in state assessments the workgroup will develop more detailed implementation plans. However, in regard to possible next steps for this objective, Mike Callam agreed to take the lead in developing the discussion for data handling and analysis.

In regard to understanding wildlife criteria, at the Oct. 2005 workgroup meeting, Jo Ellyn Hinck presented piscivorous wildlife risk assessment procedures and criteria being used by USGS/CERC. The workgroup briefly discussed if and how we might incorporate some of this work into the RAFTM program's possible information products. To follow-up on this topic, EPA Region 7 (including some risk assessment personnel) will meet with USGS/CERC in November to discuss collaborating on a RAFTM program report which might include some of these criteria and methods. In addition, EPA Region 7 will request its risk assessment personnel provide a briefing to the Regional workgroup on the process for developing and appropriate application of wildlife criteria values.

2005/2006 Implementation Plans for Program Objective 5; Provide Value-Added Information Products for Resource Management and to Inform the Public:
To be determined.

Program Implementation Plans for 2009/2010

2009/2010 Implementation Plans for Program Objective 1; Build Multiple Monitoring Layers to Support Multiple Monitoring and Assessment Objectives

1. Conduct the annual Program meeting in Jan. 2009 to accomplish the following:
   a) Finish the design for the urban lakes (design to be determined). States either select 120 (30 lakes per state) targeted representative urban lake sites to represent all cities of approx. 25,000 or, draw a spatially stratified random sample (similar to Class C lakes design).
   b) Select sites for the 100 dioxin/furan samples (two years of sites). Should the sites be selected by the states to optimize geographic coverage of each state?
   c) Coordinate sample collection activities.
   d) Work on parking lot issues including consistency (if still an objective).
   e) *T*he workgroup will continue to work with and assist the EJ program to finish identifying all the sensitive and subsistence fishing (and/or mussel & crayfish consuming) populations (including any tribes) and, to identify and ground-truth appropriate target water bodies for sampling in 2009/2010.
   f) Determine how to use the existing probability-based data (possibly in combination with GIS tools) to screen for areas which may need more targeted investigation. This could be done in consultation with Region 7's GIS contractor. However the work needs to be more defined and this will be explored as part of the workgroup agenda.

2. In summer and fall of 2009/2010, implement the sampling design for the urban lakes study and for sensitive and subsistence populations.

3. Continue work on assessment of previous years' program data.

4. **Begin discussing and planning for program needs, adjustments and redesign for 2011.**

2009/2010 Implementation Plans for Program Objective 2; Provide Adequate Resources to Operate the Redesigned Program:
To be determined.

2009/2010 Implementation Plan for Program Objective 3; Periodically Examine and Adjust Parameter Coverage and Methods:
At the annual program meeting, use the workgroup's expertise to discuss emerging contaminants. Adjust the program if additional contaminants of concern are identified.

2009/2010 Implementation Plan for Program Objective 4; Develop Consistency in Fish Consumption Assessments and Message:
To be determined

2009/2010 Implementation Plans for Program Objective 5; Provide Value-Added Information Products for Resource Management and to Inform the Public:
To be determined

Attachment 1

Attendees and Participants of Regional Fish Tissue Monitoring Meetings

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Attachment 2

Table 1, RAFTM Program Design, 2006 - 2010

Waterbody Class	Monitoring Design	Spatial Scale to assess	Sample Size	Population Size	Sig. Fishing Pressure (Y, N)	High Public profile and use	Sampling Year
STREAMS big rivers (Mo, Miss)	TR	R	TBD	Miss. 675 miles Mo. 668 miles (490 in MO + 178 in IA)	Y	Y	2006 then every other year (trends)
Non-wadeable rivers & streams	C (per river)	S	TBD	Thousands of miles	Y	Y	Every year via existing program
Wadeable streams	P	R	60	Tens of thousands	Y	Y	2006
Small streams	NA	NA	NA	hundreds of thousands of miles	**N**	**N**	NA
LAKES Large Public (Class A)	C rotating	S	TBD	dozens	Y	Y	Every year via existing program
Medium Public (Class B)	P	S	100+ ?	hundreds	Y	Y	2007/08
Small Public or Private with public access (Class C)	P	R	40	thousands	Y	Y	2008/08
Large Urban Lakes and Rivers 305(b) & 303(d)	C rotating	S	TBD		Y	Y	Covered via existing program
Small Urban Streams	NA	NA	NA	Hundreds of miles	N	N	-------
Small Urban Lakes 305(b) and 303d	P	R, S	120	thousands	Y	Y	2009/2010
Subsistence & Sensitive Populations	TBD	Local	30 estimated	unknown	NA	NA	2009/2010
Wetlands	NA	NA	NA	thousands	N	N	---------

C = Census (all sites sampled) P = Probability (sites selected by random design)
R = Representative (sites selected to be representative of population or area)
TR = Targeted representative (special study sites selected for studying point, NPS or other problems)
S = State

Appendix B

Fish Tissue SOP

STANDARD OPERATING PROCEDURE

No. 2334.13B

SAMPLING FISH FOR TISSUE RESIDUE DETERMINATIONS

OCTOBER 26, 2001

by

Lorenzo Sena

APPROVED:

Joe Arello

Manager, Environmental Monitoring and Water Compliance

10/29/01
Date

Diane E. Harris

Regional Quality Assurance Manager

11/07/2001
Date

Recertified:

Branch					
Date					

ATTACHMENTS:

A. PURPOSE AND APPLICABILITY

The purpose of this standard operating procedure (SOP) is to establish uniform procedures for the collection, identification, and the preservation of fish tissues for chemical analysis. The procedures contained in this SOP are applicable to all personnel of the Environmental Monitoring and Water Compliance (EMWC) Branch involved in fish collection.

B. SUMMARY OF METHOD

1. Fish are normally collected for chemical analyses as indicators of the quality of ambient water. The purpose of these analyses is to detect the presence of toxicants which may have adverse effects on aquatic life or may pose hazards to human health if contaminated fish are consumed.

2. The specific objectives of the study or program for which the fish are collected will dictate the specific numbers, species and size of fish to be collected, as well as the specific tissues and parameters to be analyzed (See Region VII Ambient Fish Tissue (RAFT) Monitoring Program QAPP) . Fish are collected for chemical analysis as whole fish, edible portion (fillet) or specific tissues.

   a. Whole fish are analyzed when the objective of the study is to determine if there is an aquatic life impact or as a trend monitoring mechanism.

   b. Edible portions are analyzed when the objective of the study is to determine the presence of specific toxicants in the edible portions of legal size fish which could pose a potential hazard to human consumption. For the purposes of this SOP, the term fillet is synonymous with the edible portion which is used in the United States Food and Drug Administration (U.S. FDA) guidelines for establishing edibility criteria of consumables.

   c. Specific tissues; e.g., liver kidney, bone , skin, etc., are analyzed when the objective of the study is to determine the presence of specific toxicants which are known to accumulate in certain tissues of the fish, or to determine if these toxicants accumulate in these tissues of the fish.

C. DEFINITIONS

Not Required

D. HEALTH AND SAFETY WARNINGS

High voltages are used during sample collection by electrofishing. These voltages (typically about 400V) and amperages (3A to 12A) can cause death on contact. Extreme care must be taken when samples are being collected. Users of electrofishing equipment should use nets with insulated handles as well as rubber gloves to provide further insulation. Users should also wear some type of insulative footwear with rubber soles (sandals or other open toed shoes must not be used due to increased risk of electrical shock). Sampling should stop during rain and can be continued after the rain stops unless lightning is present in which case one should get out of the water immediately (This is applicable to all collection methods). The pulsator and control box are weather resistant but should be covered (with care taken around the hot generator so as to not melt plastic onto it) to reduce the amount of exposure to water.

Polarized sunglasses should be used to reduce glare as well as to protect your eyes from unseen branches and UV rays reflected off of the water. Proper PFDs should be worn during any type of sample collection onboard a water craft. Boating safety equipment should be at least as stringent as the state requires.

E. CAUTIONS

All electrical safety equipment such as the foot switches (deadman switch) must be tested and deemed functional prior to sample collection. If any of the safety equipment is not functioning properly the sampling should be postponed until the equipment is repaired.

F. INTERFERENCES

If samples are being collected near wastewater treatment plants or industrial discharges, the conductivity of the water may change enough to overload the generator or trip the circuit breaker. If the conductivity of the water is higher than the conductivity of the fish (which decreases with decreasing temperature) electrofishing effectiveness will be significantly decreased. The only way to raise the effectiveness is to increase the power output and/or decrease the size of the anode, this can be accomplished by wrapping the anode loop with vinyl electrical tape, this increases the current density around the anode, the downside to this is that the effective radius of the useable electric field is significantly decreased. The only way to determine if the changes made have been effective is to try it.

G. PERSONNEL QUALIFICATIONS

All personnel should have the following safety prior to sample collection

1. CPR and First Aid
2. 40 Hour Health and Safety Training (with the annual 8- hour refresher course)
3. US Coast Guard Boating Safety

The following training is also recommended:

1. Principals and Techniques of Electrofishing

H. EQUIPMENT AND SUPPLIES

Elecrofishing is the most frequently used method of sample collection. If other methods of sample collection are used the equipment list will be in need of adjustment to replace the equipment associated with the pulsators with the equipment for this alternate method of sample collection. The sample storage and packing materials will be the same however.

Creeks/ Streams

1. Coffelt MARK - 10 backpack electrofisher
2. Electrodes for backpack electrofisher
3. D - nets
4. Containers for samples or aluminum foil to wrap fish
5. Ice (if samples are used for chemical residue determinations)
6. 10% Formalin (if samples are used for population density determinations)
7. Cooler to store or ship samples
8. Gasoline for generator **100:1 ratio 2-cycle oil specifically for air cooled engines**
9. Rubber Gloves

Small Rivers/ Ponds

1. 14 foot Jon or modified V boat with associated boating safety equipment and plug
2. Smith-Root 7.5 GPP electrofishing system
3. Wiring harness for pulsator with dual safety switches
4. Anode pole with loop or SA6 array
5. Cooler for fish storage and shipping
6. Rubber gloves
7. Dip nets (one about 8 feet and the other about 4 feet)
8. Aluminum foil and plastic bags for wrapping fish
9. Gasoline for 7.5 GPP and gasoline oil mix TCW-III for outboards (50:1 ratio)
10. Check oil level (replace oil after every season with API SAE 30W SG/SH)
11. Grease bearing buddies on trailer
12. Check trailer lights
13. Waders
14. State specific scientific collectors permit
15. Spare propeller
16. Spare tire for boat trailer

Large Rivers/ Lakes

Same as above with the substitution of the 14 foot Jon or modified V boat with an 18 foot work barge.

I. PROCEDURAL STEPS

A. SELECTION OF SAMPLING LOCATION

1. The objectives of the study or program for which the fish collection is being accomplished

will determine the sampling locations or stations on a specific water body.

a. The following guidance is provided for selecting long-term biological trend monitoring stations (See Reference 1):

- At key locations in water bodies which are of critical value for sensitive uses such as domestic water supply, recreation, and propagation and maintenance of fish and aquatic life.
- In major impoundments near the mouths of major tributaries
- At locations in major water bodies largely unaffected by human activities

b. For special studies of stream or river segments, sampling stations should be established upstream of the study area to provide background information and within the study area to meet the objectives of the study.

c. The specific sampling locations should be established and defined as points on a map in the study plan or program network.

2. Passive and active methods of sample collection can be used. Electrofishing is the most frequently used method of sample collection. Passive sampling, seining and angling are used only on rare occasions. Sampling locations (sites) are defined as follows :

a. For passive sampling (entanglement nets and entrapment devices) a site is defined as the point where the net or trap was installed.

b. For electrofishing, a site is defined as follows:

- On streams whose width is less than 100 feet, one mile upstream and one mile downstream of a reference point including both banks.
- On streams whose width is greater than 100 feet, or that have been channelized, a site is defined as one mile upstream and one mile downstream of a reference point along one bank. If both banks are sampled above and below a reference point, this effort constitutes two sites. Sampling for predatory and bottom feeding fish appears to be most productive about 2 meters away from the bank, and around underwater structure.
- Unless otherwise defined in a study plan, a sampling site in a reservoir or lake, is along the shoreline of the dam not to exceed one mile in length. The reference point in a lake or reservoir is defined as the center of the area sampled along the shore or dam. Again sampling about 2 meters from the rip-rap shoreline of reservoirs has proven to be the most productive in yielding both predatory as well

as bottom feeding fish.

- The two mile sampling station definition assumes that there are no interferences, natural or man-made, that would cause the quality of the water or sediment between the specific reference point and point where the fish are collected to be different. This includes dams, waterfalls, point sources, etc.

c. For seining, the site is defined as follows:

- The site is defined as 100 meters upstream and 100 meters downstream of a reference point including both banks. A diagram of the site should be included with the field sheets.

- The 200 meter sampling station definition assumes that there are no interferences, natural or man-made, that would cause the quality of the water or sediment between the specific reference point and point where the fish are collected to be different. This includes dams, waterfalls, point sources, etc.

d. For angling, the site is defined as follows:

- the site is defined as the location where the bait is thrown or cast, if multiple lines are used then the site would be defined as a location at the center of where the upstream most and downstream most lines are cast. The distance between the upstream most and the downstream most line should not exceed 200 meters. A diagram of the sample site and the location of the lines should be included with the field sheets.

- as mentioned above the sample site should be free of any interferences which may cause the quality of the water or sediment to differ from the reference point and the point where the fish was caught.

3. Since it may not always be possible to collect the fish within the site, the fish may be collected outside the sampling area. If the fish are collected outside of the area , the specific location where the fish are collected must be described in the field sheets. In order for the data generated to be representative, the distance outside the specified sampling area should be kept to a minimum.

4. Prior to sample collection Global Positioning System (GPS) readings must be taken at each sample reference point (As per SOP 2110.7 and Generic QAPP for Locational Data Collection). The exact location is a required field when the data is entered in STORET. This GPS reading should be taken at the reference point of the stream or river. In reservoirs the GPS reading should be taken at the center of the sampling location along the dam or shoreline which is sampled.

b. PARAMETERS TO BE ANALYZED

1. The specific parameters or groups of parameters to be analyzed for in the fish tissues will be determined by the objectives of the study or program. These parameters should be clearly defined in the study plan or monitoring program. The study plan or monitoring program should also specify if the whole fish, edible portion or specific tissue(s) should be analyzed.

2. In addition to the parameters requested for chemical analyses, the length and weight should be documented (in the comments section of the field sheets) for each fish collected.

- Any scale which is capable of measuring the fish within +/- 1 gram can be used. The weight of the fish means the total weight of the whole fish (to the nearest gram) prior to any processing.

- The length of the fish is defined as the total length of the whole fish (to the nearest 0.5 centimeter) as measured from the snout to the tip of the tail. Any ruler or tape measure with a scale in centimeters (with gradations in millimeters) and with an overall useable length of at least 50 centimeters, can be used.

C. SAMPLE COLLECTION

1. For the purpose of this SOP, a sample is defined as three to five uniformly sized specimens of one specific species of fish. Uniformly sized is defined as when the smallest specimen is no less than 75% of the length of the largest specimen. The specific species, and the size of fish to be collected should be clearly defined in the study plan or monitoring program guidance.

2. If the study plan does not specify the species of fish to be collected, or the tissue(s) to be analyzed, then a sample should consist of uniformly sized common carp (Cyprinus carpio). The total length of the smallest specimen should not be less than 75% of the total length of the largest specimen. The suggested size of a carp for fish tissue collection is about 40 centimeters (16 inches). The whole specimens are to be homogenized and analyzed as a unit for the parameter(s) of concern.

3. Prior to any fish collection activities , the activity leader must obtain a scientific collectors permit from the appropriate state in which fish are to be collected. The permit must be in the activity leaders possession at the time the fish are collected. The activity leader must also list the names of any assistants in the designated area during the application for a scientific collectors permit.

4. Any specific requirements of the appropriate state agency regarding fish collection activities will be adhered to at all times.

5. The specific method of collecting fish will be selected based on the regulations of the appropriate state agency and the field situation. The collection method will normally be

determined during the planning of the study and should be included in the study plan.

6. Acceptable methods for collecting fish are electrofishing, seining, angling, entanglement (e.g., gill nets, trammel nets) and entrapment devices (e.g., hoop nets, fyke nets). Specific guidance for electrofishing is provided in the table below.

Electrofishing Rig	Operating Range	Suggested mode of operation	Suggested Operating Range	Suggested Frequency	Pulse Width/ Duty Cycle
Coffelt Mark-10 Backpack Honda 350 EX Generator	0-350 watts	DC Pulse	Maximum Possible Output	40 to 80 Hz For Bass and Carp	20%
Smith-Root GPP 7.5 Electrofisher	0-7500 watts	DC Pulse	At Least 10A@400V	40 to 80 Hz For Bass and Carp	20%

Maximum Possible Output is defined as the maximum <u>sustainable</u> output before the generator is overloaded and the breaker is thrown. This will change with the conductivity of the water.

7. Samples should be collected in the fall when fish are storing a reserve of fat for the winter. Unless otherwise directed in a study plan, fish should not be collected during spawning. This is due to the fact that fish collected during spawning may have migrated from locations a great distance from the sampling site.

G. SAMPLE IDENTIFICATION

1. Proper identification of each species is critical to all fish collection efforts. Each specimen must be properly identified in the field utilizing an appropriate taxonomic key (such as Fishes of Kansas) to determine the species, genus and/or family.

2. The combining of specimens of different species into one sample is permitted only in rare instances when a complete sample of the target species cannot be collected. The study plan or program must address this situation since it is a possible outcome. In situations where different species of fish are collected to comprise a sample, each individual specimen should be labeled to indicate the sample number and common name of the specimen. When the sample consists of specimens that are all of the same species, the specimens can bundled and labeled collectively.

3. The identity of each specimen (common and scientific name), the number of each specimen collected, and their individual lengths (snout to tail) in centimeters should be annotated on the field sheet for the sample in addition to the other information required for sample identification (See SOP No. 2420.5).

4. Each sample (group of specimens) will be assigned a unique sample number in accordance with SOP No. 2420.5 and will have a sample tag (See Attachment 1) attached to it.

5. Duplicate samples are defined as follows:

   a. Each sample contains at least three specimens.

   b. Each sample contains an equal number of specimens.

   c. Both samples contain <u>only</u> specimens of the same species.

   d. The length of the smallest specimen is no less than 75% of the length of the largest specimen in a given sample.

   e. The difference between the average lengths of the fish in the two samples is no greater than 10%

   f. No more than 24 hours elapses between sampling efforts if more than one effort is required to complete one or both samples.

H. SAMPLE HANDLING, PACKAGING AND PRESERVATION

1. Care should be observed during fish collection, identification and packaging to avoid contaminating the specimens.

   a. Prior to identification and packaging, collected fish should be kept in the water from which they were taken. Suitable containers include the boat live-well, a clean ice chest containing river or lake water, a net or on a stringer suspended in the water.

   b. Surfaces on which collected fish are placed for identification and packaging must be kept clean.

   c. Collected fish should be rinsed with ambient water from which they were collected prior to identification and packaging.

   d. The sampler(s) should ensure that his/her hands are clean or nitrile gloves should be worn prior to handling the fish or a pair of clean nitrile gloves should be used. This is particularly important after handling gasoline and gasoline powered equipment.

2. All of the specimens must be wrapped in aluminum foil prior to preservation. The specimens should be wrapped to prevent the fish from being exposed. Only heavy duty or extra heavy duty aluminum foil should be used. If heavy duty foil is used the specimen should be double wrapped. If extra heavy duty foil is used, a single wrapping is adequate.

a. Unless a sample consists of numerous small specimens (e.g., 20 green sunfish each about 2 inches in length), each specimen should be individually wrapped. If the sample contains numerous small specimens, the fish may be wrapped as a group.

b. Each sample should be combined into a bundle; e.g., tape the individually wrapped specimens together, and label. The sample tag (See Attachment 1) should be attached to the wrapping and not to the fish.

3. Once the samples have been wrapped and labeled, they should be frozen immediately.

a. The use of dry ice in an ice chest is recommended to achieve freezing in the field.

b. In the event dry ice is not available, the samples should immediately be chilled with wet ice until they can be frozen

- If wet ice is used, steps must be taken to prevent the melted ice from coming into contact with the samples.

- if chilling is used, it should be used for temporary preservation only. The total amount of time during which the samples are chilled prior to freezing should be specifically noted on the field sheet.

c. If the samples must be shipped via a commercial courier, the procedures contained in SOP No. 2420.7 must be adhered to.

d. The samples must be kept frozen until they can be processed by the receiving laboratory.

e. Chain-of-custody procedures should be adhered to for all samples (see SOP No. 2420.4).

J. DATA AND RECORDS MANAGEMENT

All data from each state will be reviewed and then sent to the specific state RAFT coordinator in which the samples were collected. A hard copy and an electronic copy of the data will be kept at the Region VII Laboratory. The state RAFT coordinators along with their addresses are as follows:

Lorenzo Sena ENSV/EMWC
U.S. EPA Region VII
901 N. 5th Street
Kansas City, KS 66101

Michael Callam

NE Dept. of Environmental Quality
1200 N Street, Suite 400
Lincoln, NE 68509-8922

John Olson
IA Dept. of Natural Resources
Wallace State Office Building
900 E. Grand Avenue
Des Moines, IA 50319

Steve Cringan, BEFS
Kansas Dept. of Health and Environment
Division of Environment
1000 SW Jackson, Suite 430
Topeka, KS 66612-1367

John Ford
MO Dept. of Natural Resources
P.O. Box 176
Jefferson City, MO 65102

K. QUALITY ASSURANCE AND QUALITY CONTROL

The only true test to determine if the electrofishing equipment is functioning properly is to test it by generating an electrical field which should induce electrotaxis (fish movement towards the anode) or electronarcosis (stunned or immobilized) and determine if it actually does by looking for fish around the anode.

Fish lengths should be measured by the same person with a final check done by the person recording lengths.4

To ensure the accuracy of the weight measurement, a duplicate weighing should be conducted (every 10 weighings with another scale with the same specifications (+/- 1 gram). If the readings from the two scales are not within ½ percent of each other both scales should be checked against a check weight. If the reading from the scale is not within ½ percent of the value the check weight, the scale should be discarded and replaced with another scale with comparable specifications (+/- 1 gram). Scales used for this purpose should be checked against check weights at least once per year.

L. REFERENCES

1. Fishes of Kansas, Cross, Frank B. and Collins, Joseph T., Kansas Natural History Museum. University of Kansas. 2nd Edition, 1995.
2. QAPP Region VII Ambient Fish Tissue (RAFT) Monitoring Program, U.S. EPA Region

VII QAPP, August 1997.

3. National Water Monitoring Panel Model State Water Monitoring Program, U.S. EPA Office of Water and Hazardous Materials, EPA-440/9/74-002, June 1975.
4. Identification, Documentation and Tracking of Samples, U.S. EPA Region VII SOP No. 2420.5, August 1994.
5. Sample Shipping to Contract Laboratories, SOP U.S. EPA Region VII SOP No.2420.7, December 1996.
6. Field Chain of Custody for Environmental Samples, U.S. EPA Region VII SOP No. 2420.4, March 1994.
7. Generic Quality Assurance Project Plan for Locational Data Collection, U.S. EPA Region VII QAPP, December 2000.
8. Use of the Magellan Global Positioning System Receivers, U.S. EPA Region VII SOP No. 2110.7, November 2000.

Appendix C

Fish Tissue Data

Table 1. Concentrations of Mercury in Large Mouth Bass Not Within 20 Miles of Mercury Emission Source

lat	long	ppm mercury	location
39.9996	-91.5207	0.096	Wakonda Lake
37.8975	-93.3153	0.232	Pomme de Terre Lake
38.8071	-93.2015	0.157	Muddy Creek near Sedalia (Treasure Rd.)
41.2427	-94.6335	0.565	Mormon Trail Pond
40.7483	-93.7764	0.174	Little River Lake - Leon
40.7091	-94.6899	0.37	Lake of 3 Fires - Bedford
38.7488	-93.5816	0.724	Lake Buteo
41.4254	-94.7786	0.252	Lake Anita SW of Anita
40.0922	-91.8985	0.427	La Belle Lake #2
40.66854	-99.0908	0.22	kea lake
39.9903	-93.8105	0.228	Jamesport City Lake
39.7714	-94.2934	0.194	Grindstone Reservoir
38.3837	-91.3392	0.282	Foxboro Lake
40.0948	-91.6614	0.16	Crowder State Park Lake
41.0842	-102.467	0.19	Chappell Interstate Lake
40.3143	-94.0327	0.346	Bethany Reservoir
Mean Hg ppm		**0.2885625**	

Table 2. Concentrations of Mercury in Large Mouth Bass Within 20 Miles of Mercury Emission Source

Latitude	Longitude	Mercury (ppm)	location
37.39523	-94.7399	0.235	1.1 mi.S and 0.9 mi.W of K-126 and US 69 Bypass, Pittsburg
41.11637	-100.834	0.19	Birdwood Lake
38.8564	-94.6069	0.465	Blue River at Kenneth
41.12507	-100.9	0.29	East Hershey Lake
37.304	-93.205	0.19	Fellows Lake
38.8701	-94.3389	0.21	Gopher Lake
38.558	-90.4704	0.318	Grand Glaize Creek (Simson Park pond)
38.5577	-90.4689	0.574	Grand Glaize Creek (Simson Park pond)/Field Duplicate of sample 216
40.8196	-91.3849	0.51	Lake Geode E. of Lowell
39.7806	-92.5215	0.235	Long Branch Reservoir
38.9109	-94.4689	0.541	Longview Lake
42.6099	-90.6995	0.204	Mississippi River above Dubuque (Mud Lake) (Pool 11)
41.5271	-90.5367	0.184	Mississippi River at Davenport (Pool 15)
42.5083	-90.6471	0.206	Mississippi River Below Dubuque (Hamm Island) (Pool 12
42.5083	-90.6471	0.311	Mississippi River Below Dubuque (Hamm Island) (Pool 12
41.4437	-93.5497	0.413	N Banner Lake - Indianola
37.2841	-89.5513	0.372	Pond near U.S. 61 and Hwy. 74
41.439	-93.5524	0.517	S Banner Lake - Indianola
37.0242	-94.7219	0.111	Spring River at Baxter Springs
39.2316	-94.2316	0.642	Weatherby Lake
38.8336	-94.3761	0.638	Winnebago Lake
Mean Hg ppm		**0.350285714**	

Table 3. Concentrations of Mercury in Carp Within 20 Miles of Mercury Emission Source			
lat	long	ppm mercury	location
37.69614	-95.5258	0.331	0.5 mi.N and 2.6 mi.W of K39 and US169, CHANUTE
37.39523	-94.7399	0.161	1.1 mi.S and 0.9 mi.W of K-126 and US69 Bypass, Pittsbug, Cow Creek
39.23622	-96.2437	0.261	3 mi. West of Belvue
38.8422	-94.6125	0.086	Blue River at Kenneth
41.9479	-91.6306	0.184	Cedar Bend Lake - Cedar Rapids
42.5209	-92.3904	0.166	Cedar River, Waterloo
41.629	-91.1451	0.266	Cedar River, West Branch
37.7821	-90.1737	0.363	Clearwater Reservoir
41.571	-93.5592	0.122	Des Moines River at Des Moines
41.29194	-96.2817	0.069	Elkhorn River
41.29194	-96.2817	0.13	Elkhorn River (Waterloo)
41.29194	-96.2817	0.13	Elkhorn River (Waterloo)
37.304	-93.205	0.541	Fellows Lake
41.66	-91.0701	0.195	Iowa River at Iowa City
41.1711	-91.1689	0.196	Iowa River at Wapello
41.1941	-91.1742	0.183	Iowa River, Wapello (REMAP site #45)
39.0472	-94.7843	0.17	Kansas River at Holiday
38.9756	-95.2382	0.22	Kansas River at Lawrence
38.9756	-95.2382	0.226	Kansas River at Lawrence
38.9266	-94.4692	0.189	Little Blue River below Longview Dam
39.7806	-92.5215	0.156	Long Branch Reservoir
38.9109	-94.4689	0.28	Longview Lake
41.04836	-100.8	0.26	Maloney Reservoir Outlet Canal
42.6099	-90.6995	0.0909	Mississippi River above Dubuque (Mud Lake) (Pool 11)
41.5271	-90.5367	0.0897	Mississippi River at Davenport (Pool 15)
39.7382	-91.3766	0.11	Mississippi River at Hannibal
43.3687	-91.2186	0.062	Mississippi River at Lansing
41.35	-91.0701	0.131	Mississippi River at Muscatine (Pool 17)
40.3956	-91.375	0.252	Mississippi River at/above Keokuk (Pool 19)
41.4619	-90.6819	0.179	Mississippi River downstream from Linwood
41.4619	-90.6819	0.232	Mississippi River downstream from Linwood
39.127	-94.46	0.062	Missouri River at Kansas City
39.7231	-94.9024	0.054	Missouri River at St. Joseph
39.8958	-94.7866	0.118	One Hundred and Two River
41.3406	-92.5938	0.201	S. Skunk River NE of Oskaloosa (Glendale Access)
42.3709	-96.0757	0.132	Site 173, West Fork Little Sioux River @ Bronson
41.9494	-91.5635	0.305	Site 185, Cedar River @ Bertram
42.4226	-94.0929	0.239	Site 221, Des Moines @ Coalville
41.6681	-91.5568	0.181	Site 302, Iowa River @ Iowa City
40.7323	-91.2182	0.191	Skunk River at Augusta
40.7282	-91.2132	0.218	Skunk River, Burlington IA-REMAP-194
41.11389	-101.356	0.151	South Platte River
41.1024	-101.095	0.11	Sutherland Outlet Canal
36.7651	-89.5326	0.276	Swift Ditch at Hwy. 80
39.6236	-92.6247	0.16	Thomas Hill Reservoir
39.6236	-92.6247	0.169	Thomas Hill Reservoir/Field Duplicate of sample 114
41.7592	-90.6772	0.0533	Wapsipinicon River north of Donahue
42.17531	-97.5721	0.202	willow creek lake
42.17531	-97.5721	0.234	willow creek lake
Mean Hg ppm		0.185467347	

Table 4. Concentrations of Mercury in Carp Not Within 20 Miles of Mercury Emission Source

41.1945	-91.8079	0.196	Skunk River - N of Brighton
42.5718	-93.101	0.159	Site 174, Beaver Creek @ Ackley
42.2988	-94.8834	0.222	Site 164, North Raccoon @ Auburn
42.9031	-94.4621	0.283	Site 117, Des Moines River @ West Bend
40.688	-99.7802	0.43	Phillips Lake
38.4264	-92.2206	0.148	Osage River near St. Thomas
37.9476	-97.7811	0.207	North of Haven, Arkansas River
36.179	-89.6352	0.07	Mississippi River at Caruthersville
42.4697	-91.4496	0.178	Maquoketa River, Manchester (REMAP site #28)
42.0813	-90.6293	0.117	Maquoketa River at Maquoketa
42.5676	-95.7332	0.102	Little Sioux River near Washta
40.03778	-97.0381	0.134	Little Blue River
38.986	-92.989	0.279	Lamine River near Blackwater
43.0652	-95.9184	0.121	Floyd River @ Hospers (Site 225)
40.5974	-91.7155	0.258	Des Moines River, Farmington, IA-REMAP-202
40.76105	-91.9764	0.133	Des Moines River at Keosauqua
38.0578	-97.9484	0.203	Cow Creek at Hutchinson
40.04444	-96.5861	0.121	Big Blue River
39.4719	-95.6118	0.183	7.5 mi.E and 0.7 mi.N of US75/K16 (Holton) Elk Creek
39.76942	-95.7019	0.204	5 mi.S and 1.1 mi.E of FAIRVIEW, Delaware River
38.92661	-97.1021	0.203	1.7 mi.N and 0.8 mi.E of ENTERPRISE
39.0304	-98.1822	0.132	1.5 mi.S and 2.5 mi.W of K-14, K-18 intersection in Lincoln, KS.
38.56619	-95.1312	0.286	1.1 mi.N and 1.6 mi.W of RANTOUL
Mean Hg ppm		0.189956522	

Table 6. Concentrations of Mercury in Catfish Not Within 20 Miles of Mercury Emission Source

Lat	**long**	**ppm mercury**	**location**
40.04306	-95.52	0.054	Nemaha River
38.4896	-95.8025	0.0737	Melvern Lake
40.7483	-93.7764	0.186	Little River Lake - Leon
38.6743	-94.9226	0.151	Hillsdale Lake
41.03693	-102.125	0.01	Goldeneye
38.0578	-97.9484	0.0623	Cow Creek at Hutchinson
37.24133	-96.8131	0.435	8.5 mi.E of WINFIELD and 0.2 mi.S of US.160
38.9629	-96.8919	0.186	2.7 mi.S and 2 mi.W of I-70, K-77 intersection S. of Junction City
38.92661	-97.1021	0.156	1.7 mi.N and 0.8 mi.E of ENTERPRISE
39.0304	-98.1822	0.177	1.5 mi.S and 2.5 mi.W of K-14, K-18 intersection in Lincoln, KS.
Mean Hg ppm		0.1491	

Table 5. Concentrations of Mercury in Catfish Within 20 Miles of Mercury Emission Source

lat	long	ppm mercury	location
39.03099	-96.2672	0.272	1 mi.N and 1 mi.E of ALMA, Mill Creek
38.9183	-95.3644	0.0886	Clinton Lake
40.9576	-92.3409	0.115	Des Moines River at Cliffland Access Ottumwa
38.9756	-95.2382	0.17	Kansas River at Lawrence
41.76167	-103.417	0.1	North Platte River (NP3-10000)
37.0242	-94.7219	0.0376	Spring River at Baxter Springs
41.10646	-101.131	0.079	Sutherland Reservoir
37.0424	-95.5922	0.063	Verdigris River at Coffeyville
42.1594	-91.4299	0.263	Wapsipinicon River, Central City
Mean Hg ppm		0.132022222	

Appendix D

TRI Data

' TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in All Industries for Chemicals Selected by User (see footnote for list of selected chemicals) Kansas 2006 '

Facility	Address	City	State	Latitude	Longitude	On-site Fugitive Air	On-site Point Source Air	On-site Surface Water Discharges
GREAT PLAINS ENERGYLACYGNE GENERATING STATION	25166 E 2200 RD	LA CYGNE	KS	38.3485	-94.6454	0	999	0
JEFFREY ENERGY CENTER	25905 JEFFREY RD	SAINT MARYS	KS	39.283738	-96.114688	0	695.2	0
ASH GROVE CEMENT CO	1801 N SANTA FE	CHANUTE	KS	37.69902	-95.457064	78	440	0
HOLCOMB UNIT 1	2440 HOLCOMB LN BOX 430	HOLCOMB	KS	37.926982	-100.99266	0	281.6	.
LAWRENCE ENERGY CENTER	1250 N 1800 RD	LAWRENCE	KS	39.0114	-95.2764	0	169.4	0
KANSAS CITY BPU QUINDARO POWER STATION	3601 N 12TH ST	KANSAS CITY	KS	39.148832	-94.641213	0.005	94.8	0
LAFARGE MIDWEST INC. (INCLD SYSTECH ENVIRONMENTAL)	1400 S CEMENT RD	FREDONIA	KS	37.510833	-95.824333	0.01	69	.
NEARMAN CREEK POWER STATION	4240 N 55TH ST	KANSAS CITY	KS	39.164926	-94.697509	0.003	61.1	0
RIVERTON GENERATING STATION	HWY 66	RIVERTON	KS	37.073138	-94.699888	0	58.52	0.13
TECUMSEH ENERGY CENTER	2ND & DUPONT RD	TECUMSEH	KS	39.053888	-95.568888	0	56.8	0
ATCHISON STEEL CASTING & MACHINING	400 S FOURTH ST	ATCHISON	KS	39.558625	-95.11772	4.8	43	0
PHILIPS LIGHTING CO.	3861 S 9TH ST	SALINA	KS	38.767803	-97.613047	1	26.8	.
MONARCH CEMENT CO	449 1200TH ST	HUMBOLDT	KS	37.79138	-95.435154	0	23.25	0
COFFEYVILLE RESOURCES REFINING & MARKETING	400 N LINDEN	COFFEYVILLE	KS	37.046594	-95.605241	0	14	.
HEARTLAND CEMENT CO DBA BUZZI UNICEM USA	1765 LIMESTONE LN	INDEPENDENCE	KS	37.211814	-95.681072	0	14	.
FRONTIER EL DORADO REFINING CO	1401 S DOUGLAS RD	EL DORADO	KS	37.795187	-96.879514	0	3	0.4
GOODYEAR TIRE & RUBBER CO	2000 NW HWY US 24	TOPEKA	KS	39.090711	-95.691966	0	0.22	.
WICHITA ASPHALT	3600 N W ST	WICHITA	KS	0	0	0	0.02	.
FORDYCE CONCRETE CO INC CENTRAL AVENUE FACILITY	211 CENTRAL AVE	KANSAS CITY	KS	39.103475	-94.612968	0	0.0141	.
LAFARGE NA INC. - BUNKER READY MIX	317 S 3RD	KANSAS CITY	KS	39.10067	-94.617276	0	0.006	.
LAFARGE NORTH AMERICA INC DERBY READY MIX	355 W WASHINGTON ST	DERBY	KS	37.543162	-97.273607	0	0.0059	.
CENTURY CONCRETE INC OLATHE FACILITY	1340 W 149TH ST	OLATHE	KS	38.858362	-94.842072	0	0.005	.
LAFARGE NORTH AMERICA INC WICHITA NORTHSHORE READY MIX	2460 N SHORE BLVD	WICHITA	KS	37.72799	-97.417086	0	0.005	.
LAFARGE NORTH AMERICA INC 149TH ST	1245 W 149TH ST	OLATHE	KS	38.858243	-94.837699	0	0.0043	.
CENTURY CONCRETE INC EDWARDSVILLE FACILITY	8901 WOODEND	EDWARDSVILLE	KS	39.05109	-94.787308	0	0.004	.
LAFARGE NORTH AMERICA INC ANDOVER READY MIX	611 W 13TH	ANDOVER	KS	37.711944	-97.139444	0	0.0019	.
CERTAINTEED CORP	103 FUNSTON RD	KANSAS CITY	KS	39.142981	-94.614144	0	0	.
COFFEYVILLE RESOURCES NITROGEN FERTILIZERS LLC	701 E MARTIN ST	COFFEYVILLE	KS	37.046346	-95.60513	0	0	.
ETCO SPECIALTY PRODUCTS INC.	621 W ST JOHN	GIRARD	KS	37.513728	-94.850732	0	0	.
GEORGIA-PACIFIC GYPSUM LLC	2127 HWY 77	BLUE RAPIDS	KS	39.704166	-96.644997	0	0	0
INTERVET INC	35500 W 91ST ST	DE SOTO	KS	38.963953	-94.992616	0	0	.
JAYHAWK FINE CHEMICALS CORP	8545 SE JAYHAWK DR	GALENA	KS	37.11818	-94.67105	0	0	.
REMEL INC	12076 SANTA FE TRAIL DR	LENEXA	KS	38.967778	-94.725833	0	0	0
ROOFMART INTERNATIONAL INC	2735 RAIN RD	CHAPMAN	KS	38.972	-97.035	0	0	.

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in All Industries Iowa 2006

Facility	Address	City	State	Latitude	Longitude	On-site Fugitive Air	On-site Point Source Air	On-site Surface Water Discharges
ADM CORN PROCESSING	1350 WACONIA AVE, SW	CEDAR RAPIDS	IA	41.92734	-91.68988	0	92	.
ADM SOYBEAN PROCESSING	1940 E HULL AVE	DES MOINES	IA	41.62244	-93.58555	0	6.78	.
ALLIANT ENERGY INTERSTATE POWER LIGHT SIXTH ST GENERATING STA	509 6TH ST NE	CEDAR RAPIDS	IA	41.95054	-91.67667	0	3.7	.
BARNSTEAD INTERNATIONAL	2555 KERPER BLVD	DUBUQUE	IA	42.5293	-90.64838	0	0	.
CAMBREX CHARLES CITY INC.	1205 11TH ST	CHARLES CITY	IA	43.05453	-92.69339	0	0	0
CARGILL CORN MILLING	1 CARGILL DR	EDDYVILLE	IA	41.13991	-92.64277	0	48.93	.
CEDAR FALLS UTILITIES	UTILITY PKWY	CEDAR FALLS	IA	42.52778	-92.43961	0	5.4	.
CEDAR RIVER PAPER A WEYERHAEU SER BUSINESS	4600 C ST SW	CEDAR RAPIDS	IA	41.9307	-91.63755	0	0	.
CENTRAL IOWA POWER COOPERATIVE (CIPCO) - FAIR STATION	3800 HWY 22	MUSCATINE	IA	41.45861	-90.82266	0	26.87	.
CITY OF AMES	200 E 5TH ST	AMES	IA	42.02394	-93.60169	0	25.8	.
CORN LP	1303 HWY 3 E	GOLDFIELD	IA	42.7324	-93.9114	0	15	.
DUBUQUE POWER PLANT	920 KERPER BLVD	DUBUQUE	IA	42.50284	-90.65944	0.005358	11.690774	0.1
FORT DODGE ANIMAL HEALTH - MAIN PLANT	800 5TH ST NW	FORT DODGE	IA	42.52006	-94.20764	0.048	0	0
FORT DODGE ANIMAL HEALTH-CHARLES CITY	2000 ROCKFORD RD	CHARLES CITY	IA	43.05977	-92.6942	0.027	0	.
GERDAU AMERISTEEL U.S. INC	1500 W 3RD ST	WILTON	IA	41.58809	-91.04034	0	26	0
GRIFFIN PIPE PRODUCTS CO	2601 W 9TH AVE	COUNCIL BLUFFS	IA	41.25356	-95.8873	0.01	24.95	.
HACH CO	100 DAYTON AVE	AMES	IA	42.02403	-93.57961	0	0	.
HOLCIM (US) INC.	1840 N FEDERAL AVE	MASON CITY	IA	43.1714	-93.20911	0	95.73	.
INTERSTATE POWER & LIGHT BURLINGTON GENERATING STATION	4282 SULLIVAN SLOUGH RD	BURLINGTON	IA	40.80496	-91.14201	0.1429	113.58	0.5
INTERSTATE POWER & LIGHT CO SUTHERLAND STATION	3001 E MAIN ST	MARSHALLTOWN	IA	42.04926	-92.86328	0	22.2	0
IPSCO STEEL INC.	1770 BILL SHARP BLVD	MUSCATINE	IA	41.48361	-90.82278	0	93.38	.
LAFARGE NORTH AMERICA	301 E FRONT ST	BUFFALO	IA	41.45903	-90.69799	0.021	22	.
LANSING POWER STATION	2320 POWER PLANT DR	LANSING	IA	43.33495	-91.16708	0.3	165.2	3.4
LEHIGH CEMENT CO	700 25TH ST NW	MASON CITY	IA	43.17685	-93.21203	0	184	.
LINWOOD MINING & MINERALS LIME PLANT	401 E FRONT ST	DAVENPORT	IA	41.46342	-90.68275	0.0008	3.03	.
M. L. KAPP GENERATING STATION	2001 BEAVER CHANNEL PKWY	CLINTON	IA	41.80921	-90.23402	0	108.4	0.2
MIDAMERICAN ENERGY CO COUNCIL BLUFFS ENERGY CENTER	7215 NAVAJO	COUNCIL BLUFFS	IA	41.18559	-95.84211	0	340	.
MIDAMERICAN ENERGY CO GEORGE NEAL NORTH	1151 260TH ST	SERGEANT BLUFF	IA	42.32666	-96.3792	0	400	.
MIDAMERICAN ENERGY LOUISA GENERATING STATION	8602 172ND ST	MUSCATINE	IA	41.31481	-91.09214	0	300	.
MIDAMERICAN ENERGY-GEORGE NEAL SOUTH	2761 PORT NEAL CIR	SALIX	IA	42.30194	-96.35801	0	300	.
MIDAMERICAN ENERGY-RIVERSIDE GENERATING STATION	6001 STATE ST	BETTENDORF	IA	41.54075	-90.45107	0	40	.
MONSANTO CO	2500 WIGGINS RD	MUSCATINE	IA	41.34853	-91.0811	0	2.7	.
MUSCATINE POWER & WATER GEN ERATION	1700 INDUSTRIAL CONNECTOR RD	MUSCATINE	IA	41.39036	-91.0618	0	170	2
NOVARTIS ANIMAL HEALTH US INC	1447 140TH	LARCHWOOD	IA	43.44222	-96.49667	0	0	.
OTTUMWA GENERATING STATION	20775 POWER PLANT RD	OTTUMWA	IA	41.09689	-92.55389	0.2	288.4	.
PB LEINER USA	7001 BRADY ST	DAVENPORT	IA	41.59158	-90.56843	0	103.6	.
PRAIRIE CREEK GENERATING STATI ON	3300 C ST SW	CEDAR RAPIDS	IA	41.94429	-91.63799	0	32.1	.
ROQUETTE	1004 S 5TH ST	KEOKUK	IA	40.39028	-91.39583	0	5	.
UNITED STATES GYPSUM CO FORT DODGE PLANT	2110 PARAGON AVE	FORT DODGE	IA	42.48535	-94.14526	0.06	0.02	0
UNITED STATES GYPSUM SPERRY	13425 210TH ST	MEDIAPOLIS	IA	40.97967	-91.19033	0	0	.

' TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in All Industries for Chemicals Selected by User (see footnote for list of selected chemicals) Nebraska 2006 '

Facility	Address	City	State	Latitude	Longitude	On-site Fugitive Air	On-site Point Source Air	On-site Surface Water Discharges
GERALD GENTLEMAN STATION	S HWY 25	SUTHERLAND	NE	41.08361	-101.1456	0	290	.
OMAHA PUBLIC POWER DISTRICT NEBRASKA CITY STATION	7264 L RD	NEBRASKA CITY	NE	40.65377	-95.84712	0	289	.
OMAHA PUBLIC POWER DISTRICT NORTH OMAHA STATION	7475 PERSHING DR	OMAHA	NE	41.32875	-95.95012	0	234	.
NUCOR STEEL NEBRASKA	2911 E NUCOR RD	NORFOLK	NE	42.07583	-97.46507	0.1	147.2	.
WHELAN ENERGY CENTER	4520 E S ST	HASTINGS	NE	40.58245	-98.33735	0.0002	40.53	.
NEBRASKA PUBLIC POWER DISTRICT SHELDON STATION	4500 W PELLA RD	HALLAM	NE	40.55206	-96.78323	0	40	.
PLATTE GENERATING STATION	1035 W WILDWOOD DR	GRAND ISLAND	NE	40.8551	-98.34868	0	38	.
CLEAN HARBORS ENVIRONMENTAL SE RVICES INC.	2247 S HWY 71	KIMBALL	NE	41.15442	-103.6585	0	36.425	0
CITY OF FREMONT DEPARTMENT OF UTILITIES LON D. WRIGHT POWER	2701 E FIRST ST	FREMONT	NE	41.42841	-96.46121	0.1	29	0
ASH GROVE CEMENT CO	16215 HWY 50	LOUISVILLE	NE	41.00388	-96.15866	0.1	24.4	.
WESTERN SUGAR COOPERATIVE	2100 E OVERLAND DR	SCOTTSBLUFF	NE	41.85957	-103.6373	0	15.02	.
ADM	7800 THAYER ST	LINCOLN	NE	40.86645	-96.61982	0	7.59	.
PFIZER INC	601 W CORNHUSKER HWY	LINCOLN	NE	40.83549	-96.72763	0	0.1	.
READY MIXED CONCRETE CO ELKHORN PLANT	848 N 192ND ST	ELKHORN	NE	41.27413	-96.21578	0.000036	0.0000194	0.000036
READY MIXED CONCRETE CO BELLEVUE PLANT	1820 HWY 370	BELLEVUE	NE	41.14117	-95.9364	3.05E-05	0.0000151	0.0000305
READY MIXED CONCRETE CO 87TH & MAPLE PLANT	2728 N 85TH ST	OMAHA	NE	41.28377	-96.04462	2.19E-05	0.0000118	0.0000219
READY MIXED CONCRETE CO MILLARD PLANT	4765 S 135TH ST	OMAHA	NE	41.2116	-96.12673	0.000021	0.0000112	0.000021
READY MIXED CONCRETE CO CHALCO PLANT	15353 CHANDLER RD	OMAHA	NE	41.18412	-96.15371	1.96E-05	0.0000102	0.0000196
SIOUXLAND CONCRETE CO	200 E 48TH ST	SOUTH SIOUX CITY	NE	42.45139	-96.41167	0.000036	0.0000102	0.000036
CARGILL CORN MILLING NORTH AMERICA	650 INDUSTRIAL RD	BLAIR	NE	41.53306	-96.09889	0	0	.

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in All Industries for Chemicals Selected by User (see footnote for list of selected chemicals) Missouri 2006 '

Facility	Address	City	State	Latitude	Longitude	On-site Fugitive Air	On-site Point Source Air	On-site Surface Water Discharges
AMERENUE LABADIE POWER PLANT	226 LABADIE POWER PLANT RD	LABADIE	MO	38.56419	-90.83728	0	1366.9	0
AMERENUE MERAMEC POWER PLANT	8200 FINE RD	SAINT LOUIS	MO	38.401348	-90.334862	0	359	0
AMERENUE RUSH ISLAND POWER STATION	100 BIG HOLLOW RD	FESTUS	MO	38.089722	-90.263055	0	760.5	0
AMERENUE SIOUX POWER STATION	8501 N STATE RT 94	WEST ALTON	MO	38.914722	-90.29	0	353.7	0
ANHEUSER-BUSCH INC.	ONE BUSCH PL	SAINT LOUIS	MO	38.596064	-90.21288	0	0.81	.
AQUILA INC SIBLEY GENERATING STATION	33200 E JOHNSON RD	SIBLEY	MO	39.176128	-94.183151	0	81	.
ASSOCIATED ELECTRIC COOPERATIVE INC NEW MADRID POWER PLANT	41 ST JUDE RD	MARSTON	MO	36.5966	-89.6539	0	160	0
BOEHRINGER INGELHEIM VETMEDICA INC	2621 N BELT HWY	SAINT JOSEPH	MO	39.790772	-94.809076	0	0	.
BP PRODUCTS NORTH AMERICA INC SUGAR CREEK TERMINAL	1000 N STERLING	SUGAR CREEK	MO	39.121738	-94.443123	0	0	0
BUZZI UNICEM USA CAPE GIRARDEAU	2524 S SPRIGG ST	CAPE GIRARDEAU	MO	37.269779	-89.538267	0	153	0
CENTRAL CONCRETE CO	1811 PARIS RD	COLUMBIA	MO	38.964568	-92.310929	0	0.0008	1.00E-05
CENTURY CONCRETE INC BELTON FACILITY	5901 E 155 ST	BELTON	MO	38.843244	-94.52654	0	0.0066	.
CENTURY CONCRETE INC HARRISONVILLE FACILITY	19100 E 231 ST	HARRISONVILLE	MO	38.700809	-94.374168	0	0.0026	.
CENTURY CONCRETE INC LEES SUMMIT FACILITY	2400 NW QUARRY	KANSAS CITY	MO	38.941916	-94.421222	0	0.0064	.
CENTURY CONCRETE INC TIFFANY SPRINGS FACILITY	7900 NW TIFFANY SPRINGS RD	KANSAS CITY	MO	39.262932	-94.672211	0	0.0028	.
CHAMOIS POWER PLANT	9321 HWY 100	CHAMOIS	MO	38.684638	-91.756694	0	13	0
CHEMICAL LIME CO	20947 WHITE SANDS RD	SAINTE GENEVIEVE	MO	38.009472	-90.079941	0	0	0
CHRISTIAN COUNTY CONCRETE	433 TRACKER RD	NIXA	MO	37.065621	-93.297995	0.0022	0	.
CITY OF INDEPENDENCE	21500 E TRUMAN RD PO BOX 1019	INDEPENDENCE	MO	39.081682	-94.263775	0.3	18	.
COLUMBIA MUNICIPAL POWER PLANT	1501 BUS LOOP 70 E	COLUMBIA	MO	38.965277	-92.316944	0	3.28	0
CONCRETE CO OF SPRINGFIELD- REPUBLIC	3400 US HWY 60 E	REPUBLIC	MO	37.0992	-93.5109	0.002	0	.
CONCRETE CO OF SPRINGFIELD- SHERMAN STREET	510 SHERMAN ST	SPRINGFIELD	MO	37.212522	-93.281236	0.0031	0	.
CONCRETE CO OF THE OZARKS- BRANSON EAST	586 QUARRY RD	HOLLISTER	MO	36.59671	-93.228515	0.004	0	.
CONTINENTAL CEMENT CO LL C	10107 HWY 79	HANNIBAL	MO	39.676718	-91.314116	0	50	0
EAGLEPICHER TECHNOLOGIES LLC	C & PORTER ST	JOPLIN	MO	37.09407	-94.527802	0	0	.
EMPIRE DISTRICT ELECTRIC CO ASBURY GENERATING STATION	21133 UPHILL LN	ASBURY	MO	37.361388	-94.589166	0	46	.
FORDYCE CONCRETE CO INC 63RD ST FACILITY	5810 E 63RD ST	KANSAS CITY	MO	39.015263	-94.518376	0	0.0032	.
FORDYCE CONCRETE CO INC RANDOLPH FACILITY	3700 N SKILES RD	KANSAS CITY	MO	39.161232	-94.484146	0	0.0012	.
FRANKLIN COUNTY CONCRETE WASHINGTON PLANT	528 W FRONT ST	WASHINGTON	MO	38.563553	-91.016423	0	0.006	0.0001
HAWTHORN GENERATING FACILITY	8700 E FRONT ST	KANSAS CITY	MO	39.130833	-94.47777	0	52	0

TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in Missouri 2006 (continued)

Facility	Address	City	State	Latitude	Longitude	On-site Fugitive Air	On-site Point Source Air	On-site Surface Water Discharges
HOLCIM U.S. INC CLARKSVILLE PLANT	14738 HWY 79	CLARKSVILLE	MO	39.376389	-90.945833	0	51	1
IATAN GENERATING STATION	20250 HWY 45N	WESTON	MO	39.448333	-94.978611	0	69	.
INVENSYS APPLIANCE CONTROLS W EST PLAINS PLANT	210 ALLEN ST	WEST PLAINS	MO	36.730138	-91.841131	0	0	.
JAMES RIVER POWER STATION	5701 KISSICK RD	SPRINGFIELD	MO	37.108158	-93.258308	0	81	1
LAFARGE NORTH AMERICA	2200 N COURTNEY RD	SUGAR CREEK	MO	39.14566	-94.41687	0.001	24	.
LAFARGE NORTH AMERICA INC 85TH STREET READY MIX	3101 E 85TH ST	KANSAS CITY	MO	38.97234	-94.552016	0	0.0031	.
LAFARGE NORTH AMERICA INC BLUE SPRINGS READY MIX	E 40 HIGHWAY&INDUSTRIAL DR	BLUE SPRINGS	MO	39.013276	-94.250512	0	0.004	.
LAKE ROAD STATION	1413 LOWER LAKE RD	SAINT JOSEPH	MO	39.725277	-94.876944	0	20	1
MALLINCKRODT INC	3600 N SECOND ST	SAINT LOUIS	MO	38.661846	-90.193427	0.04	2	.
MARCHEM CORP	2500 ADIE RD	MARYLAND HEIGHTS	MO	38.707245	-90.417517	.	.	.
MATERIALS PACKAGING CORP	23018 S 291 HWY	HARRISONVILLE	MO	38.700472	-94.369388	0	0.0143	.
MCDONNELL DOUGLAS CORP	AIRPORT & MCDONNELL BLVD	BERKELEY	MO	38.756	-90.340666	0	0	.
MISSISSIPPI LIME CO	16147 US HWY 61	SAINTE GENEVIEVE	MO	37.974579	-90.063408	0	35	.
MISSOURI CHEMICAL WORKS	11083 HWY D	LOUISIANA	MO	39.425	-91.02833	0	10	.
MONTROSE GENERATING STATION	400 SW HWYP	CLINTON	MO	38.313049	-93.932991	0	300	0
POLY ONE CORP	2700 PAPIN ST	SAINT LOUIS	MO	38.623619	-90.219978	0	0	.
PROCTER & GAMBLE MANUFACTURING CO SAINT LOUIS	169 E GRAND AVE	SAINT LOUIS	MO	38.67521	-90.199819	0	0.2031	.
RIVER CEMENT CO (DBA BUZZI UNICEM USA)	1000 RIVER CEMENT RD	FESTUS	MO	38.174585	-90.349352	0.07	145.2	.
SIKESTON POWER STATION	1551 W WAKEFIELD ST	SIKESTON	MO	36.8786	-89.6169	0	122	.
SOUTHWEST POWER STATION	5050 FARM RD 164	BROOKLINE STATION	MO	37.152882	-93.387741	0	69	0.1
THOMAS HILL ENERGY CENTER POWER DIV	5693 HWY F	CLIFTON HILL	MO	39.550678	-92.637398	0.9	280	0.4

Appendix E

National Energy Technology Laboratory Coal Database Selected Fields for Coal-fired Power Plants in States of Iowa, Kansas, Missouri, and Nebraska (2008)

Utility Name	Plant Name	State	Plant Location Latitude (degrees)	Plant Location Longitude (degrees)	Boiler Status	Primary Fuel	Coal Origin State (Largest Source in 2005)	Generator Nameplate Rating (MW)	Net Annual Electrical Generation (MW-h)
Interstate Power & Light Co	Dubuque	IA	42.5069	-90.6607	Operating (in commercial service or out of service less than 365 days)	NL	NL	38	164,192
Interstate Power & Light Co	Dubuque	IA	42.5069	-90.6607	Operating (in commercial service or out of service less than 365 days)	NL	NL	29	50,058
Interstate Power & Light Co	Dubuque	IA	42.5069	-90.6607	Operating (in commercial service or out of service less than 365 days)	NL	NL	15	130,045
Interstate Power & Light Co	Lansing	IA	43.3339	-91.17	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	15	-1,922
Interstate Power & Light Co	Lansing	IA	43.3339	-91.17	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	12	4,670
Interstate Power & Light Co	Lansing	IA	43.3339	-91.17	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	38	111,104
Interstate Power & Light Co	Lansing	IA	43.3339	-91.17	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	275	1,295,831
Interstate Power & Light Co	Milton L Kapp	IA	41.8117	-90.23	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	218	1,225,857
Interstate Power & Light Co	Sixth Street	IA	41.9839	-91.6686	Operating (in commercial service or out of service less than 365 days)	NL	NL	10	0
Interstate Power & Light Co	Sixth Street	IA	41.9839	-91.6686	Operating (in commercial service or out of service less than 365 days)	NL	NL	6	10,790
Interstate Power & Light Co	Sixth Street	IA	41.9839	-91.6686	Operating (in commercial service or out of service less than 365 days)	NL	NL	15	40,451
Interstate Power & Light Co	Sixth Street	IA	41.9839	-91.6686	Operating (in commercial service or out of service less than 365 days)	NL	NL	10	0
Interstate Power & Light Co	Prairie Creek	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	23	65,015
Interstate Power & Light Co	Prairie Creek	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	23	106
Interstate Power & Light Co	Prairie Creek	IA	41.9378	-91.6383	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	50	98,904
Interstate Power & Light Co	Prairie Creek	IA	41.9378	-91.6383	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	149	706,549
Interstate Power & Light Co	Sutherland	IA	42.0472	-92.8627	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	38	210,202
Interstate Power & Light Co	Sutherland	IA	42.0472	-92.8627	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	38	210,202
Interstate Power & Light Co	Sutherland	IA	42.0472	-92.8627	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	82	453,592
MidAmerican Energy Co	Riverside	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	5	16,173
MidAmerican Energy Co	Riverside	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	*	*
MidAmerican Energy Co	Riverside	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	*	*
MidAmerican Energy Co	Riverside	IA	41.5386	-90.4478	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	136	640,217
MidAmerican Energy Co	Council Bluffs	IA	41.18	-95.8408	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	49	297,837
MidAmerican Energy Co	Council Bluffs	IA	41.18	-95.8408	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	82	635,618
MidAmerican Energy Co	Council Bluffs	IA	41.18	-95.8408	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	726	5,312,810
MidAmerican Energy Co	Council Bluffs	IA	NL	NL	New unit under construction	Subbituminous	Wyoming	923	0
MidAmerican Energy Co	George Neal North	IA	42.3167	-96.3667	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	147	953,847
MidAmerican Energy Co	George Neal North	IA	42.3167	-96.3667	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	349	1,862,634
MidAmerican Energy Co	George Neal North	IA	42.3167	-96.3667	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	550	3,695,860
Interstate Power & Light Co	Burlington	IA	40.7389	-91.1222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	212	1,143,174
Ames City of	Ames Electric Services Power Plant	IA	42.0247	-93.6069	Operating (in commercial service or out of service less than 365 days)	NL	NL	33	156,380
Ames City of	Ames Electric Services Power Plant	IA	42.0247	-93.6069	Operating (in commercial service or out of service less than 365 days)	NL	NL	65	351,759
Cedar Falls City of	Streeter Station	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	16	50,740
Cedar Falls City of	Streeter Station	IA	42.5267	-92.4394	Operating (in commercial service or out of service less than 365 days)	NL	NL	35	109,692
Muscatine City of	Muscatine Plant #1	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	25	98,538

Utility Name	Plant Name	State	Plant Location Latitude (degrees)	Plant Location Longitude (degrees)	Boiler Status	Primary Fuel	Coal Origin State (Largest Source in 2005)	Generator Nameplate Rating (MW)	Net Annual Electrical Generation (MW-h)
Muscatine City of	Muscatine Plant #1	IA	41.3925	-91.0544	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	75	148,807
Muscatine City of	Muscatine Plant #1	IA	41.3925	-91.0544	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	176	1,033,623
Pella City of	Pella	IA	41.3969	-92.9058	Operating (in commercial service or out of service less than 365 days)	NL	NL	12	3,208
Pella City of	Pella	IA	41.3969	-92.9058	Operating (in commercial service or out of service less than 365 days)	NL	NL	26	106,922
Pella City of	Pella	IA	41.3969	-92.9058	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Corn Belt Power Coop	Earl F Wisdom	IA	43.1606	-95.2569	Operating (in commercial service or out of service less than 365 days)	NL	NL	33	138,410
Central Iowa Power Coop	Fair Station	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	25	127,013
Central Iowa Power Coop	Fair Station	IA	41.4569	-90.8233	Operating (in commercial service or out of service less than 365 days)	NL	NL	38	238,377
Interstate Power and Light	Ottumwa	IA	41.0961	-92.5556	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	726	3,355,680
MidAmerican Energy Co	Louisa	IA	41.3153	-91.0936	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	738	3,795,667
MidAmerican Energy Co	George Neal South	IA	42.3022	-96.3622	Operating (in commercial service or out of service less than 365 days)	Subbituminous	NL	640	3,953,585
Cargill Inc	Cargill Corn Milling Division	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	20	1,041
Cargill Inc	Cargill Corn Milling Division	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	20	51,412
Cargill Inc	Cargill Corn Milling Division	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	8	28,425
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	4	26,306
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	9	61,986
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	4	22,740
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	7	56,397
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Clinton	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Archer Daniels Midland Co	Archer Daniels Midland Cedar Rapids	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	31	132,826
Archer Daniels Midland Co	Archer Daniels Midland Cedar Rapids	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	31	189,454
Archer Daniels Midland Co	Archer Daniels Midland Cedar Rapids	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	31	155,753
Archer Daniels Midland Co	Archer Daniels Midland Cedar Rapids	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	31	214,950
Archer Daniels Midland Co	Archer Daniels Midland Cedar Rapids	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	31	147,788
Iowa State University	Iowa State University	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	13	48,340
Iowa State University	Iowa State University	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	6	13,410
Iowa State University	Iowa State University	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	12	60,571
Iowa State University	Iowa State University	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	15	33,553
Iowa State University	Iowa State University	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Iowa State University	Iowa State University	IA	NL	NL	Out of service (365 days or longer)	NL	NL	*	*
Iowa State University	Iowa State University	IA	NL	NL	Out of service (365 days or longer)	NL	NL	*	*

Utility Name	Plant Name	State	Plant Location Latitude (degrees)	Plant Location Longitude (degrees)	Boiler Status	Primary Fuel	Coal Origin State (Largest Source in 2005)	Generator Nameplate Rating (MW)	Net Annual Electrical Generation (MW-h)
John Deere Dubuque Works	John Deere Dubuque Works	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	4	2,760
John Deere Dubuque Works	John Deere Dubuque Works	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	3	775
John Deere Dubuque Works	John Deere Dubuque Works	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	8	21,145
John Deere Dubuque Works	John Deere Dubuque Works	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Iowa	University of Iowa Main Power Plant	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	3	5,353
University of Iowa	University of Iowa Main Power Plant	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	3	21,234
University of Iowa	University of Iowa Main Power Plant	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	15	61,481
University of Iowa	University of Iowa Main Power Plant	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Iowa	University of Iowa Main Power Plant	IA	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Sunflower Electric Power Corp	Holcomb	KS	37.555	-100.5821	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	349	2,684,902
Empire District Electric Co	Riverton	KS	37.0719	-94.6986	Operating (in commercial service or out of service less than 365 days)	NL	NL	38	174,627
Empire District Electric Co	Riverton	KS	37.0719	-94.6986	Operating (in commercial service or out of service less than 365 days)	NL	NL	50	313,874
Kansas City Power & Light Co	La Cygne	KS	38.3472	-94.6389	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	893	3,811,222
Kansas City Power & Light Co	La Cygne	KS	38.3472	-94.6389	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	685	5,227,644
Westar Energy	Lawrence Energy Center	KS	39.0114	-95.2764	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	49	331,036
Westar Energy	Lawrence Energy Center	KS	39.0114	-95.2764	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	114	744,724
Westar Energy	Lawrence Energy Center	KS	39.0114	-95.2764	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	403	2,256,537
Westar Energy	Tecumseh Energy Center	KS	39.0522	-95.5669	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	150	896,209
Westar Energy	Tecumseh Energy Center	KS	39.0522	-95.5669	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	82	508,011
Kansas City City of	Quindaro	KS	39.0878	-94.6464	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	82	409,574
Kansas City City of	Quindaro	KS	39.0878	-94.6464	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	158	612,294
Kansas City City of	Nearman Creek	KS	39.1714	-94.6958	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	261	1,478,198
Westar Energy	Jeffrey Energy Center	KS	39.2853	-96.1086	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	720	5,002,463
Westar Energy	Jeffrey Energy Center	KS	39.2853	-96.1086	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	720	5,573,650
Westar Energy	Jeffrey Energy Center	KS	39.2853	-96.1086	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	720	4,569,615
Empire District Electric Co	Asbury	MO	37.2733	-94.6083	Operating (in commercial service or out of service less than 365 days)	Subbituminous	NL	213	1,366,270
Kansas City Power & Light Co	Hawthorn	MO	39.1317	-94.4739	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	594	3,716,185
Kansas City Power & Light Co	Montrose	MO	38.3108	-93.9331	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	188	1,124,149
Kansas City Power & Light Co	Montrose	MO	38.3108	-93.9331	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	188	1,124,183
Kansas City Power & Light Co	Montrose	MO	38.3108	-93.9331	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	188	1,094,570
Aquila Inc	Sibley	MO	39.1778	-94.1861	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	55	314,149
Aquila Inc	Sibley	MO	39.1778	-94.1861	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	50	320,879
Aquila Inc	Sibley	MO	39.1778	-94.1861	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	419	2,245,000
Aquila Inc	Lake Road	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	*	*
Aquila Inc	Lake Road	MO	39.7278	-94.8786	Operating (in commercial service or out of service less than 365 days)	Bituminous	Wyoming	90	610,924

Utility Name	Plant Name	State	Plant Location Latitude (degrees)	Plant Location Longitude (degrees)	Boiler Status	Primary Fuel	Coal Origin State (Largest Source in 2005)	Generator Nameplate Rating (MW)	Net Annual Electrical Generation (MW-h)
Ameren UE	Labadie	MO	38.5583	-90.8361	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	574	4,635,684
Ameren UE	Labadie	MO	38.5583	-90.8361	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	574	4,492,892
Ameren UE	Labadie	MO	38.5583	-90.8361	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	621	4,753,293
Ameren UE	Labadie	MO	38.5583	-90.8361	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	621	4,757,085
Ameren UE	Meramec	MO	38.4017	-90.3358	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	138	937,915
Ameren UE	Meramec	MO	38.4017	-90.3358	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	138	966,581
Ameren UE	Meramec	MO	38.4017	-90.3358	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	289	1,896,179
Ameren UE	Meramec	MO	38.4017	-90.3358	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	359	1,889,095
Ameren UE	Sioux	MO	38.9158	-90.2917	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	550	2,947,855
Ameren UE	Sioux	MO	38.9158	-90.2917	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	550	3,688,067
Columbia City of	Columbia	MO	38.9658	-92.3175	Operating (in commercial service or out of service less than 365 days)	NL	NL	16	25,392
Columbia City of	Columbia	MO	38.9658	-92.3175	Operating (in commercial service or out of service less than 365 days)	NL	NL	22	29,009
Columbia City of	Columbia	MO	38.9658	-92.3175	Standby (or inactive reserve, i.e., not normally used, but available for service)	NL	NL	35	18,757
Independence City of	Blue Valley	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	Bituminous	Missouri	25	80,926
Independence City of	Blue Valley	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	Bituminous	Missouri	25	75,196
Independence City of	Blue Valley	MO	39.0919	-94.3261	Operating (in commercial service or out of service less than 365 days)	Bituminous	Missouri	65	173,196
Marshall City of	Marshall	MO	NL	NL	Standby (or inactive reserve, i.e., not normally used, but available for service)	NL	NL	4	-366
Marshall City of	Marshall	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	6	7,721
Marshall City of	Marshall	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	16	38,591
Springfield City of	James River Power Station	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	22	146,268
Springfield City of	James River Power Station	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	22	144,571
Springfield City of	James River Power Station	MO	37.1086	-93.2592	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	44	272,769
Springfield City of	James River Power Station	MO	37.1086	-93.2592	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	60	421,827
Springfield City of	James River Power Station	MO	37.1086	-93.2592	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	105	674,595
Associated Electric Coop Inc	New Madrid	MO	36.5147	-89.5617	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	600	3,532,641
Associated Electric Coop Inc	New Madrid	MO	36.5147	-89.5617	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	600	3,499,999
Associated Electric Coop Inc	Thomas Hill	MO	39.5531	-92.6392	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	180	1,248,024
Associated Electric Coop Inc	Thomas Hill	MO	39.5531	-92.6392	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	285	1,969,327
Associated Electric Coop Inc	Thomas Hill	MO	39.5531	-92.6392	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	670	4,578,751
Central Electric Power Coop	Chamois	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	15	123,971
Central Electric Power Coop	Chamois	MO	38.6853	-91.7556	Operating (in commercial service or out of service less than 365 days)	NL	NL	44	292,833
Independence City of	Missouri City	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	23	41,513
Independence City of	Missouri City	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	23	46,969
Kansas City Power & Light Co	Iatan	MO	39.4464	-94.9856	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	726	4,899,448
Ameren UE	Rush Island	MO	38.1306	-90.2625	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	621	4,225,196
Ameren UE	Rush Island	MO	38.1306	-90.2625	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	621	4,696,883

Utility Name	Plant Name	State	Plant Location Latitude (degrees)	Plant Location Longitude (degrees)	Boiler Status	Primary Fuel	Coal Origin State (Largest Source in 2005)	Generator Nameplate Rating (MW)	Net Annual Electrical Generation (MW-h)
Springfield City of	Southwest Power Station	MO	37.1519	-93.3892	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	194	1,274,892
Sikeston City of	Sikeston Power Station	MO	36.8786	-89.6169	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	261	1,981,791
Hercules Incorporated	Hercules Missouri Chemical Works	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	9	36,660
Hercules Incorporated	Hercules Missouri Chemical Works	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	9	44,410
Hercules Incorporated	Hercules Missouri Chemical Works	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	11	43,421
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	11	54,291
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	4	11,728
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Anheuser-Busch Inc	Anheuser Busch St Louis	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	6	27,031
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	12	44,853
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	20	17,330
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	14	48,849
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
University of Missouri-Columba	University of Missouri Columbia	MO	NL	NL	Operating (in commercial service or out of service less than 365 days)	NL	NL	*	*
Hastings City of	Whelan Energy Center	NE	40.5806	-98.3106	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	76	549,295
Fremont City of	Lon Wright	NE	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	NL	17	32,451
Fremont City of	Lon Wright	NE	NL	NL	Operating (in commercial service or out of service less than 365 days)	Subbituminous	NL	22	70,114
Fremont City of	Lon Wright	NE	41.4333	-96.4978	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	92	449,362
Nebraska Public Power District	Sheldon	NE	40.5589	-96.7842	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	109	744,968
Nebraska Public Power District	Sheldon	NE	40.5589	-96.7842	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	120	807,432
Omaha Public Power District	North Omaha	NE	41.2519	-95.9222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	74	361,170
Omaha Public Power District	North Omaha	NE	41.2519	-95.9222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	109	600,520
Omaha Public Power District	North Omaha	NE	41.2519	-95.9222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	109	597,538
Omaha Public Power District	North Omaha	NE	41.2519	-95.9222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	136	785,291
Omaha Public Power District	North Omaha	NE	41.2519	-95.9222	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	218	1,072,896
Nebraska Public Power District	Gerald Gentleman	NE	41.0836	-101.1456	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	681	4,888,554
Nebraska Public Power District	Gerald Gentleman	NE	41.0836	-101.1456	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	681	4,592,568
Omaha Public Power District	Nebraska City	NE	40.6242	-95.7785	Operating (in commercial service or out of service less than 365 days)	Subbituminous	Wyoming	652	4,622,838

Appendix F

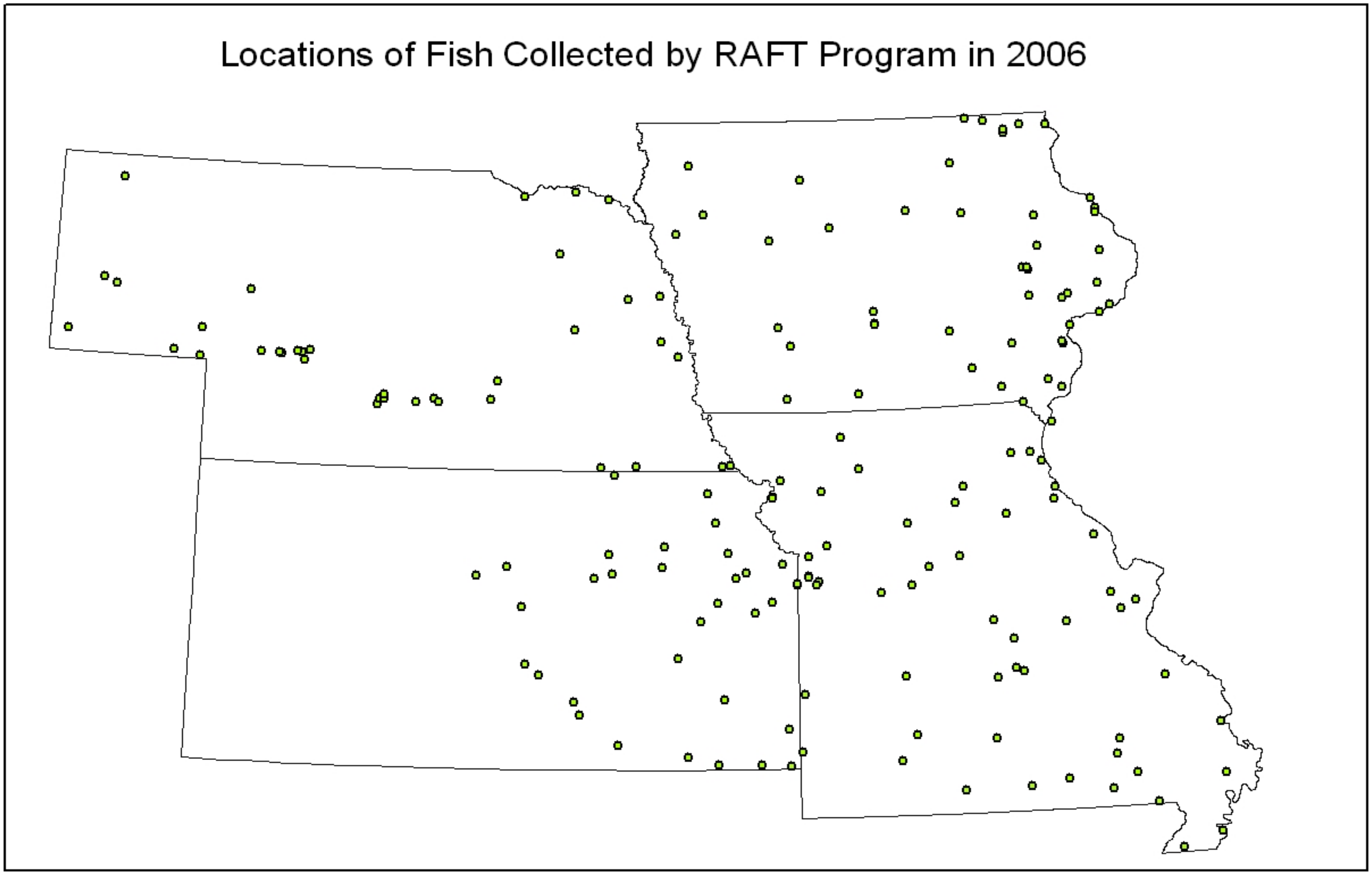
STORET Results

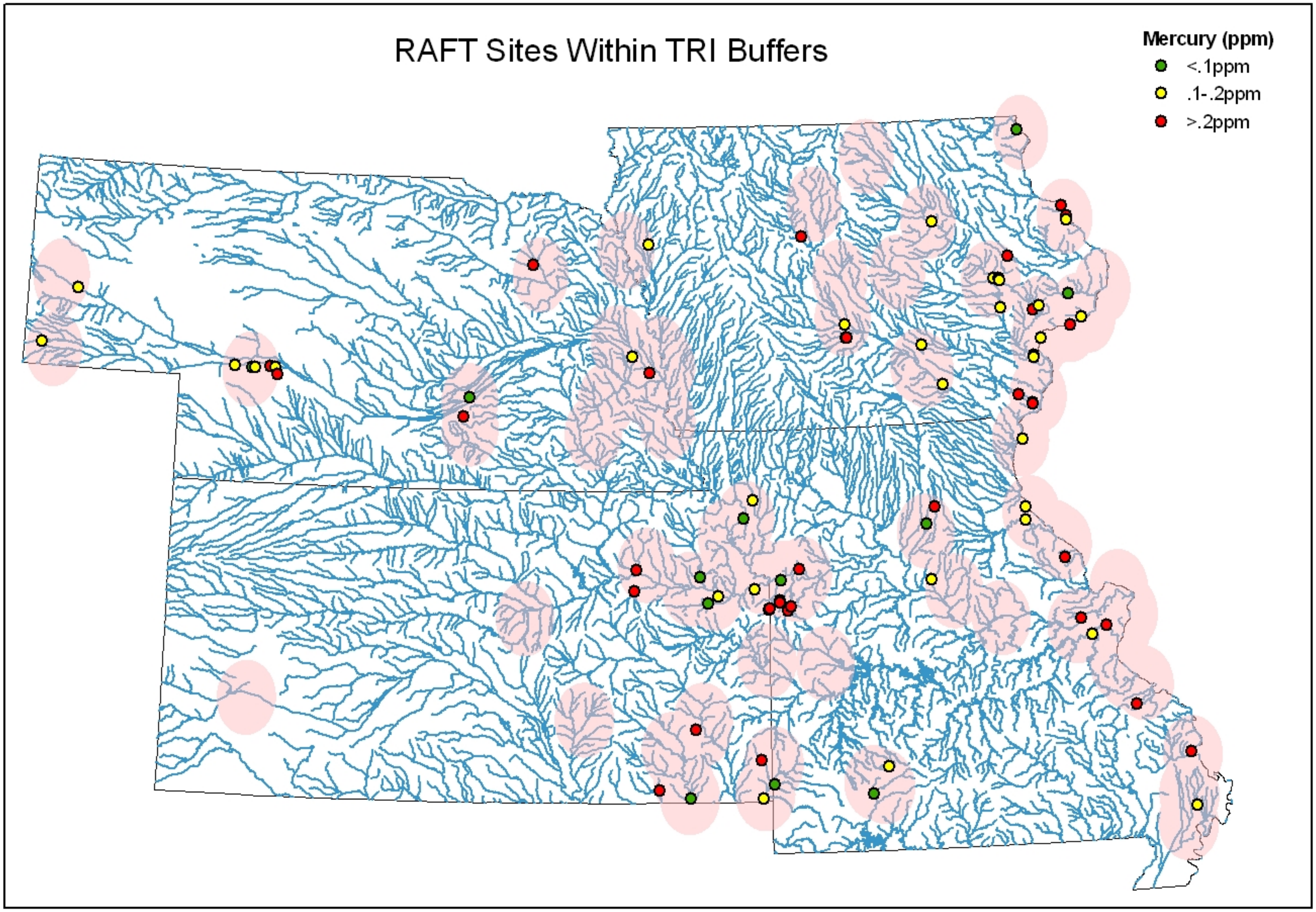
State	County	Generated HUC	Station Latitude	Station Longitude	Activity Start	Result	Units
IOWA	BOONE	7100004	42.080746	-93.938228	10/1/2002 9:15	0.34	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	4/17/2001 16:00	0.34	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	4/17/2001 13:55	0.31	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	10/1/2002 14:50	0.29	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	10/1/2002 13:20	0.29	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	10/1/2002 10:50	0.26	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	2/6/2001 14:30	0.24	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	4/17/2001 12:35	0.22	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	4/17/2001 11:50	0.21	ug/l
IOWA	BOONE	7100004	42.080746	-93.938228	4/17/2001 8:50	0.19	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	2/5/2002 14:30	0.18	ug/l
IOWA	BOONE	7100004	42.080746	-93.938228	2/6/2001 8:50	0.17	ug/l
IOWA	BOONE	7100004	42.080746	-93.938228	2/5/2002 9:00	0.17	ug/l
IOWA	BOONE	7100004	42.080746	-93.938228	4/23/2002 9:40	0.16	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	2/5/2002 13:00	0.14	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	2/5/2002 10:30	0.12	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	7/2/2002 12:30	0.12	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	7/2/2002 16:00	0.12	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	10/1/2002 12:00	0.1	ug/l
IOWA	BOONE	7100004	42.080746	-93.938228	7/2/2002 8:55	0.09	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	2/6/2001 11:20	0.09	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	2/6/2001 10:20	0.07	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	2/6/2001 13:00	0.07	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	2/5/2002 11:15	0.06	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	4/23/2002 15:40	0.06	ug/l
IOWA	POLK	7100004	41.680488	-93.668669	4/23/2002 11:30	0.06	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	4/23/2002 12:35	0.05	ug/l
IOWA	POLK	7100008	41.565395	-93.511728	4/23/2002 14:10	0.04	ug/l
IOWA	DALLAS	7100006	41.5342	-93.95035	7/2/2002 14:25	0.03	ug/l
IOWA	MARION	7100009	41.362168	-92.971759	7/2/2002 17:15	0.03	ug/l
IOWA	MARSHALL	7080208	42.0917	-93.0002	12/10/2001 10:45	0.0007	mg/l
IOWA	CEDAR	7080206	41.788012	-91.312406	7/2/2003 13:00	0.0004	mg/l
IOWA	CLAY	10230003	43.1338	-95.112	1/8/2001 13:15	0.0003	mg/l
IOWA	WAPELLO	7100009	41.0874	-92.5258	1/3/2002 12:50	0.0003	mg/l
IOWA	JACKSON	7060006	42.090158	-90.671987	1/6/2003 11:35	0.0002	mg/l
IOWA	WAPELLO	7100009	40.956766	-92.339974	2/3/2003 9:15	0.0001	mg/l
IOWA	STORY	7080105	42.0663	-93.6201	11/27/2000 12:30	0.0001	mg/l
IOWA	MARSHALL	7080208	42.0508	-92.8464	12/10/2001 11:30	0.0001	mg/l
IOWA	STORY	7080105	42.0663	-93.6201	12/11/2001 11:45	0.0001	mg/l
IOWA	WAPELLO	7100009	41.0874	-92.5258	2/3/2003 10:15	0.0001	mg/l
IOWA	ALLAMAKEE	7060002	43.4215	-91.5088	7/1/2002 14:30	8E-05	mg/l
IOWA	LEE	7100009	40.462	-91.5669	1/3/2000 10:30	7E-05	mg/l
KANSAS	LABETTE	11070205	37.22995	-95.1975	8/8/2000 13:25	0.0042	mg/l
KANSAS	JEFFERSON	10270103	39.40482	-95.5021	4/25/2001 15:50	0.0039	mg/l
KANSAS	PHILLIPS	10250015	39.98522	-99.47373	2/22/2000 14:45	0.0029	mg/l
KANSAS	MARION	11070202	38.34817	-97.08484	1/10/2001 11:50	0.0025	mg/l
KANSAS	LYON	11070203	38.36582	-96.11486	1/11/2001 10:00	0.0012	mg/l
KANSAS	CHEYENNE	10250003	39.787793	-101.81452	10/24/2000 11:32	0.0009	mg/l

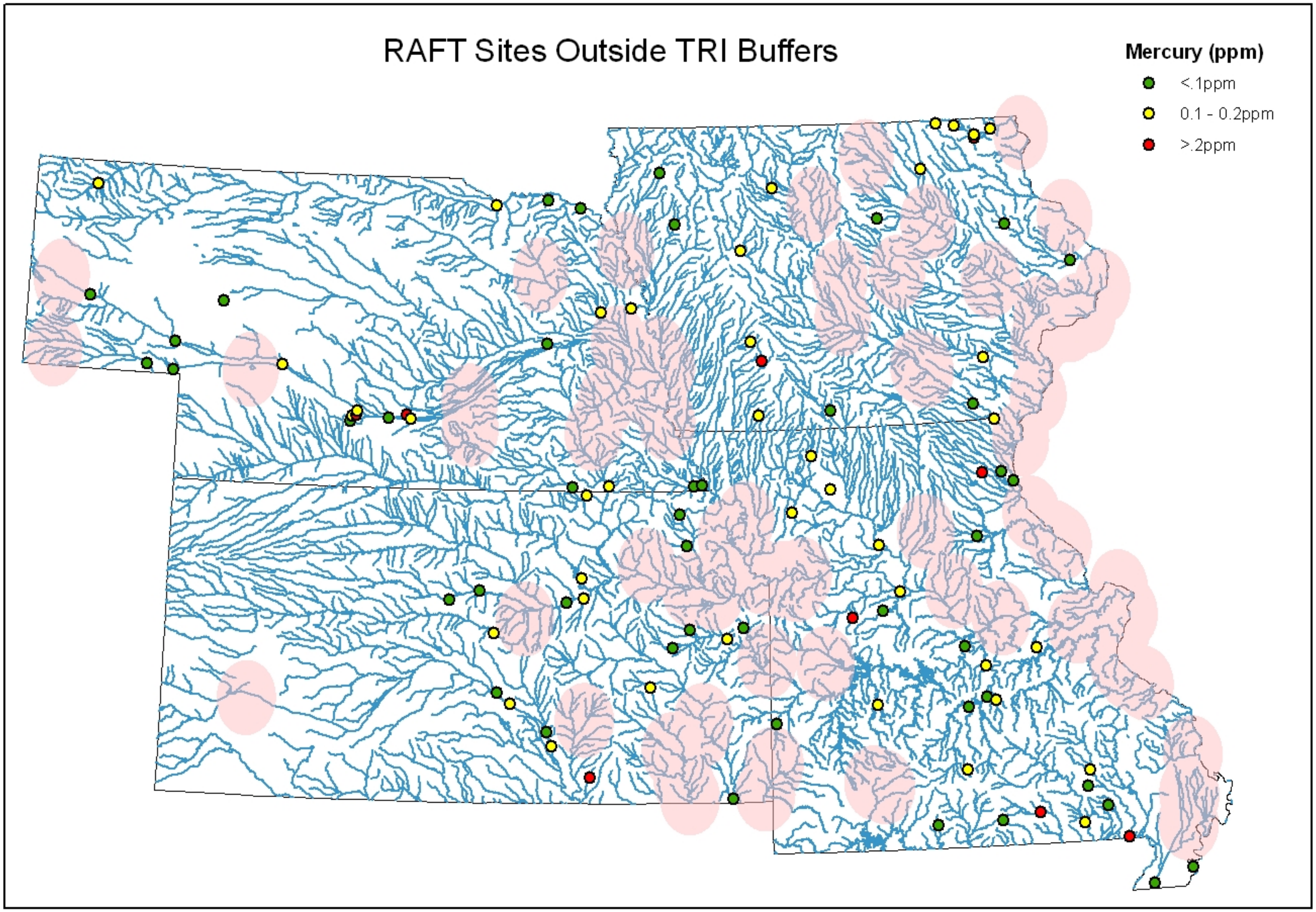
State	County	Generated HUC	Station Latitude	Station Longitude	Activity Start	Result	Units
KANSAS	SEDGWICK	11030013	37.607044	-97.306842	7/24/2001 16:45	0.0009	mg/l
KANSAS	SUMNER	11060005	37.01225	-97.60679	1/17/2001 14:05	0.0009	mg/l
KANSAS	BUTLER	11030018	37.58886	-97.00027	5/15/2001 9:40	0.0008	mg/l
KANSAS	JOHNSON	10300101	38.93855	-94.60819	8/10/2000 13:45	0.0008	mg/l
KANSAS	OSBORNE	10260014	39.42317	-98.54541	2/22/2000 10:05	0.0008	mg/l
KANSAS	MIAMI	10290102	38.50525	-94.85319	7/6/2000 10:55	0.0007	mg/l
KANSAS	GEARY	10260008	38.94916	-96.85801	9/20/2000 8:45	0.0006	mg/l
KANSAS	JEFFERSON	10270103	39.40482	-95.5021	9/27/2000 13:45	0.0006	mg/l
KANSAS	BOURBON	10290104	37.81318	-94.78002	10/4/2000 10:25	0.0005	mg/l
KANSAS	COWLEY	11030018	37.17018	-96.95398	8/22/2000 11:00	0.0005	mg/l
KANSAS	GEARY	10270101	39.06087	-96.73034	9/20/2000 9:35	0.0005	mg/l
KANSAS	NORTON	10250015	39.77057	-100.07719	2/22/2000 14:58	0.0005	mg/l
KANSAS	PHILLIPS	10260012	39.673686	-99.102982	2/22/2000 12:55	0.0005	mg/l
KANSAS	RENO	11030011	37.999423	-97.863318	8/21/2000 15:10	0.0005	mg/l
KANSAS	SUMNER	11030016	37.36385	-97.27648	10/17/2000 14:45	0.0005	mg/l
KANSAS	TREGO	10260003	38.78535	-99.89353	11/26/2001 11:55	0.0005	mg/l
KANSAS	COWLEY	11060001	37.07816	-96.85957	2/15/2000 12:45	0.0001	mg/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/25/2000 12:36	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/25/2000 12:35	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	6/27/2000 18:15	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	6/27/2000 16:10	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	6/27/2000 16:00	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/3/2001 13:00	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/3/2001 13:15	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/8/2002 11:41	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	4/8/2002 12:56	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/8/2002 11:55	0.5	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	1/29/2003 12:35	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	1/29/2003 11:21	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	1/29/2003 12:40	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	4/7/2003 13:00	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/7/2003 14:30	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	4/7/2003 14:35	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	8/26/2003 13:30	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	8/26/2003 16:30	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	8/26/2003 16:40	0.1	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	10/4/2004 10:09	0.05	ug/l
MISSOURI	MCDONALD	11070208	36.63	-94.58	10/4/2004 10:58	0.05	ug/l
MISSOURI	MCDONALD	11070208	36.54	-94.12	10/4/2004 10:09	0.05	ug/l
NEBRASKA	DUNDY	10250001	40.0293	-101.96786	9/25/2001 10:05	0.0006	mg/l
NEBRASKA	RICHARDSON	10240008	40.00023	-95.56552	9/28/2000 9:45	0.0006	mg/l
NEBRASKA	RICHARDSON	10240008	40.0003	-95.62706	9/28/2000 9:30	0.0006	mg/l
NEBRASKA	DUNDY	10250001	40.0293	-101.96786	2/22/2000 11:01	0.0005	mg/l
NEBRASKA	DUNDY	10250003	40.01042	-101.54242	2/22/2000 11:43	0.0005	mg/l

Appendix G

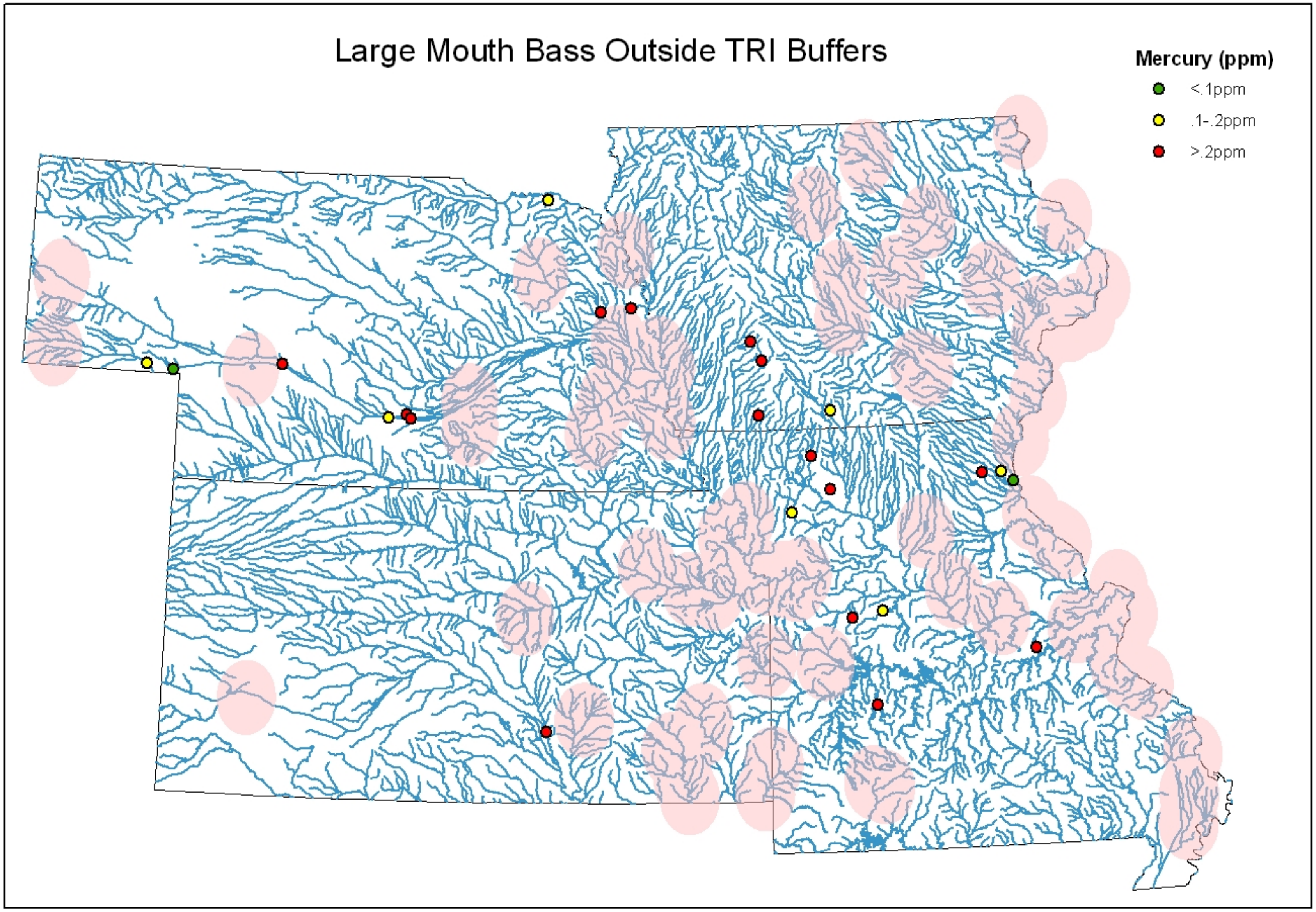
GIS Figures

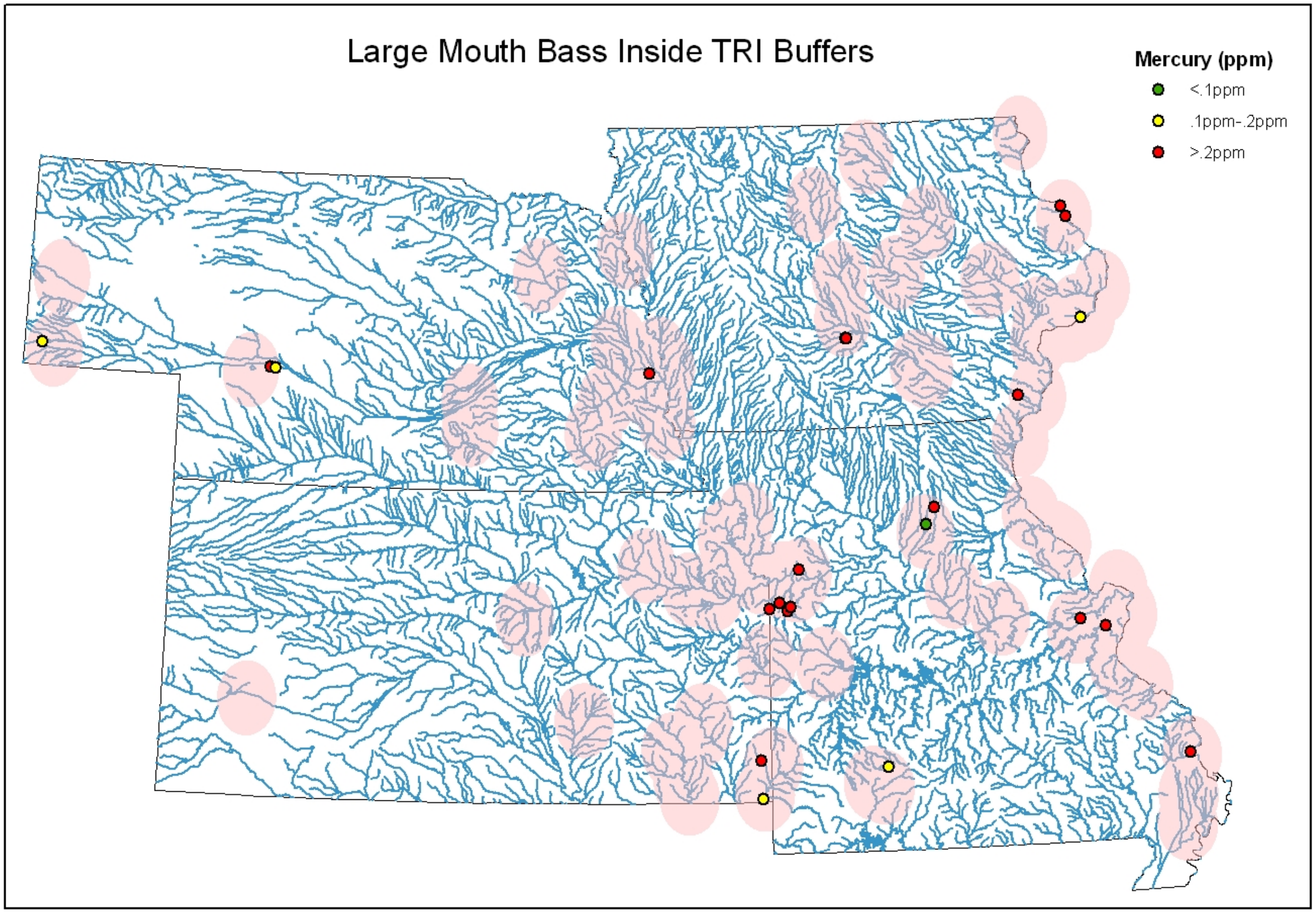

Locations of Fish Collected by RAFT Program in 2006

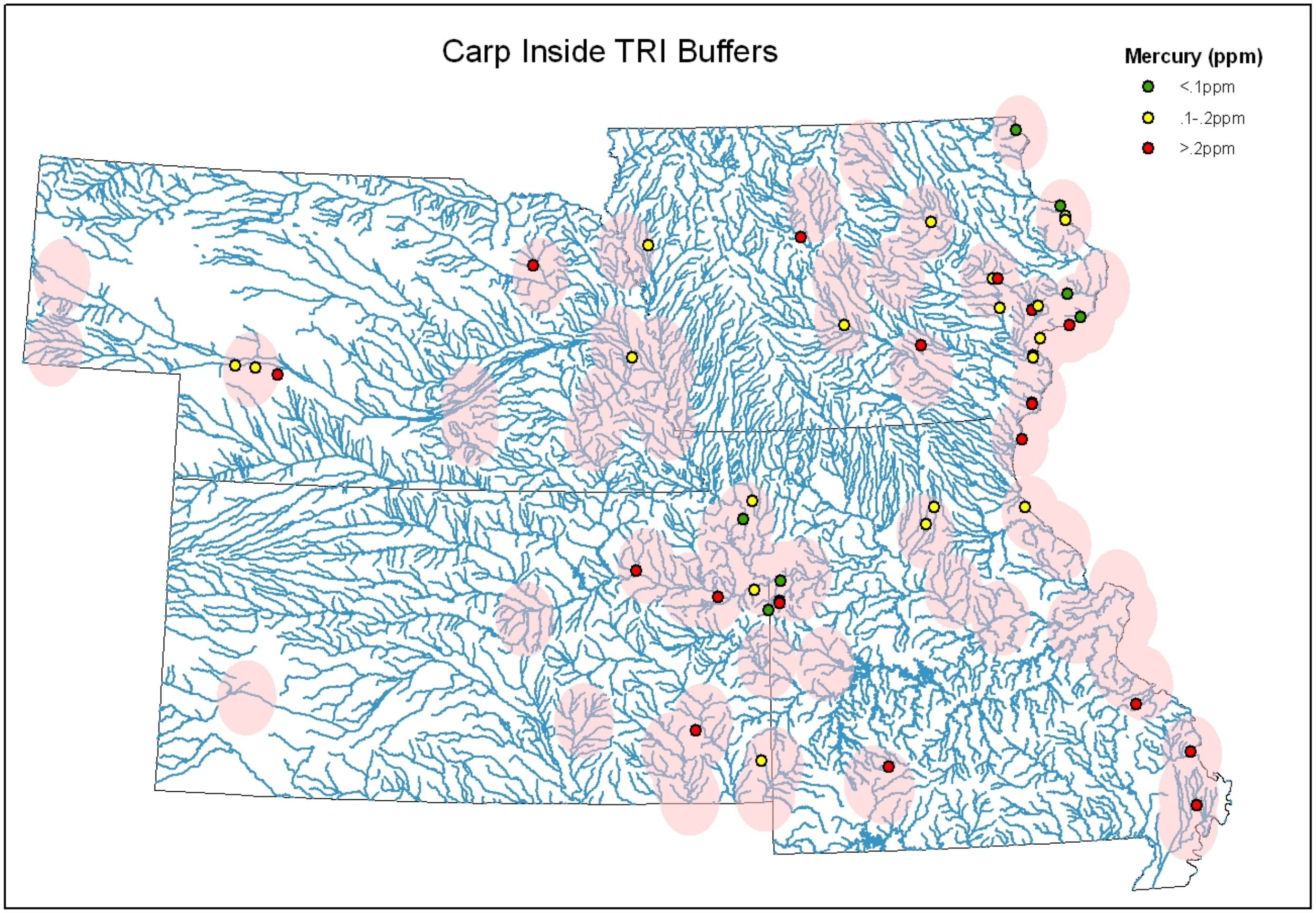

RAFT Sites Within TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm



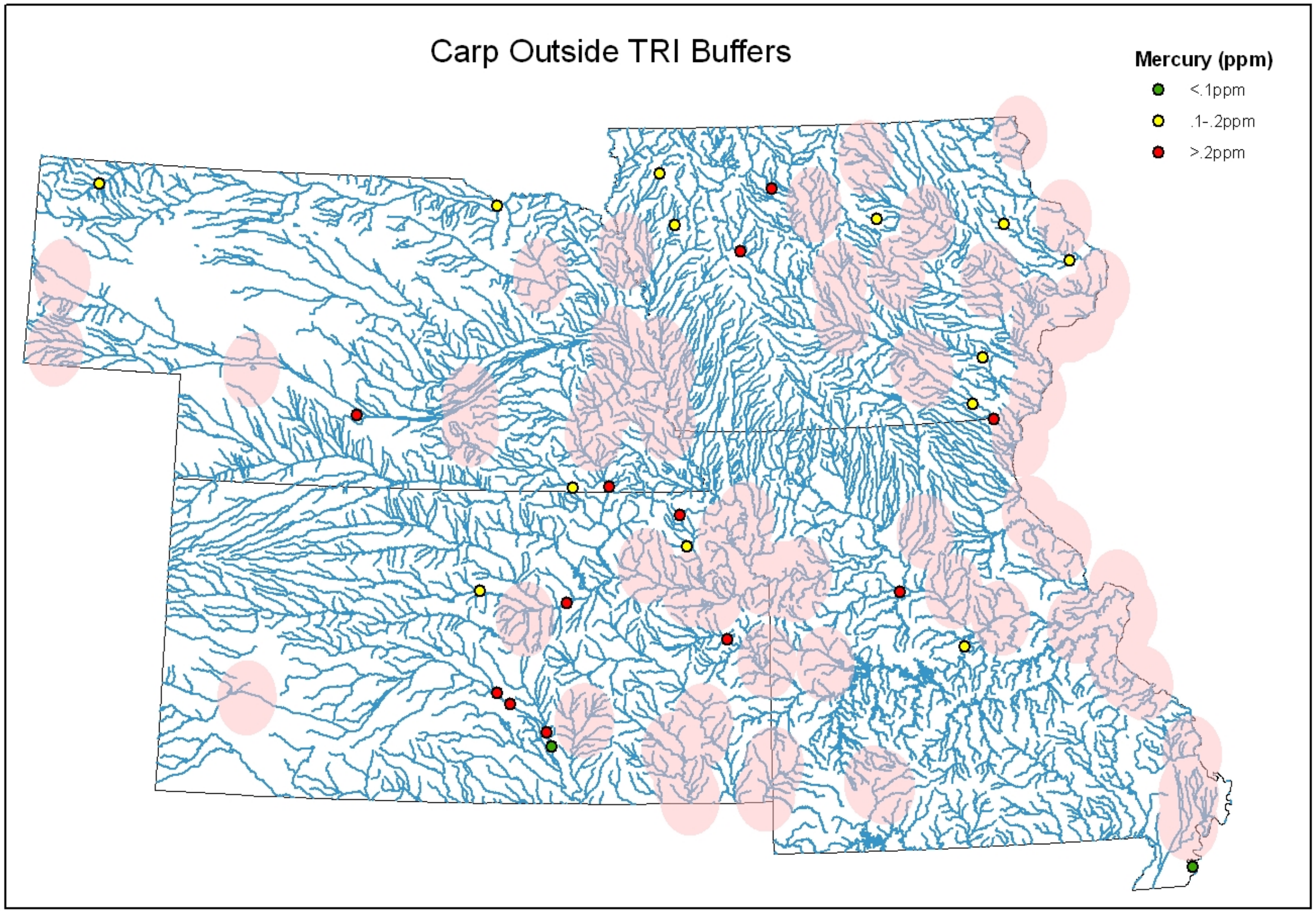
RAFT Sites Outside TRI Buffers
Mercury (ppm)
<.1ppm
0.1 - 0.2ppm
>.2ppm

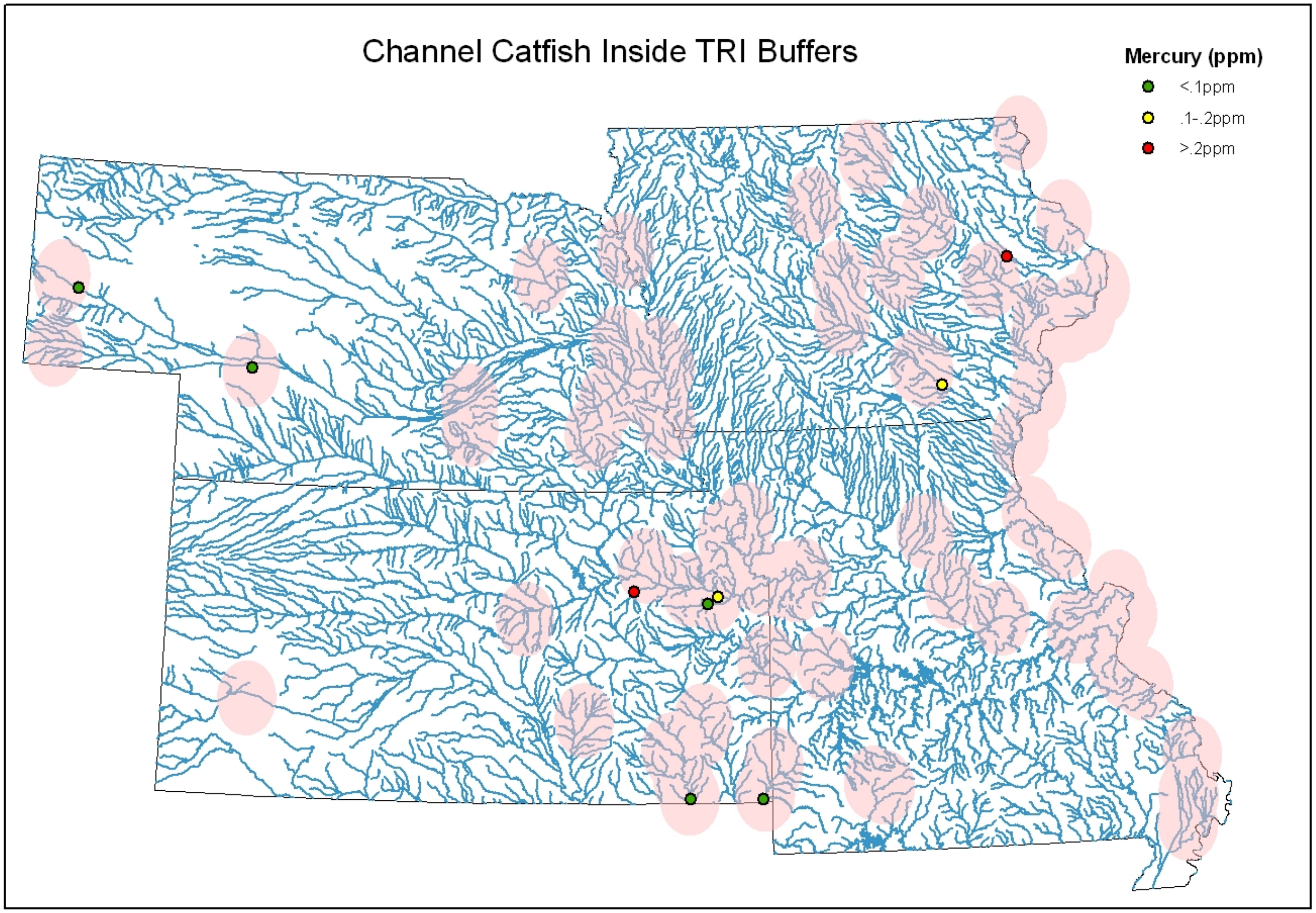

Large Mouth Bass Outside TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm

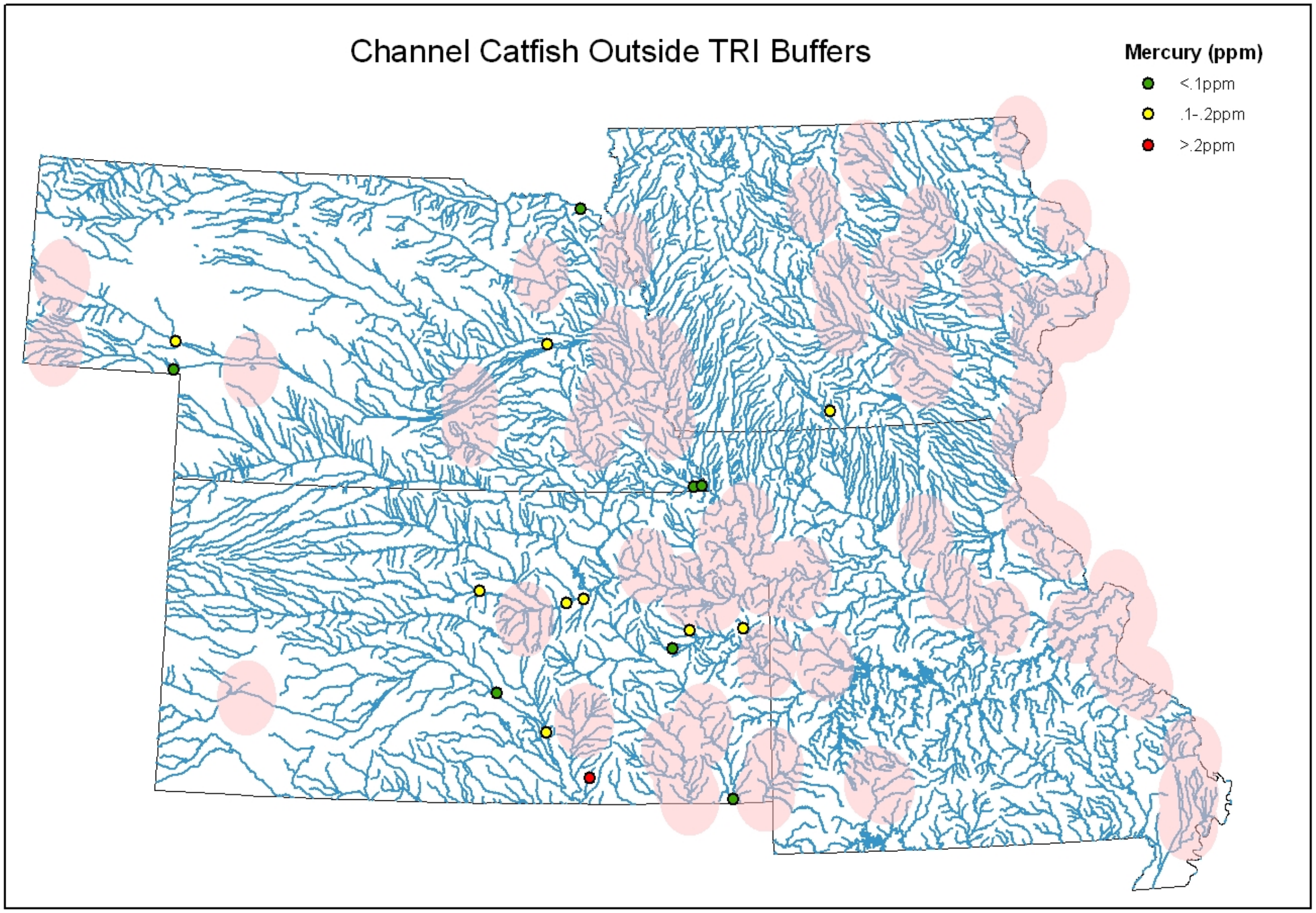

Large Mouth Bass Inside TRI Buffers
Mercury (ppm)
<.1ppm
.1ppm-.2ppm
>.2ppm

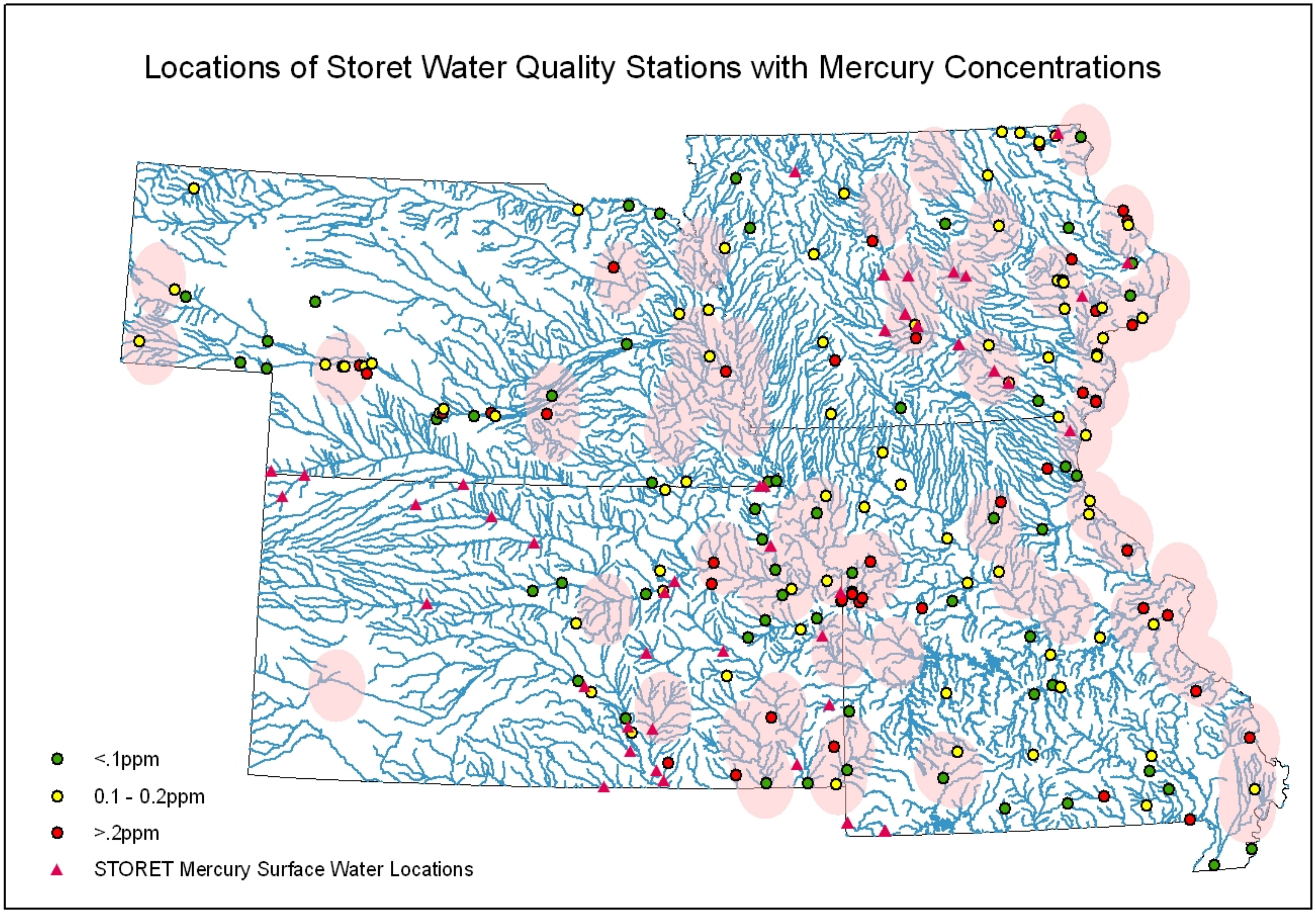


Carp Inside TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm


Carp Outside TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm


Channel Catfish Inside TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm

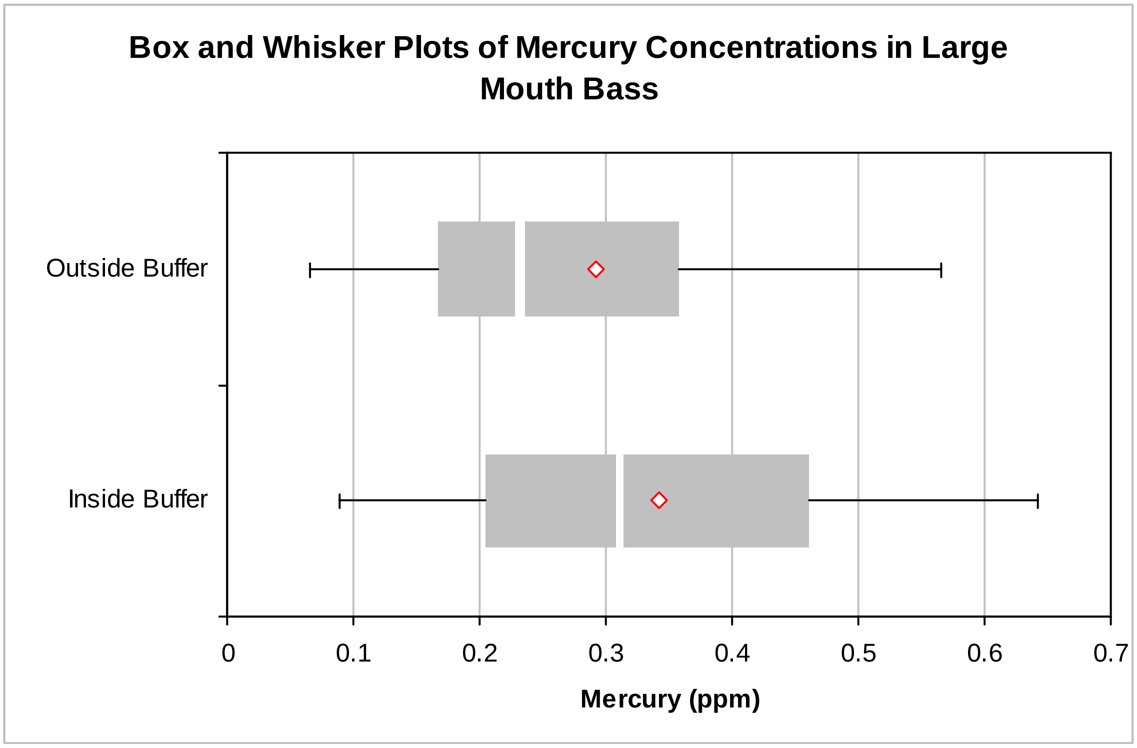

Channel Catfish Outside TRI Buffers
Mercury (ppm)
<.1ppm
.1-.2ppm
>.2ppm



Locations of Storet Water Quality Stations with Mercury Concentrations
<.1ppm
0.1 - 0.2ppm
>.2ppm
STORET Mercury Surface Water Locations

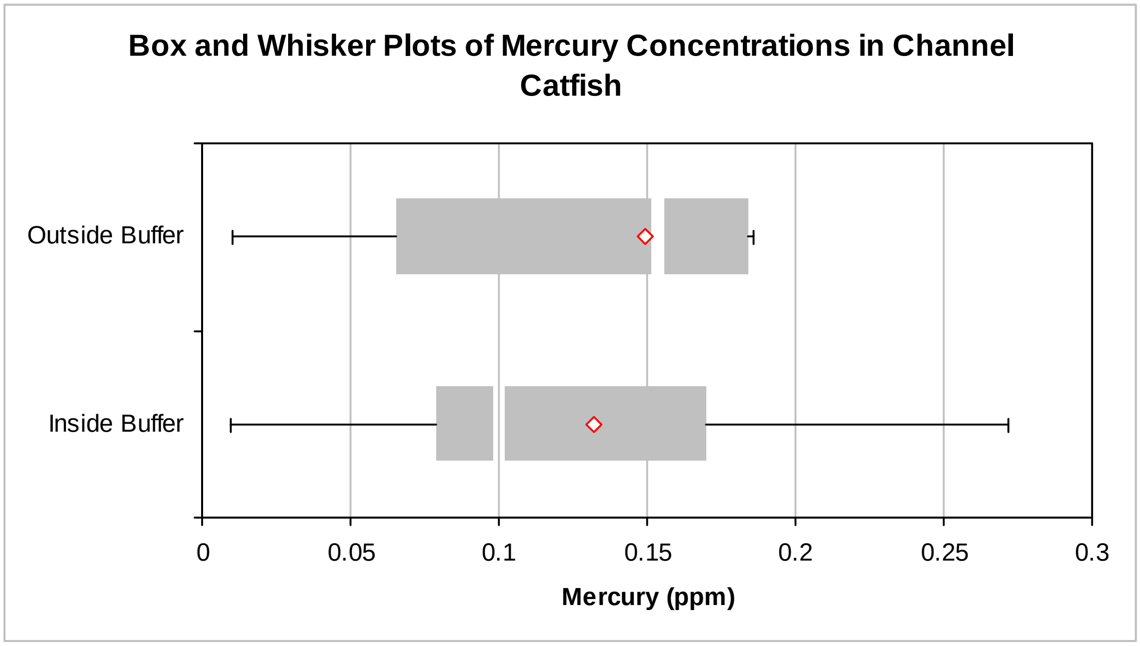
Appendix H

Box and Whisker Charts



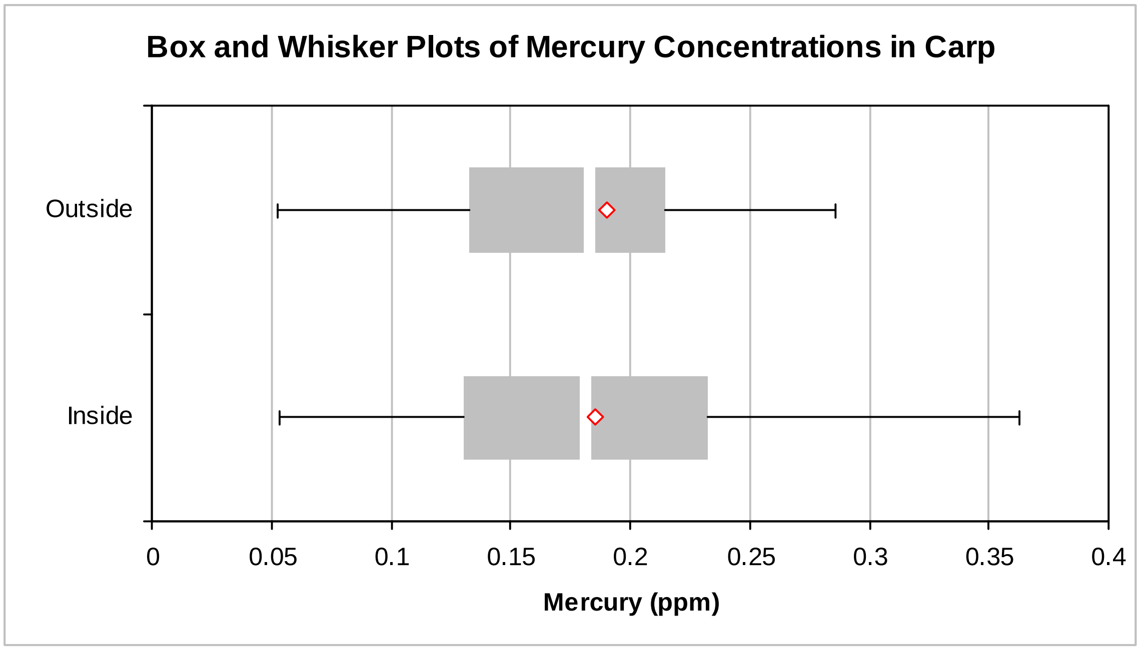
Box and Whisker Plot Data

	Outside Buffer	Inside Buffer
Count	27	27
Min	0.066	0.089
25th	0.167	0.205
Median	0.232	0.311
75th	0.358	0.4615
Max	0.793	0.642
Mean	0.29262963	0.342962963
SD	0.182838758	0.161839541
IQ	0.191	0.2565
25th - 3 IQ	-0.406	-0.5645
25th - 1.5 IQ	-0.1195	-0.17975
75th + 1.5 IQ	0.6445	0.84625
75th + 3 IQ	0.931	1.231
Min Fence	0.066	0.089
Max Fence	0.565	0.642



Box & Whisker Plot Data

	Outside Buffer	Inside Buffer
Count	10	9
Min	0.01	0.0376
25th	0.06515	0.079
Median	0.1535	0.1
75th	0.18375	0.17
Max	0.435	0.272
Mean	0.1491	0.132022222
SD	0.118745236	0.085060945
IQ	0.1186	0.091
25th - 3 IQ	-0.29065	-0.194
25th - 1.5 IQ	-0.11275	-0.0575
75th + 1.5 IQ	0.36165	0.3065
75th + 3 IQ	0.53955	0.443
Min Fence	0.01	0.009575
Max Fence	0.186	0.272



Box and Whisker Plot Data

	Outside	Inside
Count	23	49
Min	0.07	0.0533
25th	0.1325	0.13
Median	0.183	0.181
75th	0.2145	0.232
Max	0.43	0.541
Mean	0.189956522	0.185467347
SD	0.079645509	0.089879443
IQ	0.082	0.102
25th - 3 IQ	-0.1135	-0.176
25th - 1.5 IQ	0.0095	-0.023
75th + 1.5 IQ	0.3375	0.385
75th + 3 IQ	0.4605	0.538
Min Fence	0.0528123	0.0533
Max Fence	0.286	0.363