Mercury Deposition Monitoring in Kansas: Network Report

Our Vision – Healthier Kansans living in safe and sustainable environments.

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Mercury Deposition Monitoring in Kansas: Network Report

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Summary of Mercury Deposition Network Monitoring

Introduction

KSA 75-5673 required that the Kansas Department of Health and Environment (KDHE) establish a statewide mercury deposition network consisting of at least six monitoring sites. Monitoring for a period of time long enough to determine trends (five or more years) is also specified.

The network was designed to assure compatibility with the Mercury Deposition Network (MDN). The MDN, coordinated through the National Atmospheric Deposition Program (NADP), is designed to study and quantify the atmospheric fate and deposition of mercury. The MDN collects weekly samples of wet deposition (rain and snow) for analysis to determine total mercury.

Discussion of Factors Affecting Mercury Deposition

Most mercury in the atmosphere is present as elemental mercury (Hg^0). Some of this mercury is converted to reactive gaseous mercury (Hg^{2+}), which is the predominant form flushed from the atmosphere by precipitation. It is generally believed that most atmospheric Hg^{2+} is in the form of mercuric chloride ($HgCl_2$). In general, concentration and deposition amounts are higher during the warmer months.

Seasonal variation occurs for several reasons:

1) Higher temperatures and faster reaction rates cause more rapid chemical conversion.

2) More oxidants, such as ozone (O_3) and hydroxyl ions (OH^-), which can convert Hg^0 to Hg^{2+} are present.

3) Higher concentrations of Hg^0 are present in the atmosphere (due to higher emissions from increased power generation, etc.).

4) More precipitation generally occurs and flushes more mercury out of the air more efficiently.

5) The atmosphere contains particulate matter, and therefore, more mercury to be flushed.

There are three factors which affect deposition of atmospheric mercury at any given location. These are:

1) **Concentration,** which is affected by local, regional and global sources.

   The total amount of mercury from non-local sources circulating freely in the Earth's atmosphere at any given time constitutes the "global pool" of mercury. It is estimated that 95 per cent of the global pool is Hg^0, and this mercury circulates for a period estimated at between 6 months to 2 years. Local contributions to mercury concentrations vary considerably across the planet and within the United States, depending upon the distance from the point of measurement to local and regional sources. Much of a local mercury contribution impacts local and/or regional deposition, especially if it is emitted in a reactive form (e.g., Hg^{2+}).

2) **Precipitation,** which removes mercury from the atmosphere.

   Precipitation essentially "flushes" mercury from the atmosphere. It is this mercury that is measured to determine our deposition data. In general, mercury concentrations appear to be higher when it begins to rain or snow, and lower at the end of a precipitation event. This is most evident during periods of prolonged precipitation (i.e., over a period of several hours to several days).

3) **Location** with regard to proximity of local sources.

   As stated above (Factor 1), local mercury concentrations vary considerably across the planet and within the United States, depending upon the distance from the point of measurement to local and regional sources. This factor also varies with wind direction, i.e., whether the sampling point is upwind or downwind of such sources at the time of sampling. In general, the closer a monitor is to a source, provided that it is downwind of that source, the higher the mercury concentration.

Atmospheric mercury concentrations also tend to be higher at positions near to and downwind of emitting sources. This is described as "local influence" with regard to higher mercury concentration and deposition measurements. These are the local contributions described above (under Factor 1) which impact local and/or regional deposition. Across Kansas, there can also be dramatic shifts in sources of the air coming in from out of state. For example, southeast Kansas is much more likely to receive tropical air from the south. Out west, flow is dominated by the flows from farther west (i.e., Pacific air, continental air, etc). This can exert a significant influence on what the atmosphere contains and what gets flushed out. Kansas sources include electrical generating units, cement kilns and mining operations. We do not yet have enough data to see whether effects of local and/or regional influences apply to Kansas, but this may become evident after several years of sampling.

Mercury Deposition Network Data

The purpose of the MDN is to collect mercury deposition data over a long period of time to monitor trends in the levels of mercury deposited over the earth's surface. Short term data analysis is difficult because of seasonal and year to year variability in precipitation amounts and mercury concentrations.

Quality assurance of MDN data occurs at two levels. All data are first reviewed by the national contract laboratory for completeness and accuracy, and assigned codes for samples that were mishandled, contaminated, or affected by equipment malfunction. The final laboratory data set is then forwarded to the MDN Program Office for final quality assurance before generation of annual average concentration and deposition maps and posting to the Web.

Data generated by the Kansas Mercury Deposition Network will be posted to the KDHE Web site as available and annually to a national database. Total mercury results are reported as:

1) Concentration, expressed in nanograms of mercury per liter (ng/L) of precipitation collected.

   This is the amount of mercury present in the water collected by the sampler. Concentration measurements provide a long-term record of mercury levels in precipitation across the United States.

2) Total precipitation depth collected, expressed in millimeters (mm).

   This is the depth of snow or rain collected, which when multiplied by the concentration, gives total deposition of mercury to the surface. (See #3)

3) Deposition, expressed in micrograms of mercury per square meter (ug/m^2).

   This is the amount of mercury deposited by precipitation on each square meter of ground at the sampling site. The deposition numbers are important because they provide annual estimates of the amount of mercury loaded onto the surface of the earth in the vicinity of each sampling site. It is a portion of this mercury which enters bodies of water and ultimately enters the food chain through aquatic systems.

National mercury data are summarized for each year by calculating the annual average values from each site and plotting the information on a national map. The most recent national average concentration and total deposition maps (for calendar year 2010) appear in Figures 1 and 2. A set of these MDN maps, dating back to 1998, can be found at http://nadp.sws.uiuc.edu/mdn/maps/ .

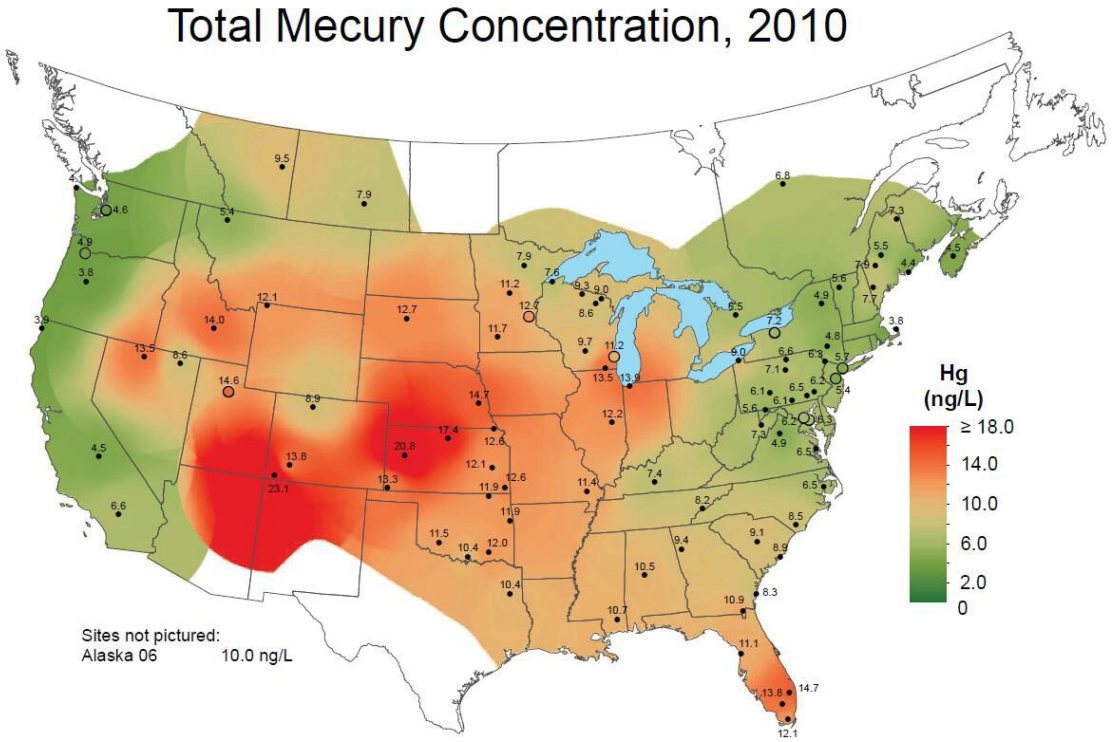

Figure 1

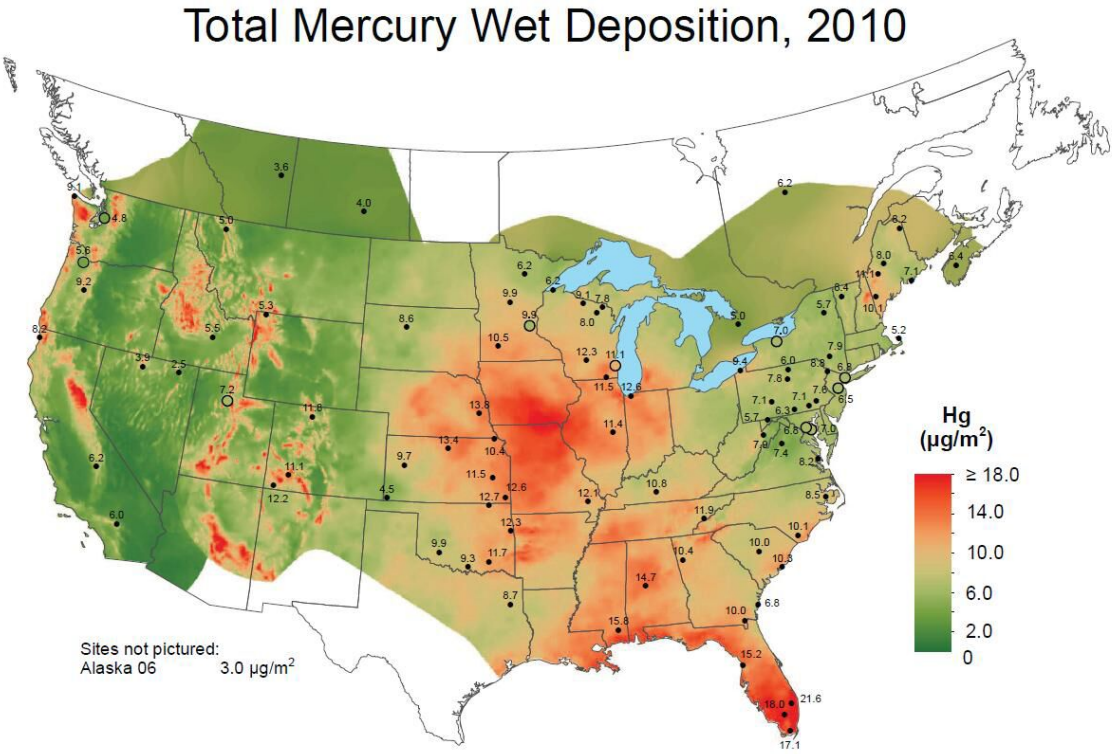

Figure 2

Description of the Kansas Mercury Wet Deposition Network

The complete Kansas Mercury Wet Deposition Monitoring Network (KMDN) consists of six sites distributed across the state. The locations of sites in the states of Nebraska and Oklahoma were also taken into consideration to optimize regional mercury network coverage. A map of the network appears below in Figure 3.

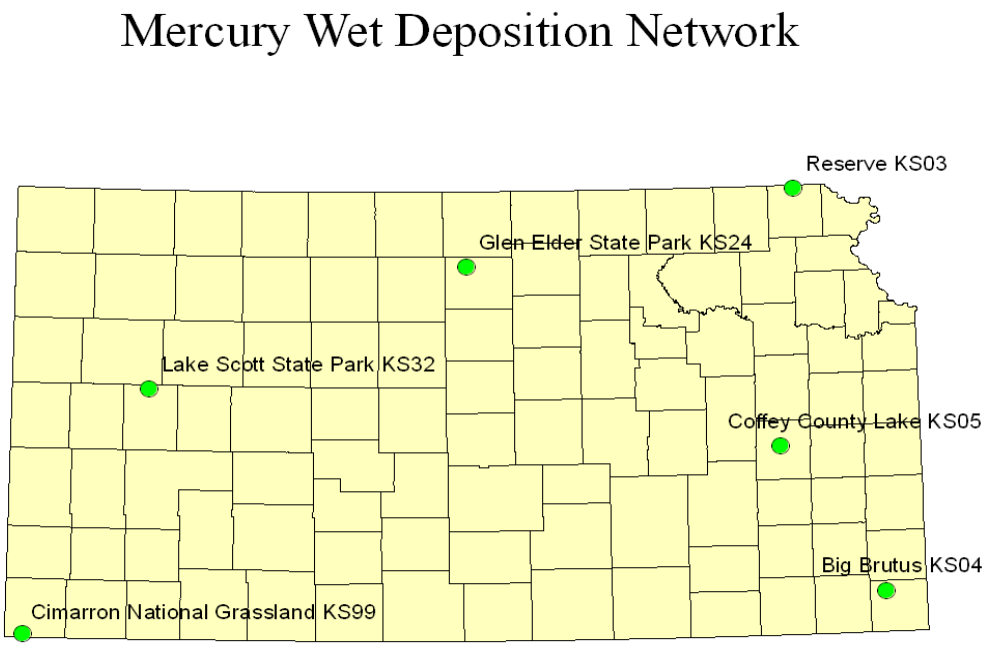

Figure 3

Each site was chosen to meet particular criteria. Specific regional and local siting criteria must be met before any site is accepted into the national MDN. A major consideration, at both the state and national levels, was relatively even distribution of monitoring sites across Kansas. Some other considerations, especially of interest from the State's perspective, were distance and direction to potential sources of airborne mercury, proximity to fish tissue monitoring locations, and distance to neighboring state boundaries. Mercury deposition sampling locations in the States of Oklahoma and Nebraska also affected placement of samplers in the network.

Kansas Deposition Data for 2011

Sampling at all sites is performed on a weekly basis, with sample retrieval every Tuesday. Clean sample glassware is installed for collection of the next week's sample at the time of the operator's site visit. All samples are sent to a national contract laboratory utilized by the MDN. Sample analysis and coordination through this national cooperative research program are performed under contract.

Preliminary data has been obtained through August 2011. The 2011 data sets have not been subjected to complete quality assurance procedures. The table below shows a comparison of the values from 2010 and January through August for 2011. The values shown are mercury deposition amounts expressed in ug/m^2 per month. Also below are trend charts (Figures 4 & 5) showing the annual average of mercury wet deposition and concentration in 2009 and 2010 for each site.

	2010 Jan-Dec		2011 Jan-Aug	
	Deposition ug/m2	Precipitation inches	Deposition ug/m2	Precipitation inches
Sac & Fox Nation	10.4	21.5	10.7	24.7
Glen Elder State Park	13.4	24.9	11.3	28.5
Lake Scott State Park	9.7	17.9	6.8	13.5
Big Brutus	12.6	24.5	15.1	26.5
Cimarron National Grassland	4.5	12.0	4.4	5.7
Coffey County Lake	11.5	27.1	12.2	23.0

Table 1

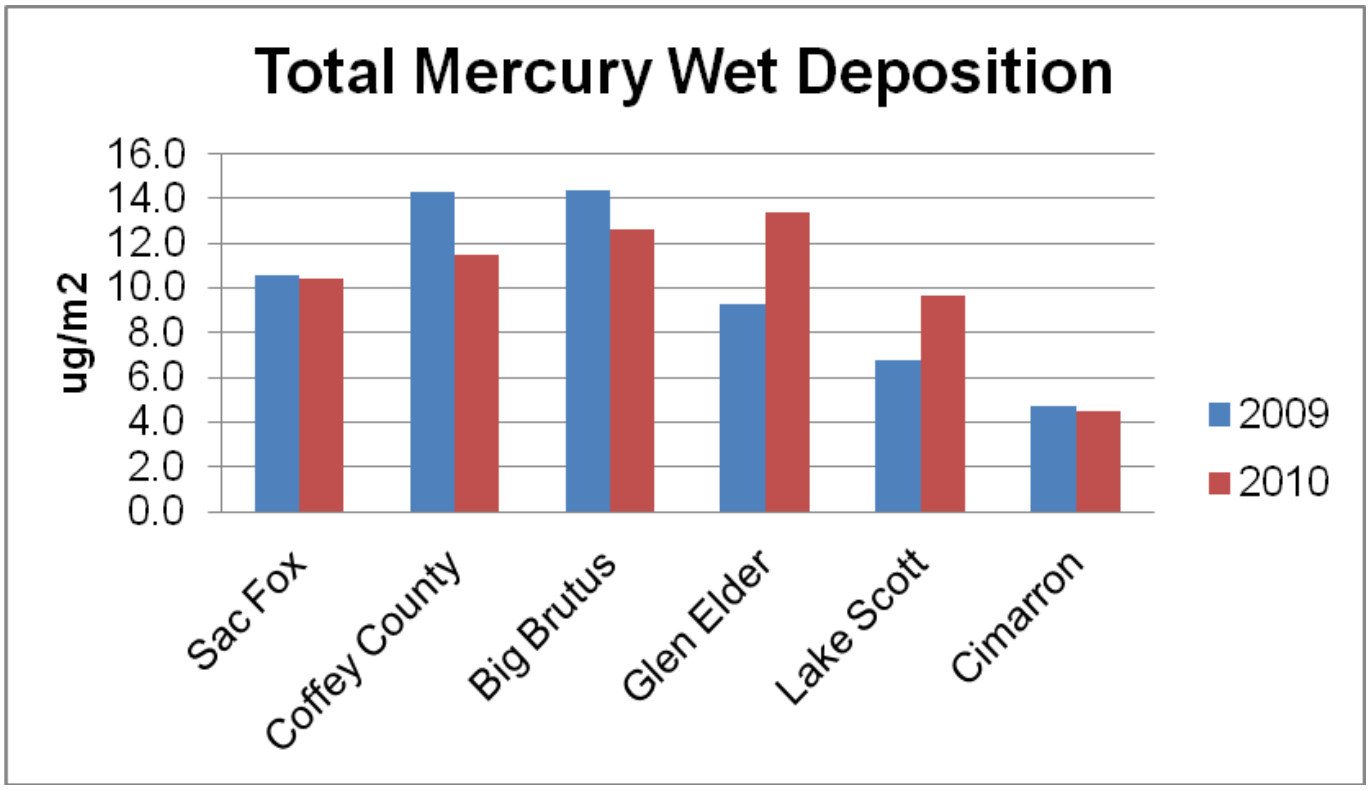

Figure 4

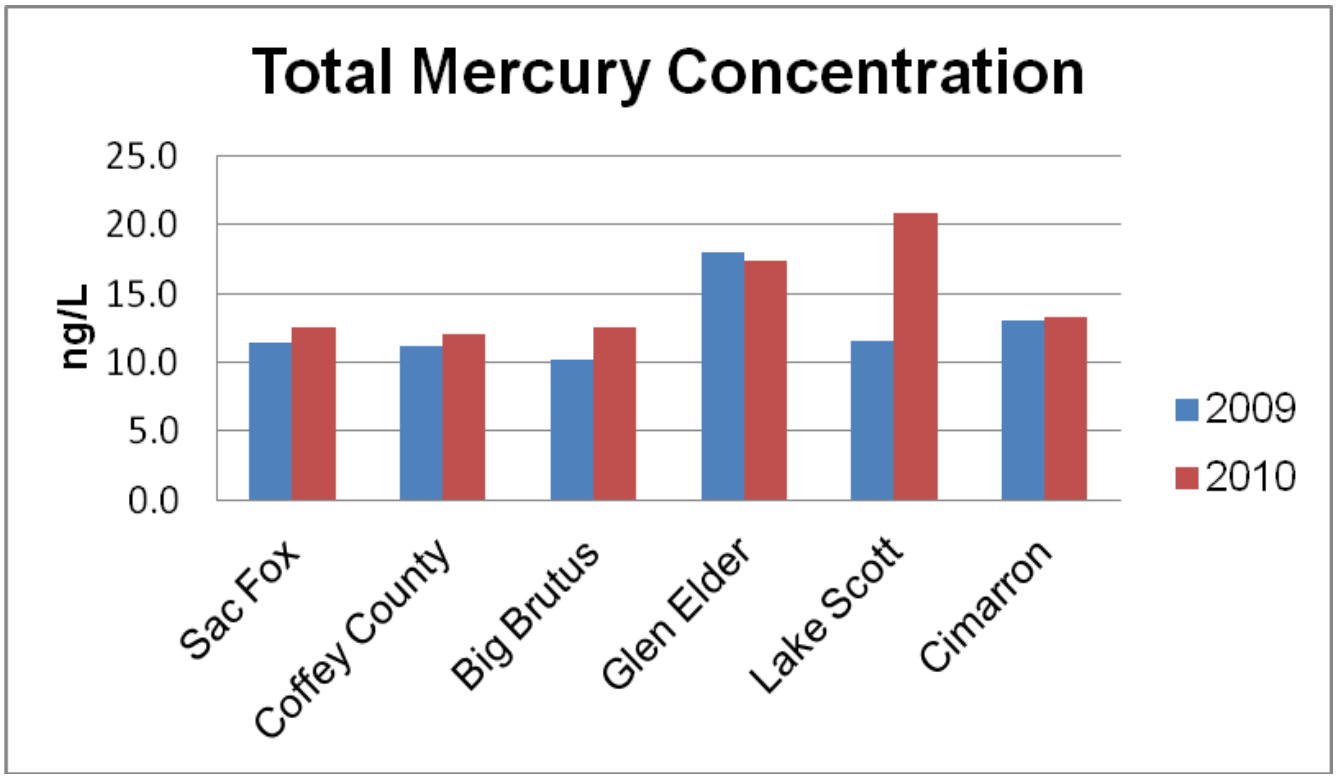

Figure 5

Sac and Fox Nation – KS03

This site is located at an existing ambient air monitoring station belonging to and operated by the Sac and Fox Nation of Missouri in Kansas and Nebraska. The Tribe's environmental department is operating the sampler under contract with KDHE. The KS03 site is downwind of coal fired electric generating units (EGUs).

The Sac and Fox mercury deposition from 2009 to 2010 showed a modest decrease. The 2011 year to date deposition data shows a likely increase for the site. The mercury concentration from 2009 to 2010 shows a modest increase. The 2011 year to date concentration data shows a likely increase for the site.

Glen Elder State Park – KS24

The Kansas Department of Wildlife and Parks (KDWP) host two sites. The first site is at Glen Elder State Park, between Glen Elder and Cawker City, KS. This site fills a gap in the north central part of the state and is in proximity to a fish tissue sampling site in alternate years. KS24 is operated by KDWP personnel.

The Glen Elder mercury depostion from 2009 to 2010 showed a substantial increase. One explanation is that the site received around 10 inches more precipitation in 2010 than 2009. The mercury concentration from 2009 to 2010 shows a slight decrease. With 2010 receiving more precipitation, it is likely the mercury concentration in the collected precipitation was diluted.

Lake Scott State Park – KS32

The second KDWP site is located north of Scott City, KS, at Lake Scott State Park. This site is an existing National Atmospheric Deposition Program (NADP) and National Trends Network (NTN) site

operated by an independent contract operator. It has no urban influences and is downwind of a Kansas coal fired electric generating unit (EGU) during the warmer seasons.

The Lake Scott data from 2009 to 2010 showed an increase in both mercury deposition and mercury concentration. The precipitation from 2009 to 2010 decreased. It is reasonable to conclude that the rain events in 2010 were very heavy, short bursts of precipitation, which would cause a higher concentration in the precipitation collected and an increase in deposition.

Big Brutus, Inc – KS04

The fourth KMDN site is located near West Mineral, KS, at the Big Brutus Museum. This site is in proximity to an interpolated "hot spot" on national MDN maps. It is downwind of Kansas cement kilns during the winter seasons, and is hosted and operated by Big Brutus, Inc.

The Big Brutus mercury deposition from 2009 to 2010 showed a modest decrease. The 2011 year to date deposition data shows a likely increase for the site. The mercury concentration from 2009 to 2010 shows a modest increase. The 2011 year to date concentration data shows a likely increase for the site.

Coffey County Lake – KS05

The fifth KMDN site is located at Coffey County Lake (Wolf Creek). This site is downwind of Kansas cement kilns during the warmer seasons. KS05 is operated by KDHE ambient air monitoring field staff.

The Coffey County Lake mercury deposition from 2009 to 2010 showed a modest decrease. The 2011 year to date deposition data shows a likely increase for the site. The mercury concentration from 2009 to 2010 shows a modest increase. The 2011 year to date concentration data shows that a similar concentration can be expected.

Cimarron National Grassland – KS99

The United States Department of Agriculture hosts the sixth and final KMDN site, which is located at the Cimarron National Grassland near Elkhart, KS. This is a remote site with no urban influences and helps fill a data gap in the national network around Kansas, Oklahoma, and Colorado. KS99 is operated by personnel at the Cimarron National Grassland.

The Cimarron National Grassland mercury depostion and concentration from 2009 to 2010 showed very little changes. This site receives far less precipitation than the other five sites. Increases in both deposition and concentration can be expected in 2011 due to precipitation events after the major wildfire in May.

Network Cost Analysis

Costs associated with the KMDN are presented in Table 2 below. All costs are covered by Air Fee Fund revenues.

Kansas Mercury Deposition Network Operating Costs: Jan. 1, 2011 – Dec. 31, 2011		
Cost Category	**Item Description**	**Category Totals**
Salaries and Fringes		**$38,909**
Supplies	Low toxicity antifreeze	**$60**
Operator and Site Use Fees		**$22,500**
Travel	Travel ($0.505/mile)	**$684**
Shipping	Samples to Laboratory	**$15,000**
Laboratory Analysis	Mercury Analysis	**$66,432**
Total Operating Cost		**$143,585**