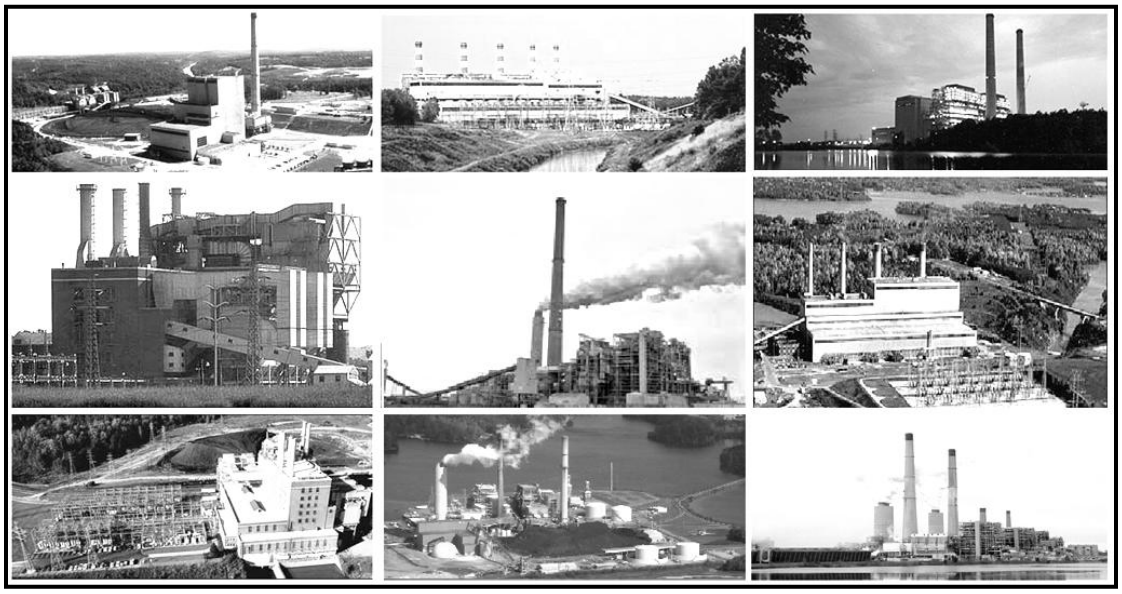
Final Report of the Division of Air Quality to the
Environmental Management Commission on the
Control of Mercury Emissions from
Coal-Fired Electric Steam Generating Units

In accordance with 15A NCAC 02D .2509(b)



July 1, 2012
Division of Air Quality
North Carolina Department of Environment and Natural Resources

Preface

The Division of Air Quality presents this report to the North Carolina Environmental Management Commission in accordance with the requirement in Title 15A North Carolina Administrative Code (NCAC) 02D .2509, Periodic Review and Reallocations.

The report provides updated information on the subjects listed under Paragraph 02D .2509(b) where it is available.

The information required includes:
(1) actual emissions from units covered under this Section 15A NCAC 02D .2509 since 2010 and all other principal sources of mercury;
(2) estimates of the amounts of the different species of mercury being emitted;
(3) create a mercury balance for North Carolina, including imported, exported and in-state mercury emissions and the fate and transport of mercury in the air and waters of the state;
(4) what are the projected mercury emissions for 2015, 2018, 2023 and 2025?;
(5) discuss the amount of new source growth and projected new units growth through 2025;
(6) what is the state of mercury control technology, including technological and economic feasibility?;
(7) assessment of cost and performance of mercury control technology as it may be applied to uncontrolled sources of mercury in North Carolina, including both coal-fired electric steam generating units and other sources that emit mercury, including an assessment of technology used to satisfy requirements of the Clean Smokestacks Act (G.S. 143-215.107D), and other requirements for controlling nitrogen oxide and sulfur dioxide (SO_2) emissions;
(8) provide a recommendation of mercury control technology, including the cost and expected reductions in mercury emissions;
(9) results of studies and monitoring on mercury and its species in fish in North Carolina, including an evaluation of the impact of reduced mercury emissions from coal-fired power plants on the levels of mercury observed in fish tissue;
(10) a summary of mercury-related health problems in North Carolina, including accumulation of mercury in humans, toxicity and mercury exposures from non-air emitting sources;
(11) results of studies on mercury deposition, applying monitoring techniques, back trajectory analysis, source attribution methodology, including other relevant methodologies, to assess the role of coal-fired units in North Carolina deposition;
(12) recommendations, if any, on rule revisions.

Images on the front cover page are photographs of several North Carolina coal-fired electrical generating units.

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Acronym List

AP-42	Air Pollution 42 (EPA Compilation of Emission Factors Series)
AQC	Air Quality Committee
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule (EPA)
CAMR	Clean Air Mercury Rule (EPA)
CDC	Center for Disease Control and Prevention
CMAQ	Community Multi-scale Air Quality
CSA	Clean Smokestack Act
CSAPR	Cross State Air Pollution Rule (EPA)
DAQ	North Carolina Division of Air Quality
D.C.	District of Colombia
DENR	Department of Environment and Natural Resources
DHHS	Department of Health and Human Services
DOC	Dissolved organic carbon
DWQ	North Carolina Division of Water Quality
EGU	Electrical generating unit
EMC	Environmental Management Commission
EPA	Environmental Protection Agency (United States)
EPRI	Electric Power Research Institute
ERMS	Eastern regional mercury study
ES	Executive summary
ESP	Electrostatic precipitator
ESP-CS	Cold-side electrostatic precipitator
ESP-HS	Hot-side electrostatic precipitator
FF	Fabric filter
FGD	Flue gas desulfurization
GEOS-CHEM	Goddard Earth Observing System – Chemistry
GW	Gigawatts
HAP	Hazardous air pollutant
HCl	Hydrogen chloride
Hg	Mercury
ICR	Information Collection Request (EPA)
kg	kilogram
km	kilometer
lb	pound
LOD	limit of detection
mg	milligram
MMBtu	Million British thermal units
MW	Megawatts
NC	North Carolina
NCAC	North Carolina Administrative Code
NCSU	North Carolina State University
NESCAUM	Northeast States for Coordinated Air Use Management
NHANES	National Health and Nutrition Examination Survey

ng/l	nanogram per liter
NOx	Nitrogen oxides
MACT	Maximum achievable control technology
MATS	Mercury and Air Toxics Standards
PAC	Powder activation carbon
PB	Particle-bound (mercury)
Ph	Potential hydrogen
Ph.D.	Doctor of Philosophy
PM	Particulate matter
POTW	Publicly owned treatment works
SAB	Science Advisory Board
SCR	Selective catalytic reduction
SDA	Spray dryer absorber
SIP	State Implementation Plan
SNCR	Selective non-catalytic reduction
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide
TBtu	Trillion British thermal units
TMDL	Total mass daily load
UNC-CH	University of North Carolina at Chapel Hill
WRRI	Water Resources Research Institute
yr	year

Executive Summary

The North Carolina Clean Smokestacks Act (CSA) and existing rules require the Division of Air Quality (DAQ) to report on whether additional controls - beyond those required by the CSA and the U.S. Environmental Protection Agency (EPA) - are warranted to further reduce airborne mercury emissions from coal-fired electric generating units (EGUs). Four related DAQ reports in 2003, 2004, 2005 and 2008 on the benefits and costs to reduce mercury emissions provided data showing coal-fired EGUs were responsible for the majority of mercury emissions in North Carolina. This 2012 report provides updated on the same issues related to the control of mercury emissions from coal-fired EGUs and other principal sources of mercury. Information was collected on the most recent and projected future mercury emissions, existing and emerging control technology performance and costs, new EPA rules with mercury emission limits, dispersion and deposition modeling, mercury in fish trends and mercury-related health indicators of people consuming local fish. The key findings of this report consist of the following:

Mercury emissions and emission control:

- The 2010 point source inventory shows 1,850 pounds per year (lbs/yr) mercury emissions from largely the same facilities designated as the principal sources of mercury in the state as in the four earlier reports. There are 22 principal sources of mercury accounting for 98 percent of the state's emissions, including 14 coal-fired EGUs and eight other industrial facilities.
- Fifty-two percent of current North Carolina mercury emissions (~960 lbs/yr) are attributed to coal-fired EGUs. In response to the CSA, new emission controls for nitrogen oxides (NOx) and sulfur dioxide (SO_2) were installed during 2005-2010 on seven of the largest EGU facilities at a cost of $2.9 billion to enhance existing control performance for a collective 90+ percent mercury emission removal. The remaining seven smaller coal-fired EGU facilities lack effective mercury controls and accordingly have been, or will be retired by 2015.
- The remaining 48 percent of statewide emissions (~890 lbs/yr) come from two metal industry facilities, industrial boilers at paper mills, waste incinerators and many small sources.
- The 2012 EPA Mercury and Air Toxics Standards Rule for certain EGUs require mercury emission control of 90 percent, verified by continuous monitors. Assessment of the installed mercury control technologies on the largest North Carolina EGUs indicate 90+ percent capture of total mercury and 95 percent of the forms of mercury prone to deposit shortly after release into the air. Minor performance improvements with costs well below the $2.9 billion CSA costs are underway at the largest EGUs to assure compliance with new EPA emission limits.

Deposition, fish levels and health problems related to mercury:

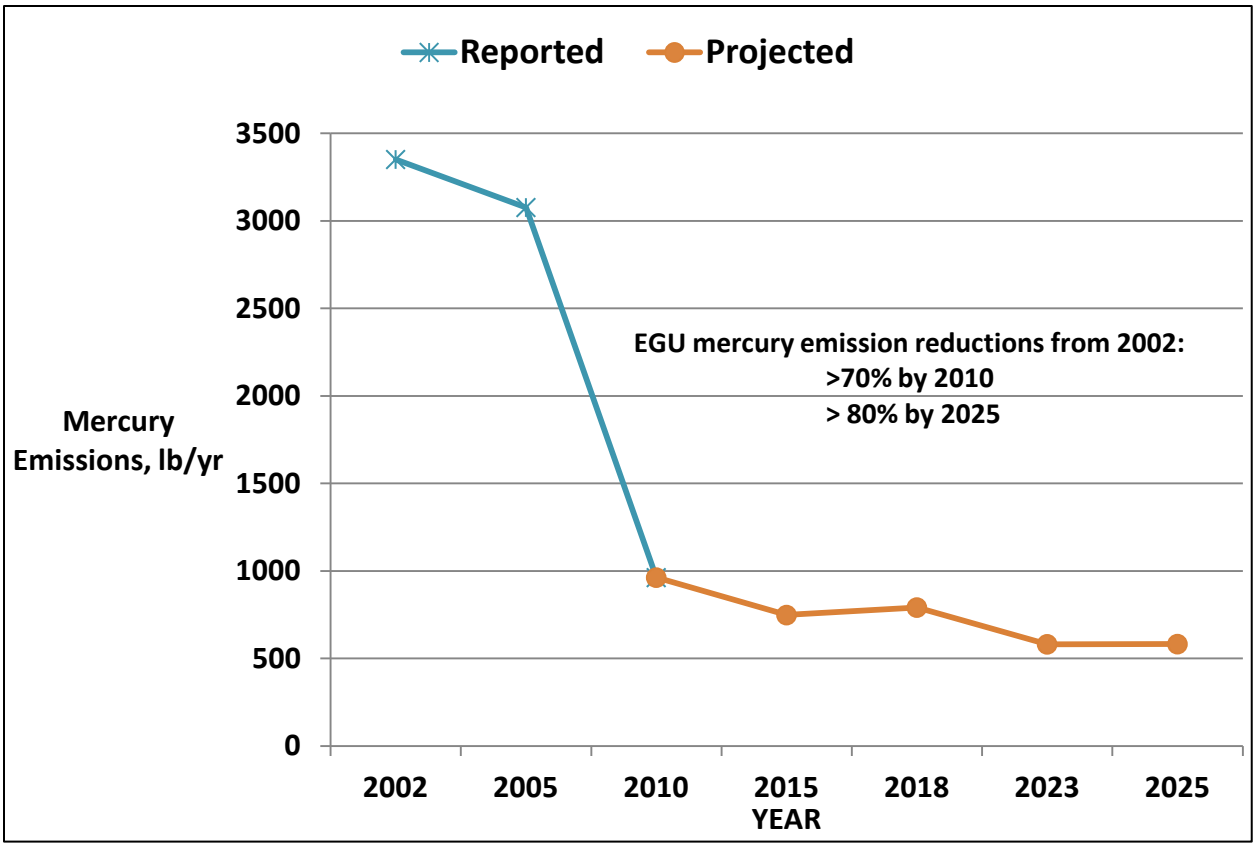
- Atmospheric deposition modeling indicates for the airborne mercury deposited in North Carolina in 2005, approximately 16 percent came from sources located in North Carolina while the majority came from distant sources outside of North Carolina. (Modeling with expected emission reductions also indicates mercury deposition in North Carolina will decline by 10 percent in 2016 compared to 2005.)

- Routine statewide monitoring of mercury in fish tissue for the state's most popular sport fish has resulted in a statewide fish advisory. Analysis results over recent years indicate no statistically significant trends in mercury-in-fish tissue levels at 13 sites near EGUs.
- In a pilot study assessing mercury-related health problems in eastern North Carolina, no correlation was found between blood mercury levels and the number of fish servings eaten.

Figure ES below shows the actual EGU mercury emissions in 2010 and projections to 2025, with reductions greater than 70 percent and 80 percent from 2002 levels, respectively. The figure reflects:

- most recent reductions were achieved during 2005-2010 from CSA-required new emission controls, and
- most future reductions will be achieved from retiring 26 smaller coal-fired EGUs and from burning less coal in the 20 largest EGUs.

Figure ES. North Carolina EGU Mercury Emission Trend from 2002-2025



In addition to this mercury report by DAQ, a statewide mercury total maximum daily load (TMDL) is being developed by the N.C. Division of Water Quality (DWQ). Through this process, DWQ will estimate the proportions of mercury contributions to water and fish from wastewater discharges, in-state and out-of-state air emission sources, and calculate appropriate reductions needed to achieve the TMDL. The TMDL will be submitted to EPA in 2012 and is subject to its approval.

Given the above findings, DAQ concludes that additional controls – beyond those required by the CSA and EPA – offer limited opportunities and benefits to further reduce mercury emissions from coal-fired EGUs. A future report similar in scope to this 2012 report is required in 2018 and 2023 under current rules [15A NCAC 02D .2509(e)] to evaluate whether the above state-of-the-science findings and trends continue and whether the EPA Mercury and Air Toxics Standards Rule for EGUs withstands the litigation challenging the rule.

Section 1. Actual emissions from units covered under this Section 15A NCAC 02D .2509 since 2010 and all other principal sources of mercury.

1.1 Definitions:

- "Actual" means presently existing in fact and not merely potential or possible.
- "Emissions" means the amount of airborne, total mercury released in one year.
- "From units covered under this section" means coal-fired utility electric generating units (EGUs).
- "All other principal sources of mercury" means industrial, commercial or institutional point sources with emissions greater than 1 percent of total mercury emissions in the most recent annual North Carolina mercury inventory.
- "Sources" means the individual units (such as boilers and incinerators) located at a facility or plant, with the sum of emissions from all sources at a plant representing the total facility-wide emission.

1.2 Actual Mercury Emission Estimates

Actual emission estimates were developed from emission factors and production levels consistent with annual actual emission inventories, reported by utilities and industries to DAQ and EPA. DAQ used 2010 emission inventory data, the latest year available for this report. Based on the estimated statewide mercury emission total of 1,850 pounds per year (lbs/yr) in 2010, principal sources of mercury were considered those with emissions greater than 18 pounds per year (>1 percent of the *estimated statewide mercury emission total* of 1,850 lbs/yr).

Table 1-1 presents the most recent stationary source air emissions inventory of mercury air annual emission rates for the top 22 principal sources (>18 lbs/yr). The top 22 sources are presented in rank order of their emissions. Analysis of the statewide inventory indicates that:

- 52 percent of the emissions (~960 lbs/yr) are attributed to coal-fired EGUs from the two primary utility companies: Duke Energy Carolinas LLC (Duke Energy) and Progress Energy Carolinas LLC (Progress Energy).
    - Currently, all Duke Energy and Progress Energy coal-fired EGUs emit mercury in the range of 18-140 lbs/yr; whereas as recently as 2006, the same units emitted mercury in the range of 100-700 lbs/yr.
    - Currently, 14 of the top 22 mercury emission facilities are coal-fired EGUs, whereas as recently as 2006, coal-fired boilers were 13 of the top 15 emission facilities. Flue gas desulfurization (FGD) scrubbers and selective catalytic reduction/non-selective catalytic reduction controls were installed in response to the CSA requirements for sulfur dioxide (SO_2) and nitrogen oxides (NOx) reduction, respectively, at seven of the largest EGU facilities (installed on the 20 largest EGU boilers by 2010) also significantly help to reduce mercury emissions.
- The remaining 48 percent of statewide mercury emissions is attributed to various steel mills, industrial coal-fired boilers at paper mills, publicly owned treatment works (POTW, sewage treatment), and numerous small sources. Currently, a manufacturing facility is the largest emitter of mercury emissions in the state. Statewide emissions from non-EGU facilities are distributed as follows:
    - 17 percent (~320 lbs/yr) from two metal industry facilities
    - 12 percent (~220 lbs/yr) from three paper industry facilities

    - 3 percent from one municipal sewage sludge incinerator facility
    - 1 percent from one fertilizer industry facility
    - 1 percent from one medical waste incinerator facility
    - 15 percent (280 lbs/yr) from the other ~600 statewide facilities reporting with all but two emitting less than 18 lbs/yr
- Emissions from the two steel mills in North Carolina were declining from implementation of the mercury switch removal program by the N.C. Division of Waste Management. Mercury emissions at Nucor were nearly 700 pounds in 2002. Nucor emitted less than 200 pounds in each year during the 2006-2009 period, however emissions rose to nearly 300 lbs in 2010.
- A few industrial coal-fired boilers have recently switched fuels from coal to natural gas, such as the Domtar Paper Mill in Plymouth and the DuPont Plant near Kinston.

Table 1-1. 2010 Actual Mercury Air Emission Inventory of North Carolina Sources
(Emissions rounded off with no decimal points, given uncertainties)

N.C. Mercury Emission Source Ranking		Total Mercury Emission, lbs/yr		Industry sector, major mercury emission source
		Utility	Non-Utility	
Rank	**Facility**			
1	Nucor Steel - Hertford		294	Steel, electric arc furnace
2	Progress - Roxboro	141		EGU, coal boilers
3	International Paper - Riegelwood		123	Paper, coal boilers
4	Progress - Sutton	116		EGU, coal boilers
5	Progress - Lee	112		EGU, coal boilers
6	Duke - Cliffside	91		EGU, coal boilers
7	Duke - Riverbend	88		EGU, coal boilers
8	Duke - Buck	81		EGU, coal boilers
9	Progress - Cape Fear	79		EGU, coal boilers
10	Progress - Mayo	69		EGU, coal boilers
11	Greensboro - Oborne		54	Government, sludge incinerator
12	Duke - Marshall	52		EGU, coal boilers
13	Blue Ridge Paper - Canton		46	Paper, coal boilers
14	Duke - Dan River	36		EGU, coal boilers
15	Progress - Weatherspoon	34		EGU, coal boilers
16	Kapstone Kraft Paper – Roanoke Rapids		29	Paper, coal boilers
17	Elementis Chromium		26	Chromium products, oil fired kiln
18	PCS Phosphate - Aurora		25	Fertilizer, coal calciners
19	Progress - Asheville	23		EGU, coal boilers
20	Duke - Belews Creek	20		EGU, coal boilers
21	Stericycle – Haw River		19	Waste, medical waste incinerator
22	Duke - Allen	18		EGU, coal boilers
Subtotals, Principal sources		962	615	
Total, Principal sources		1577		

1.3 Uncertainty in Mercury Air Emission Estimates

The mercury emissions for utility sources are estimated from site-specific emission test data, EPA emission factors[1] and Electric Power Research Institute (EPRI) correlation equations since no EGUs were using certified mercury continuous emission monitoring systems in 2010. All EGU EPRI equations are based on various factors such as control device configuration, along with the mercury, chlorine and sulfur content of coal.[2] Most mercury emissions for non-utility sources are estimated from EPA emission factors, with a few from site-specific stack test data. Some facilities such as Nucor Steel and Stericycle conduct annual stack testing, while other facilities rely on a one-time stack test potentially conducted several years ago. Uncertainty is involved with extrapolating a one-time stack test to estimate annual emissions. Even more uncertainty is involved with utilizing a published emission factor based on average test data of possibly non-similar sources. The fact that there are three published emission factors from which facilities can choose further exacerbates the uncertainty in the emission estimates. A few North Carolina sources may be over-estimating their emissions based on using an "uncontrolled" AP-42 emission factor, when there was no obvious alternative. A similar situation occurred for EGUs – where EGUs were over-estimating their mercury emissions – before more site-specific emission testing started to be performed in 1999. Future emission inventories should focus on obtaining more current site-specific test data where justified, and should focus on improved emission factors for some facilities that may be significantly over-estimating emissions.

Table 1-2 illustrates other key points in the uncertainty in the emission estimates. It presents the published mercury emission factors used for many of the industrial boilers in the 2010 North Carolina emission inventory. The table also contains values derived from the inventory for EGU emission factors and the level of mercury in coal (coal mercury). Both mercury emission factors and coal mercury values are presented in the same units of measure, pounds of mercury per trillion British thermal units (lbs mercury / TBtu coal). Review of Table 1-2 indicates that:

- For the first set of data on utility and industrial coal-fired boilers, there are three published emission factors, ranging from 4-16 lbs mercury / TBtu coal, that facilities can choose to use, independent of the type of emission control applied. Facility A could estimate lower emissions than Facility B, even though it burns twice as much coal and has a less effective type of emission control because it could select a smaller (four times smaller) emission factor than Facility B. Note that while these emission factors were developed from bituminous and sub-bituminous coals, only bituminous coal is burned in North Carolina. It is no longer the practice of North Carolina EGUs to use AP-42 emission factors because site-specific emission factors possess higher data quality than generic ones.
- For the second set of data on North Carolina EGUs, there are site-specific emission factors ranging from 0.15 - 6 lbs mercury / TBtu coal for the most effective mercury control configuration (electrostatic precipitator [ESP] cold-side with FGD and selective catalytic reduction [SCR]) and the least effective mercury control configuration (ESP hot side). This data was derived from site specific emission tests and EPRI correlation

[1] EPA, "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources" (AP-42).

[2] EPRI, "An Assessment of Mercury Emissions from U.S. Coal-Fired Power Plants," Palo Alto, CA: Report 1000608, 2000.

equation estimates. These emission factors were developed specifically from North Carolina EGUs burning bituminous coals for the respective type(s) of emission control device applied. By 2015, coal-fired EGUs will be required to operate and certify continuous emission monitoring systems (CEMS) for mercury. CEMS produce higher data quality than site-specific emission factors.

- For the third set of data on coal mercury, the EGU coal factors, ranging from 4-8 lbs mercury / TBtu coal, were derived from available bituminous coal use and coal content data in the 1999 EPA Information Collection Request (ICR) for coal-fired utilities and the 2010 North Carolina emission inventory. Bituminous coal data available from North Carolina EGUs in 2006 shows a range from 7-8 lbs mercury/TBtu. DAQ has not found any coal mercury data for N.C. industrial boilers. However, bituminous coal data available from the proposed Industrial Boiler Maximum Achievable Control Technology (MACT) Rule[3] in 2011 shows a range from 7-8 lbs mercury/TBtu,[4] comparable to North Carolina EGUs. Since N.C. industrial boilers burn bituminous coal comparable to other industrial boilers and North Carolina EGUs, this data suggests mercury-in-coal factor for industrial boilers would be 7-8 lbs mercury/TBtu coal.

[3] National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters, see http://www.epa.gov/airquality/combustion/actions.html.

[4] Eastern Regional Group, "Revised MACT Floor Analysis (Nov 2011) for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants – Major Sources, Appendix B, A-1(a)(vi)" to Brian Shrager, EPA, Nov 2011, accessed at http://www.regulations.gov in Docket No. EPA–HQ–OAR–2002–0058 in April 2012.

Table 1-2. Mercury Emission and Coal Mercury Factors

	Emission Factor lb mercury / TBtu coal	Emission Control	Coal Type
1. EGU and Industrial Coal-fired Boiler Emission Factors			
AP-42 Table 1.1-17	16	Uncontrolled	Bituminous, Sub-bituminous
AP-42 Table 1.1-18	4	ESP, FF, FGD	Bituminous, Sub-bituminous
Industrial Boiler MACT Rule	0.4 - 5	All types: ESP, FF, cyclone	Bituminous, Sub-bituminous
2. North Carolina EGU Emission Factors			
Duke & Progress Energy	5-6	ESP- HS	Bituminous
	4-5	ESP- CS	
	0.5-2	ESP- CS/ FGD	
	0.15-1	ESP- CS/ FGD/ SCR	
C. Mercury-in-Coal Factors			
1999 ICR, NC EGU	4 to 8	Uncontrolled	Bituminous
2006, NC EGUs	7 to 8		
2011 Industrial Boilers	7 to 8		

Notes: AP-42 at http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s01.pdf
NC EGUs Emission Factors derived from 2006 Emission Inventory (EI)
ESP = Electrostatic Precipitator, CS = Cold-side, HS = Hot side
FF = Fabric Filter
FGD = Flue Gas Desulfurization scrubber
SCR = Selective Catalytic Reduction
MACT = Maximum Available Control Technology
1999 ICR = EPA Information Collection Request for coal-fired utilities in 1999

1.4 2010 Actual Mercury Air Emissions Inventory – Other EGUs

Six additional coal burning co-generation boilers were not included in Table 1 because 2010 mercury emissions were 10 lbs or below. The co-generation boilers generally have low mercury emission rates and low annual mercury emissions due to low coal throughput and highly effective mercury emission controls (fabric filters with 99 percent capture efficiency).

1.5 Other Mercury Emissions (Non-Point Source)

The emissions data discussed thus far represents North Carolina's *stationary point source* contribution from permitted facilities (approximately 1,850 lbs of mercury in 2010, versus 4,150 lbs of mercury in 2006). Other types of sources emitting mercury in North Carolina include *non-point sources and mobile sources*. Based on the most recent data in the 2008 National Emissions Inventory, EPA estimates an additional 220 lbs of anthropogenic mercury emissions in North Carolina from on- and off-road mobile sources, industrial fuel use, crematoria, fluorescent lamp breakage, dental alloy production and residential fuel combustion.

Section 2. Estimates of the amounts of the different species of mercury being emitted.

2.1 Definitions

- The three "different species of mercury being emitted" means speciated mercury that includes: elemental mercury vapor, "oxidized" mercury (also known as reactive gaseous mercury) and particle-bound (PB) mercury.
- "Estimates" means calculations approximating the amount of mercury subdivided into the three different mercury species.

2.2 Speciated Mercury Emission Estimates

Numerous industry and government sponsored research studies on coal-fired EGUs have measured the three mercury species, and each have developed emission factor approaches to estimate speciated emissions based on several measurements. Speciated mercury estimates are also available for most non-EGU industry categories, but are based on a much smaller database of speciated mercury measurements, or are estimates based on engineering judgment of similar sources with similar factors affecting mercury speciation.

Mercury is more complex than other metals that are hazardous air pollutants (HAPs) that consist largely of one form. In contrast, mercury has three different forms or species of mercury emitted by coal-fired utility boilers and manufacturing facilities into the atmosphere. Each mercury species possesses its own set of unique properties that leads to distinctive behavior and reactivity characteristics. To understand how to control its emission in industrial process and how to predict its behavior in the atmosphere, one must account for each mercury species. Much of the technology to control mercury emissions was not able to be developed until after a method to reliably measure mercury species was first used in 1999.

Prior to 1999 no widely accepted reference method existed in the United States to speciate mercury emissions. EPA proposed a reference method to speciate mercury emissions as part of the 1999 Information Collection Requests for EGUs.[5] Since 1999, results from numerous studies on coal-fired EGU mercury control with the reference method were produced to develop emission estimates of the three species. The speciated mercury data were compiled into common groups by coal type and emission control configuration (*e.g.*, bituminous coal, ESP cold-side [ESP-CS] with FGD) by which to develop the average mercury speciation profiles for each EGU sub-group. Speciated mercury data presented in Table 3 for the EGUs were based on emission factor data processed by EPA.[6] Using the same ICR data, the electric utility industry developed correlation equations based on control device configuration and mercury, chlorine and sulfur contents in coal.[7] Spot checks made on N.C. facility speciated mercury data produced by EPA emission factors and industry correlation equations showed comparable results within the relative uncertainty of emission estimates.

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[5] American Society for Testing and Materials (ASTM) Method D6784-02 adopted in 2002.

[6] EPA, "Electric Generating Utility Mercury Speciation Profiles for the Clear Air Mercury Rule," EPA-454/R-11-010, November 2011.

[7] Electric Power Research Institute, "An Assessment of Mercury Emissions from U.S. Coal-Fired Power Plants," Palo Alto, CA: 2000. Report No. 1000608.

However, information is limited on speciated mercury emissions for the remaining non-EGU sources. The speciated mercury profiles for the non-EGU facilities in Table 4 were developed from data contained in another EPA report.[8]

Table 2-1 presents the estimated mercury species emitted in 2010 for the top 22 principal sources in North Carolina. Unlike Table 1, that presented the top 22 sources in rank order of their total mercury emissions, Table 2-1 presents the same 22 sources organized in groups of similarity in the speciated mercury profile and similarity in their emission control configuration. Such an arrangement facilitates discussing the 22 facilities in five common groups based on their speciated mercury profiles, rather than discussing each facility individually. The speciated data were estimated as follows:

- 14 EGU coal boilers. Speciated mercury emissions for the EGU facilities are estimated based on their 2010 total mercury inventory and the corresponding speciation profile percentages for their EGU sub-group available in Reference 3.
- 8 Other sources. Similarly, speciated mercury emissions for the non-EGUs are estimated based on the 2010 total mercury inventory and the corresponding speciation profile percentages for the following industries:
    - Two metal industry facilities
    - Three paper industry facilities
    - One municipal sewage sludge incinerator facility
    - One fertilizer industry facility
    - One medical waste incinerator facility

Review of Table 2-1 shows:

- Elemental mercury is the dominant mercury species (~80-90 percent) emitted from the first six EGU facilities listed, controlled with ESPs and FGD scrubbers on each boiler (Marshall, Asheville, Belews Creek, Allen, Roxboro and Mayo).
- Oxidized mercury is the dominant mercury species (~50-70 percent) emitted from the seven EGU facilities without an FGD on each boiler (Numbers 7-14: Cliffside, Sutton, Lee, Dan River, Cape Fear, Weatherspoon, Riverbend and Buck).
- For the hybrid facility (Cliffside), with most of its capacity controlled by an ESP and FGD and the remaining capacity controlled by an ESP, elemental and oxidized mercury emissions are estimated to be equivalent; note Cliffside has 4 smaller boilers without a FGD and one large boiler with a FGD).
- Similar to the EGUs without FGDs, the coal-fired industrial boilers and the kilns at the three paper mills, fertilizer plant and chromium facility (Numbers 15-19), are projected to emit more oxidized mercury (52 percent) than elemental mercury (48 percent).
- Elemental mercury is the dominant mercury species (~60-80 percent) projected to be emitted from the last three facilities listed (Numbers 20-22; medical waste incinerator, steel mill and the publicly owned treatment works).

[8] EPA, "Emission Inventory and Emission Processing for the Clean Air Mercury Rule," March 2005.

Table 2-1. Speciated Mercury Emission Estimates of North Carolina Principal Sources for 2010 Based on EPA Speciation Factors
(Emissions rounded off with no decimal points, given uncertainties)

N.C. Mercury Emission Facility Ranking	Speciated Mercury Emissions						Industry category, major mercury emission source
	Elemental	PB	Oxidized	Elemental	PB	Oxidized	
	percent			lbs/yr			
Facility							
1. Duke - Marshall	92%	0.2%	8%	48	0	4	EGU, coal boilers
2. Progress - Asheville	92%	0.2%	8%	21	0	2	EGU, coal boilers
3. Duke - Belews Creek	92%	0.2%	8%	18	0	2	EGU, coal boilers
4. Duke - Allen	92%	0.2%	8%	17	0	1	EGU, coal boilers
5. Progress - Roxboro	89%	0%	11%	125	0	16	EGU, coal boilers
6. Progress - Mayo	79%	1%	21%	54	0	14	EGU, coal boilers
7. Duke - Cliffside	48%	4%	48%	44	4	44	EGU, coal boilers
8. Progress - Sutton	33%	5%	61%	39	6	71	EGU, coal boilers
9. Progress - Lee	30%	6%	65%	33	6	73	EGU, coal boilers
10. Duke - Dan River	26%	6%	68%	9	2	25	EGU, coal boilers
11. Progress - Cape Fear	26%	6%	68%	20	5	54	EGU, coal boilers
12. Progress - Weatherspoon	26%	6%	68%	9	2	24	EGU, coal boilers
13. Duke - Riverbend	37%	5%	58%	33	4	51	EGU, coal boilers
14. Duke – Buck	37%	5%	58%	30	4	47	EGU, coal boilers
15. Internat'l Paper - Riegelwood	47%	1%	52%	58	1	64	Paper, coal boilers
16. Blue Ridge Paper	47%	1%	52%	22	0	24	Paper, coal boilers
17. Kapstone Kraft Paper	47%	1%	52%	14	0	15	Paper, coal boilers
18. PCS Phosphate	47%	1%	52%	12	0	13	Fertilizer, coal calciners
19. Elementis Chromium	47%	1%	52%	12	0	13	Chromium products, kiln
20. Stericycle	60%	10%	30%	11	2	6	Medical waste incinerator
21. Nucor Steel	81%	15%	4%	238	44	12	Steel, electric arc furnace
22. Greensboro - Oborne	80%	10%	10%	43	5	5	POTW
Total of Top 22 facilities				910	89	579	Total mercury = 1,577 lbs

PB = Particle-bound mercury; Duke = Duke Energy; Progress = Progress Energy

Table 2-2 summarizes the speciated mercury emission estimates of North Carolina's principal sources based on the 2010 emission inventory. Review of the summary table shows:

- Most EGU mercury emissions are estimated to be elemental (52 percent) with nearly as much oxidized mercury (44 percent), followed by 4 percent particle-bound mercury. In comparison to 2006, the 2010 inventory reflects a significant shift in the speciated

mercury emission profile as there is increasing proportion in elemental mercury and decreasing proportion of oxidized mercury. This shift is largely due to the recent installation of FGD scrubbers – which capture most of the oxidized mercury (on nearly 80 percent of the NC coal-fired EGU capacity).

- Non-EGU emissions, on average, are distributed with much more elemental mercury (67 percent) than oxidized mercury (25 percent), with 9 percent being particle-bound mercury.
- Like the EGU trend, the statewide trend in the speciated mercury emission profile is an increasing amount in elemental mercury with a decreasing level of oxidized mercury.

Table 2-2. Summary of Speciated Mercury Emission Estimates of N.C. Principal Sources for 2010

(Emissions rounded off with no decimal points, given uncertainties)

North Carolina Speciated Mercury Emissions	Elemental Mercury	Particle-bound Mercury	Oxidized Mercury	Elemental Mercury	Particle-bound Mercury	Oxidized Mercury	Averages
	Lbs/Yr			Percent of Total Mercury			
EGU Subtotal	501	35	426	52%	4%	44%	EGU Average
Non EGU Subtotal	409	54	152	67%	9%	25%	Non-EGU Avg
Total	910	89	578	58%	6%	37%	Average of Total
EGU Total Mercury - Total Emissions	962						
Non EGU Total Mercury - Total Emissions	615						

Section 3. Create a mercury balance for North Carolina, including imported, exported and in-state mercury emissions and the fate and transport of mercury in its air and waters.

Recent estimates of annual global mercury emissions from both natural and anthropogenic sources are in the range of 10 million to 16 million lbs/yr.[9] Some of the mercury released from sources deposit nearby while the remainder can travel thousands of miles in the atmosphere before it is eventually deposited back to the earth in rainfall (wet deposition) or in dry gaseous form (dry deposition). The suspended mercury traveling such great distances is referred to as the global pool of mercury. The Electric Power Research Institute calculated that up to 10 percent of mercury released is deposited within about 60 miles of a power plant, 50 percent is deposited within about 600 miles, and the rest is transported globally.[10] The amount deposited depends on the form and rates of mercury species released along with the height and exit velocity of the release point. Mercury dispersion modeling by the EPA for all sources of mercury shows similar distribution patterns.

Mercury exists in the atmosphere in three forms or species: (1) elemental gaseous mercury, which is relatively non-reactive; (2) gaseous oxidized mercury, which is highly reactive; and (3) particle-bound mercury, which is attached to particles. Given that it is gaseous and non-reactive, elemental mercury has a long atmospheric residence time on the order of a year and is capable of being transported over very long distances, forming most of the global background of mercury.[11] Due to their shorter atmospheric lifetime on the order of days to weeks, oxidized mercury and particle-bound mercury are transported over relatively short distances and can deposit via wet (rain) or dry processes within roughly 60 to 600 miles of their source.

Given the above information, EPA and DAQ conducted modeling to estimate the amount of atmospheric mercury deposition across the country and the state, respectively. EPA modeling results for the Mercury and Air Toxics Standards (MATS) rule suggests how much mercury deposition in North Carolina would occur and how much would decrease between 2005 and 2016. The DAQ sensitivity modeling indicates how much of the mercury deposition in North Carolina comes from air emission sources located in North Carolina in 2005 and how much of that is expected to drop by 2016. The following discussion describes the methodology and results of the EPA and DAQ deposition modeling.

3.1 EPA Mercury Modeling

Methodology

In support of the MATS rule, the EPA modeled total annual mercury deposition from U.S. and foreign anthropogenic and natural sources using the Community Multi-scale Air Quality (CMAQ) model. The CMAQ model (www.cmaq-model.org) is a state of the science three-dimensional Eulerian "one-atmosphere" photochemical transport model used to estimate air

[9] United Nations Environment Programme Global Atmospheric Mercury Assessment: Sources, Emissions and Transport, accessed http://www.epa.gov/international/toxics/mercury/mercury_context.html#worldwide May 2012.
[10] U.S. EPA (1997). Mercury Study Report to Congress, Vol. 3. Section 5.
[11] Northeast States for Coordinated Air Use Management (NESCAUM), "Sources of Mercury Deposition in the Northeast United States, March 1, 2008, p.3.

quality conditions.[12,13 ,14] The CMAQ model simulates the formation and fate of photochemical oxidants, ozone, primary and secondary particulate matter concentrations, and air toxics over regional and urban spatial scales for given input sets of meteorological conditions and emissions. Mercury estimates from CMAQ have been compared to observations and other mercury modeling systems in several peer reviewed publications.[15,16,17] Additional information about the model, model inputs for this assessment and model evaluation are available in the EPA Air Quality Modeling Technical Support Document[18].

The EPA conducted the modeling on a national domain that was modeled at 36 kilometer (km) grid resolution (i.e., 36 km by 36 km square grids) and an eastern U.S. domain at a 12 km grid resolution (See Fig 3-1). The eastern U.S. domain covers a smaller area. However, the smaller grid size provides higher quality results due to enhanced grid resolution.
The EPA modeled three scenarios: 1) a base year using 2005 emissions data, 2) a future year using projected 2016 emissions data and 3) the projected 2016 emissions with the emissions from the U.S. EGUs removed. The 2016 scenario is intended to represent the emissions associated with growth and controls in that year projected from the 2005 simulation year. The controls assumed full implementation of the Cross State Air Pollution Rule (CSAPR) and the MATS rule. Only the U.S. anthropogenic emissions changed between the 2005 and 2016 simulations; all other model inputs remained the same. The other model inputs that remained unchanged included the meteorology, the biogenic emissions, the Canadian emissions (based on 2006 data), the Mexican emissions (based on 1999 data) and the boundary conditions for the 36 km grid national domain.

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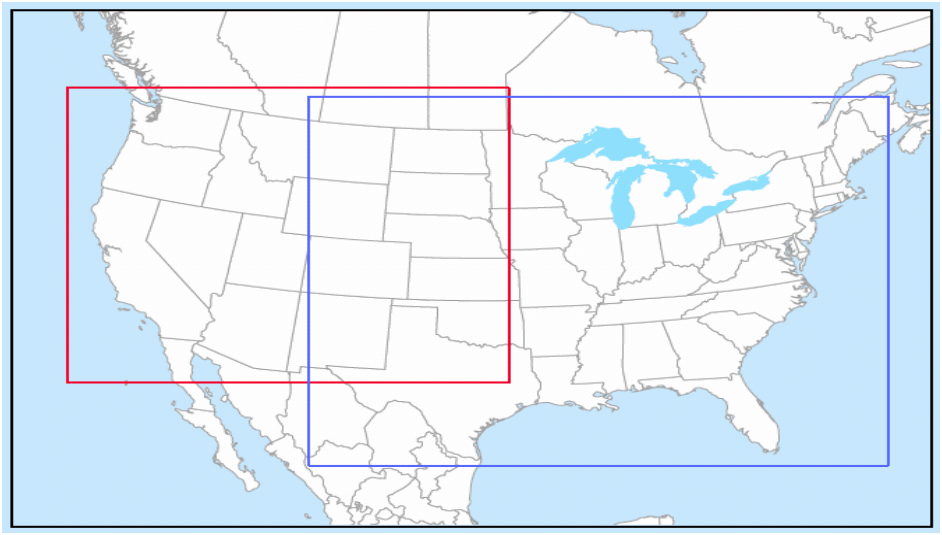
[12] Appel, K. W., A. B. Gilliland, et al. (2007). "Evaluation of the Community Multiscale Air Quality (CMAQ) model version 4.5: Sensitivities impacting model performance Part I - Ozone." Atmospheric Environment 41(40): 9603-9615.
[13] Appel, K. W., P. V. Bhave, et al. (2008). "Evaluation of the Community Multiscale Air Quality (CMAQ) model version 4.5: Sensitivities impacting model performance; Part II - particulate matter." Atmospheric Environment 42(24): 6057-6066.
[14] Byun, D., Schere, K.L. (2006). Review of the governing equations, computational algorithms, and other components of the models-3 Community Multiscale Air Quality (CMAQ) modeling system. Applied Mechanics Reviews 59, 51-77.
[15] Bullock, O.R., Atkinson, D., Braverman, T., Civerolo, K., Dastoor, A., Davignon, D., Ku, J.Y., Lohman, K., Myers, T.C., Park, R.J., Seigneur, C., Selin, N.E., Sistla, G., Vijayaraghavan, K., (2008). The North American Mercury Model Intercomparison Study (NAMMIS): Study description and model-to-model comparisons. Journal of Geophysical Research-Atmospheres 113.
[16] Bullock, O.R., Atkinson, D., Braverman, T., Civerolo, K., Dastoor, A., Davignon, D., Ku, J.Y., Lohman, K., Myers, T.C., Park, R.J., Seigneur, C., Selin, N.E., Sistla, G., Vijayaraghavan, K. (2009). An analysis of simulated wet deposition of mercury from the North American Mercury Model Intercomparison Study. Journal of Geophysical Research-Atmospheres 114.
[17] Lin, C.J., Pongprueks, P., Rusell Bulock, O., Lindberg, S.E., Pehkonen, S.O., Jang, C., Braverman, T., Ho, T.C., (2007). Scientific uncertainties in atmospheric mercury models II: Sensitivity analysis in the CONUS domain. Atmospheric Environment 41, 6544-6560.
[18] U.S. EPA. (2011b). Air Quality Modeling Technical Support Document: EGU Mercury Analysis. EPA-454/R-11-008.

Figure 3-1: Map of the CMAQ photochemical modeling domains.



The black outer box denotes the national modeling domain with a 36 km grid resolution; the red inner box is the western U.S. domain with a 12 km grid resolution; and the blue inner box is the eastern U.S. domain with a 12 km grid resolution.

The boundary conditions represent the global emissions, for both criteria and toxic pollutants that would be transported into the United States. The EPA used the GEOS-CHEM (Goddard Earth Observing System – Chemistry) model, a three-dimensional global atmospheric chemistry model, to simulate these global emissions using a 2000 based global emissions inventory. Although the global data are based on 2000 emissions, a recently published comparison of global mercury emissions by continent for 2000 and 2006 showed no discernible change in mercury emissions from Asia between 2000 and 2006.[19] The EPA chose not to adjust the global emissions for the 2016 scenarios since the Asian mercury emissions were consistent between 2000 and 2006, the declining ambient mercury concentrations in the northern hemisphere since 2000[20], and the large uncertainties surrounding projected global inventories of mercury emissions.

<u>EPA Modeling Observations</u>

Within the revised Mercury Technical Support Document[21], the EPA made the following observations regarding estimates of total mercury deposition and mercury deposition attributed to U.S. EGUs for the 2005 and 2016 scenarios:

- *Patterns of total and U.S. EGU-related mercury deposition differ considerably*: Areas of elevated total mercury deposition are distributed around the country. By contrast,

[19] Streets, D.G., Zhang, Q., Wu, Y. (2009). Projections of Global Mercury Emissions in 2050. Environmental Science & Technology 43, 2983-2988.

[20] Slemr, F., Brunke, E.G., Ebinghaus, R., Kuss, J. (2011). Worldwide trend of atmospheric mercury since 1995. Atmospheric Chemistry and Physics 11, 4779-4787.

[21] U.S. EPA. (2011c). Revised Technical Support Document: National-Scale Assessment of Mercury Risk to Populations with High Consumption of Self-caught Freshwater Fish. In Support of the Appropriate and Necessary Finding for Coal- and Oil-Fired Electric Generating Units. EPA-452/R-11 009.

U.S. EGU mercury deposition is concentrated in the eastern United States, especially in the Ohio River Valley, where there is a large number of coal-fired EGUs. While some near-coastal areas and portions of the Great Lakes have elevated EGU attributable deposition, many of the highest areas (and largest expanses) of EGU attributable deposition occur inland (e.g., Ohio River Valley, areas in northeast Texas and along the Mississippi River).

- *U.S. mercury deposition is generally dominated by sources other than U.S. EGUs and the contribution from U.S. EGUs decreases between the 2005 and 2016 scenarios:* On average, U.S. EGUs contribute 5 percent of total mercury deposition for the 2005 scenario, which decreases to 2 percent for the 2016 scenario. The remaining mercury deposition (i.e., ~95 percent and ~98 percent, respectively for the two scenarios) originates from other U.S. sources of mercury emissions and from international sources (both anthropogenic and natural). U.S. EGU-attributable deposition decreases considerably between the 2005 and 2016 scenarios, primarily from implementation of the CSAPR, state mercury regulations and federal enforcement actions.[22]
- *The contribution of U.S. EGU-attributable deposition to total deposition varies across watersheds and can represent a relatively large fraction in some instances:* In the 2005 scenario, while on average, U.S. EGUs only contributed 5 percent of total mercury deposition in the U.S., this contribution ranged up to 30 percent for the 99th percentile watershed. While overall U.S. EGU-attributable deposition decreased substantially between the 2005 scenario and the 2016 scenario, U.S. EGUs contributed 11 percent of total mercury deposition for the 99th percentile watershed in 2016. For more information on this discussion, refer to the Revised Technical Support Document: National-Scale Assessment of Mercury Risk to Populations with High Consumption of Self-caught Freshwater Fish.

Mercury Modeling Results for North Carolina

The mercury deposition results in North Carolina for the EPA modeling scenarios are displayed in Table 3-1. The modeling results indicate that the mercury deposition over North Carolina is 10 percent lower – 990 990 pounds – in 2016 compared to 2005. Removing all of the U.S. EGU mercury emissions in 2016 only reduces the 2016 total deposition by 230 pounds or 2.5 percent.

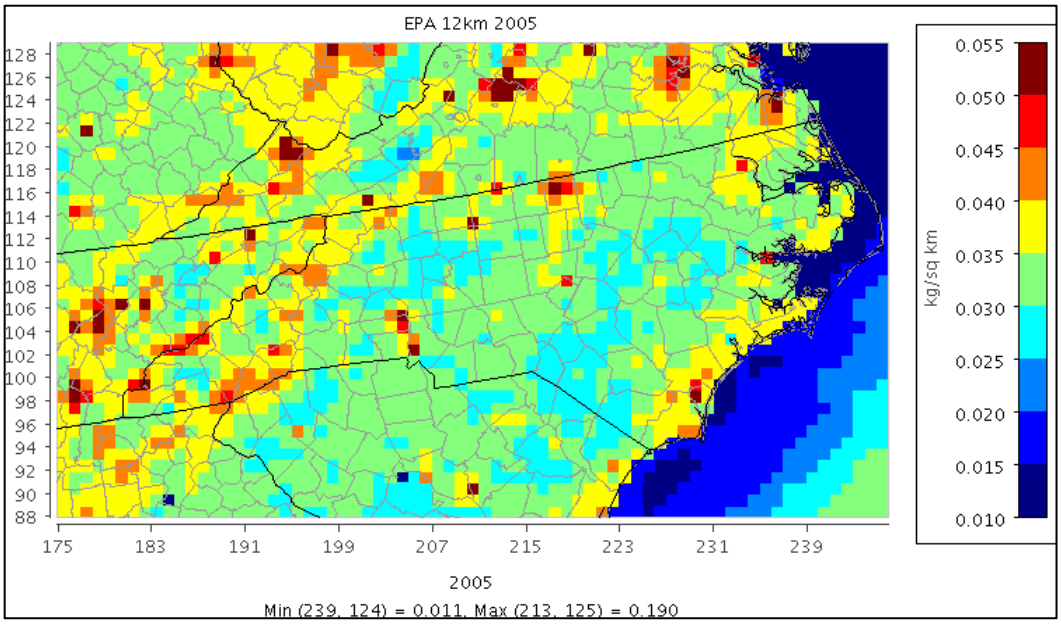
Table 3-1. Total mercury deposition over North Carolina from the EPA Modeling
(Numbers rounded, given the modeling uncertainties)

Scenarios	Total Mercury Deposition over N.C. in Kg	Total Mercury Deposition over N.C. in lbs
2005	4,500	9,930
2016	4,050	8,930
2016 with no EGUs	3,950	8,700

[22] Controls on PM precursors, including directly emitted PM and SO_2, can significantly reduce divalent and particle bound mercury, both of which primarily deposit locally and regionally. For more information on the emission reductions from CSAPR, see the final Regulatory Impact Analysis, which is available at http://www.epa.gov/airtransport/pdfs/FinalRIA.pdf.

As can be seen in Figure 3-2, the 2005 modeled distribution of mercury deposition varies across the state. The model suggests higher amounts of deposition, above 0.04 kilograms (kg)/km^2, are generally found in the mountains, where greater wet deposition of mercury occurs due to local precipitation maximums in an area downwind of mercury emission sources. Across the Piedmont, the model suggests localized maximums are found downwind of the larger mercury emission sources. In the immediate coastal region, relatively greater wet deposition values are predicted due to a combination of local precipitation maxima (sea breeze effect) in an area downwind of mercury emission sources.

Figure 3-2 Total mercury deposition (kg/ km^2) results from EPA's 2005 base scenario.



The mercury deposition in the EPA's 2016 projected scenario was significantly less than in the EPA's 2005 base scenario (see Figure 3-3). In general, the overall pattern of deposition is similar to the 2005 scenario, with higher deposition in the mountains and the coast, but the magnitude of the deposition is less. Expected controls on the coal-fired EGUs throughout the region result in much less mercury deposition by 2016.

Figure 3-3 Total mercury deposition (kg/ km^2) results from EPA's 2016 scenario.

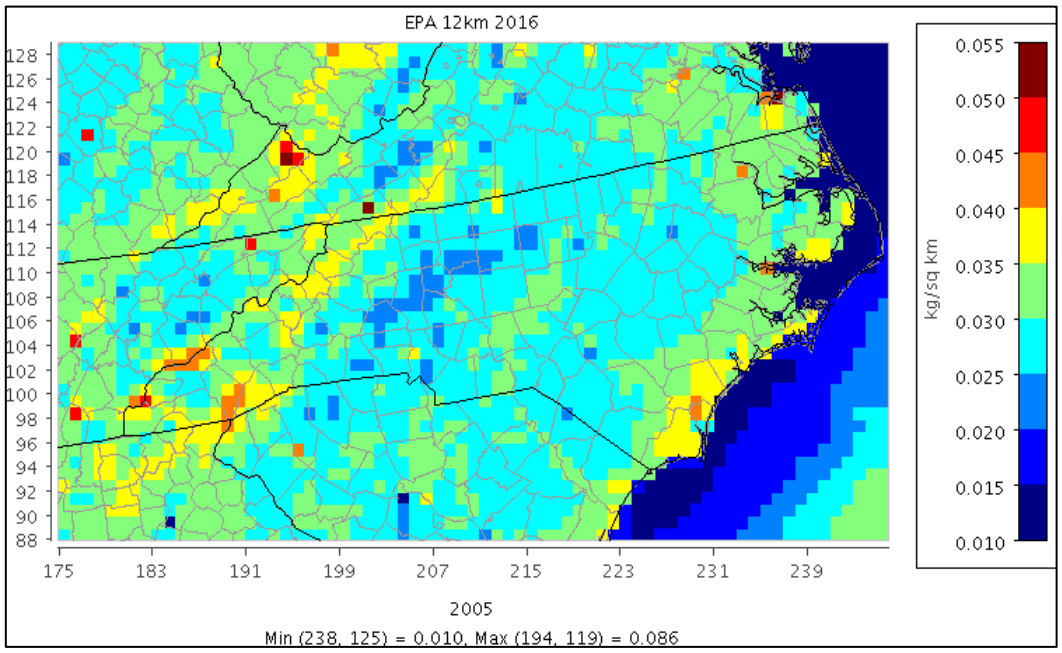
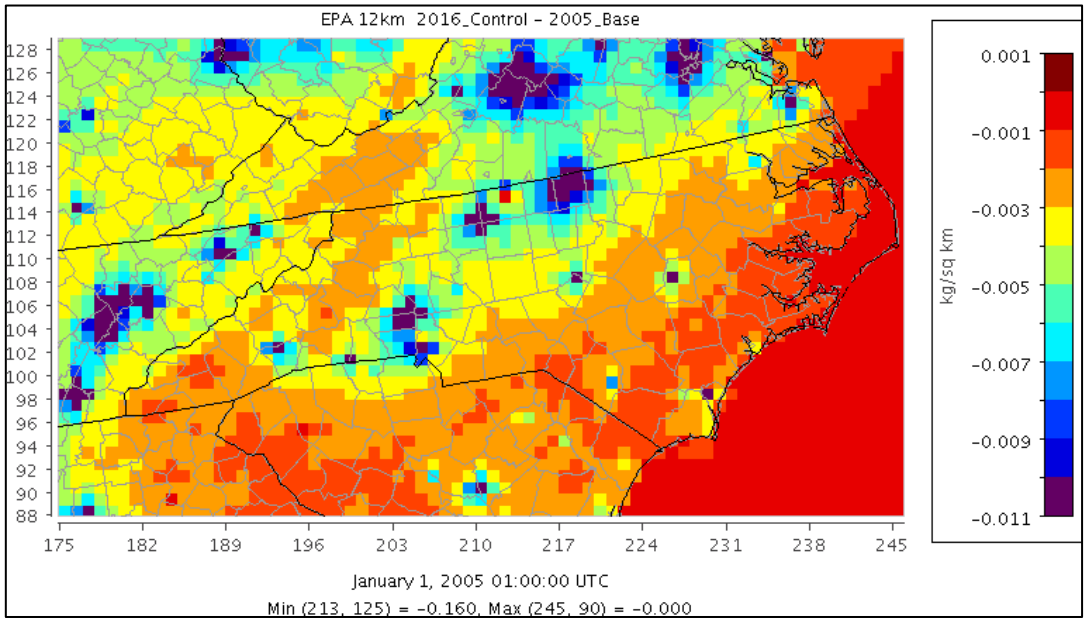


Figure 3-4 displays the difference between the 2016 and 2005 modeling scenarios. As can be seen in this figure, the greatest reductions in mercury deposition are in the Piedmont. Local maximums in deposition reduction are located near coal-fired EGU sources.

Figure 3-4. Difference in total mercury deposition (kg/km^2) from EPA's 2016 and 2005. modeling runs.



3.2 Sensitivity Runs

The DAQ conducted a series of sensitivity modeling runs to generate estimates of deposition for various mercury emission scenarios. The goals of the sensitivity runs were to estimate the amount/percentage of mercury deposition in North Carolina from in-state emission sources and the percentage of mercury deposition that is from international sources.

Methodology

A special version of the CMAQ model was obtained from EPA that included mercury chemistry, but did not require other toxics emissions. The CMAQ model inputs files were provided by EPA and included the meteorology, emissions and boundary conditions. The EPA CMAQ modeling ran the 36 km grid national domain with GEOS-CHEM boundary conditions and then modeled the 12km grid eastern US domain with boundary conditions from the national domain modeling. The EPA performed a model performance evaluation on the meteorology and air quality runs, and found the performance to be adequate.[23] Since DAQ used the same version of the CMAQ model with identical inputs for the base run, the DAQ relied upon the EPA's model performance evaluations and did not conduct a separate model performance evaluation for these sensitivity modeling runs.

DAQ conducted all model runs using the 12 km grid eastern United States modeling domain. The first set of modeling sensitivities used the EPA's 2005 base year emissions, boundary conditions from the EPA's 36 km grid national domain 2005 modeling run, and meteorology files obtained from EPA. DAQ first ran a base case CMAQ modeling run with full emissions and boundary conditions for 2005 called "Base2005_NC." Next a zero-out sensitivity was run to quantify the amount of atmospheric deposition in North Carolina due to air emission sources in North Carolina. The zero-out sensitivity run was called "Zero_NC2005" and set all mercury emissions in North Carolina to zero. The next sensitivity, called "No_BC2005," was to remove all of the mercury emissions from the boundary conditions to understand the impact of the emissions outside of the eastern United States modeling domain, which would be similar to the international impact.

The second set of modeling sensitivities used the EPA's 2016 projected year emissions, boundary conditions from the EPA's 36 km grid national domain 2016 modeling run, and meteorology files obtained from EPA. The DAQ ran the 2016 projected year with full emissions and boundary conditions that was called "Base2016_NC." Next, a series of zero-out sensitivity runs were performed. The first two sensitivities were similar to the 2005 zero-out sensitivities where the 2016 mercury emissions for North Carolina were set to zero (Zero_NC2016) and the mercury emissions in the boundary conditions were set to zero (No_BC2016). Two additional sensitivities were run where 1) all of the North Carolina's 2016 point source mercury emissions, including the EGUs, were removed leaving only the low-level mercury emissions (NoPt_NC2016) and 2) all of the 2016 EGU mercury emissions in North Carolina were set to zero (NoEGU_NC2016).

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[23] U.S. EPA. (2011b). Air Quality Modeling Technical Support Document: EGU Mercury Analysis. EPA-454/R-11-008. http://www.epa.gov/ttn/atw/utility/epa-454_r-11-008.pdf

Table 3-2 summarizes the sensitivity modeling runs and the data used in each run.

Table 3-2. DAQ Sensitivity model runs

Sensitivity Name	Emissions Year	Emissions	Boundary Conditions
Base2005_NC	2005	12km EPA Emissions	2005 36 Km EPA run
Zero_NC2005	2005	Zero out NC emissions	2005 36 Km EPA run
No_BC2005	2005	12km EPA Emissions	2005 36 Km EPA run with no mercury emissions
Base2016_NC	2016	12km EPA Emissions	2005 36 Km EPA run
Zero_NC2016	2016	Zero out NC emissions	2005 36 Km EPA run
NoEGU_NC2016	2016	Zero out NC EGU emissions	2005 36 Km EPA run
NoPt_NC2016	2016	Zero out all NC Point emissions	2005 36 Km EPA run
No_BC2016	2016	12km EPA Emissions	2005 36 Km EPA run with no mercury emissions

North Carolina Zero-Out Sensitivity Analysis to Determine Contribution from N.C. Sources

It should be noted that the estimated amount of mercury deposition in North Carolina for the base 2005 modeling that DAQ performed differs from the results from the EPA MATS 2005 base. It is believed that the difference is due to a difference in base 2005 emissions provided by EPA when the initial DAQ modeling study was started. This initial study occurred prior to availability of the MATS modeling data. The DAQ's 2016 modeling and the EPA's 2016 modeling yielded very similar numbers, which further supports that the 2005 modeling differences are due to differences in 2005 emission files provided by the EPA. Due to the uncertainty in the emission estimates, the exact amount of mercury deposition cannot be determined, and for this reason the DAQ has greater confidence in the percent contribution values.

The sensitivity modeling results that zero out North Carolina mercury emissions (Zero_NC2005 and Zero_NC2016) are shown in Table 3-3 and Table 3-4, respectively. For the 2005 runs, approximately 16 percent of the atmospheric deposition of mercury in North Carolina can be attributed to sources located in North Carolina. The amount of atmospheric deposition of mercury in North Carolina from North Carolina sources falls to 3 percent in 2016 based upon EPA's estimated emissions for 2016. Looking at the results from the sensitivities where all North Carolina point source mercury emissions or only the North Carolina EGU mercury emissions were removed, it can be estimated that of the 3 percent deposition attributed to North Carolina's air emission sources in 2016, approximately 2 percent comes from all North Carolina point sources (with North Carolina EGUs accounting for less than 1 percent of the total contribution). Natural and anthropogenic area source emissions within North Carolina make up the remaining deposition attributed North Carolina's air emission sources.

Table 3-3. Mercury Deposition Totals over North Carolina for 2005 North Carolina Zero-Out Sensitivity.
*Amount in parenthesis represents total deposition for wet and dry deposition***.**
(Numbers rounded, given the modeling uncertainties)

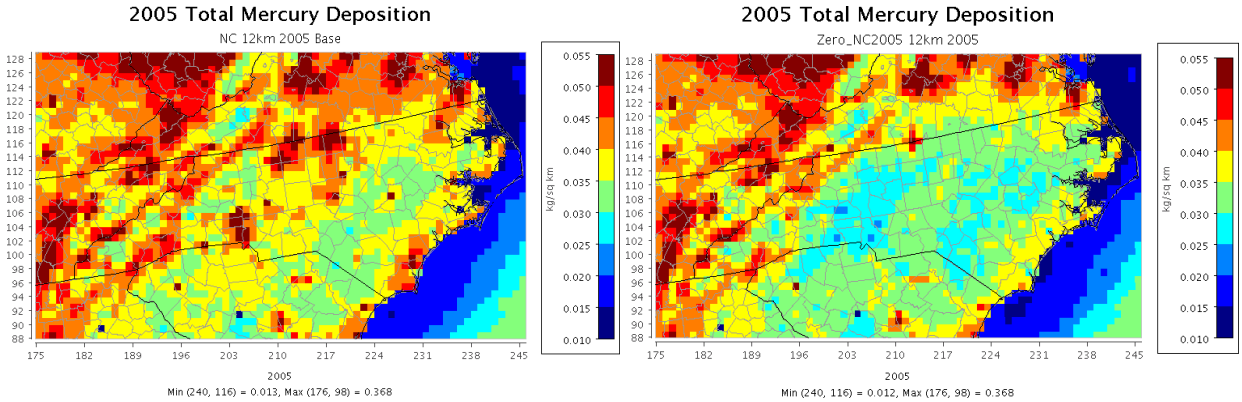
Sensitivity Run Name	Dry Deposition (lbs)	Wet Deposition (lbs)	Total Deposition (lbs)	Difference (aka NC contribution)	Percent Contribution
Base2005_NC	8,050 (70%)	3,500 (30%)	11,550	-	-
Zero_NC2005	6,730 (69%)	2,990 (31%)	9,730	1,830	16%

Table 3-4. Mercury Deposition Totals over North Carolina for 2016 North Carolina Zero-Out Sensitivities.
Amount in parenthesis represents total deposition for wet and dry deposition.
(Numbers rounded, given the modeling uncertainties)

Sensitivity Run Name	Dry Deposition (lbs)	Wet Deposition (lbs)	Total Deposition (lbs)	Difference (aka contribution)	Percent Contribution
Base2016_NC	6,060 (68%)	2,850 (32%)	8,910	-	-
Zero_NC2016	5,820 (68%)	2,780 (32%)	8,600	310	3%
NoPt_NC2016	5,910 (68%)	2,790 (32%)	8,700	210	2%
NoEGU_NC2016	6,010 (68%)	2,830 (32%)	8,840	70	1%

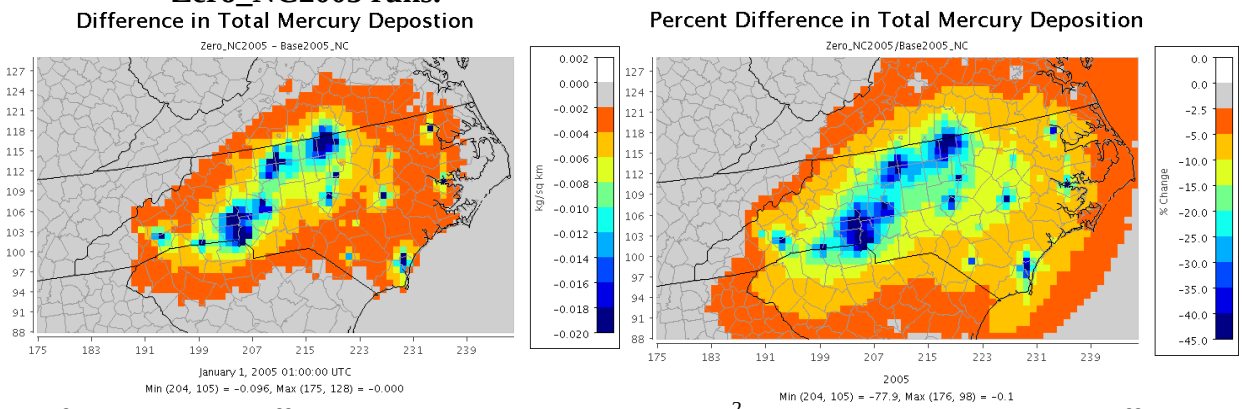
Figure 3-5 displays the estimated amount of total mercury deposition in North Carolina in 2005 as well as the estimated mercury deposition in North Carolina after removing all mercury emissions in North Carolina. The base 2005 run shows the largest amount of mercury deposition in North Carolina occurring primarily in the vicinity of the largest mercury emission sources or in areas where greater wet deposition of mercury occurs due to local precipitation maxima in an area downwind of mercury emission sources. The Zero_NC2005 modeling results illustrate that an overall mercury deposition rate between 0.025 and 0.035 kg/km^2 remains across the majority of the state, despite the North Carolina mercury emissions being set to zero. The difference between the base 2005 run and the zero out of mercury emissions in North Carolina can be seen in Figure 3-6. Additionally, Figure 3-6 displays the percent change in mercury deposition between these two runs. As expected, the greatest differences can be seen in the vicinity of the largest mercury emission sources.

Figure 3-5: North Carolina total mercury deposition.



Base2005_NC on left and Zero_NC2005 on Right.

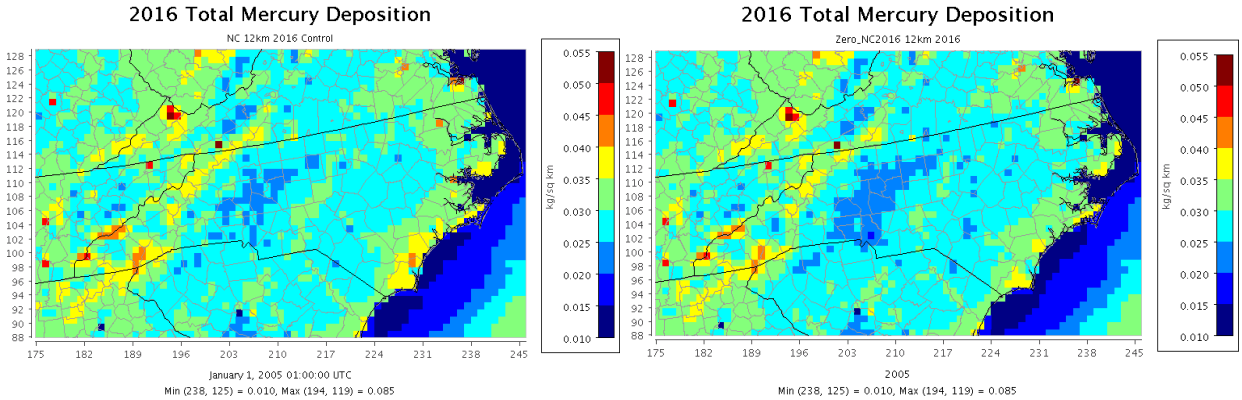
Figure 3-6: Difference in total mercury deposition between the Base2005_NC and Zero_NC2005 runs.



Left image is the difference in total deposition in kg/km^2, right image is the percent difference.

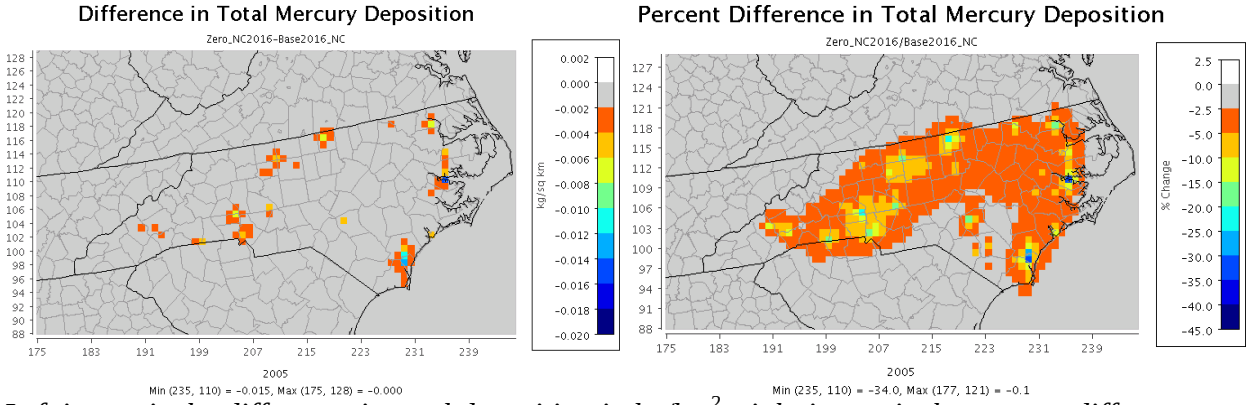
Figure 3-7 displays the estimated amount of total mercury deposition in North Carolina in 2016 as well as the estimated mercury deposition in North Carolina after removing all mercury emissions in North Carolina. The base 2016 run shows substantial reductions in mercury deposition across the state compared to the 2005 base run. The relative maxima seen in the 2005 base modeling run associated with the largest mercury emission sources in the Piedmont of North Carolina is greatly reduced. The Zero_NC2016 modeling results display an overall deposition rate around 0.020 to 0.030 kg/km^2 across the majority of the state with similar patterns of deposition as seen in the Zero_NC2005 run. The difference between the base 2016 run and the zero out run of mercury emissions in North Carolina can be seen in Figure 3-7. Additionally, Figure 3-8 displays the percent change in mercury deposition between these two runs. As can be seen in these images, the differences are much less in 2016 compared to 2005 due to emissions control assumptions in the 2016 base model run.

Figure 3-7: North Carolina total mercury deposition.



Base2016_NC on left and Zero_NC2016 on Right.

Figure 3-8: Difference in total mercury deposition between the Base2016_NC and Zero_NC2016 runs.



Left image is the difference in total deposition in kg/km^2, right image is the percent difference.

<u>Boundary Condition Sensitivity Analysis to Determine Contribution from Sources Outside the Central and Eastern U.S.</u>

Model runs were made with no mercury entering the 12km grid eastern US domain for 2005 (No_BC2005) and 2016 (No_BC2016). Table 3-5 and 3-6 display modeling results for 2005 and 2016, respectively, for both the base runs as well as the no boundary condition runs. By comparing the base to the no boundary condition runs, it is estimated that nearly 70 percent of the mercury deposition in North Carolina is from sources outside the 12 km grid domain in 2005, and increases to approximately 90 percent in 2016. The change in boundary condition contribution to mercury deposition between 2005 and 2016 is due to changes in U.S. emissions only since the EPA modeling did not make changes to their future global mercury emissions assumptions.

Table 3-5. Mercury Deposition Totals over North Carolina for the 2005 Boundary Condition Sensitivity.
(Numbers rounded, given the modeling uncertainties)

Run	Dry Deposition (kg)	Wet Deposition (kg)	Total Deposition (kg)	Total Deposition (lbs)
Base2005_NC	3,650	1,590	5,240	11,550
No_BC2005	1,200	380	1,580	3,480
Difference (12 km boundary contribution)	2,450	1,210	3,660	8,070
Percent Contribution of Mercury Deposition in NC by sources outside the 12km domain	67%	76%	70%	70%

Table 3-6. Mercury Deposition Totals over North Carolina for the 2016 Boundary Condition Sensitivity.
(Numbers rounded, given the modeling uncertainties)

Run	Dry Deposition (kg)	Wet Deposition (kg)	Total Deposition (kg)	Total Deposition (lbs)
Base2016_NC	2,750	1,290	4,040	8,910
No_BC2016	330	80	410	900
Difference (12 km boundary contribution)	2,420	1,210	3,630	8,010
Percent Contribution of Mercury Deposition in N.C. by sources outside the 12km domain	88%	9%	90%	90%

3.3 Summary of Mercury Deposition Modeling

The EPA modeling results for the MATS rule suggests that mercury deposition in North Carolina should decrease by 10 percent between 2005 and 2016 (Table 3-1). The DAQ sensitivity modeling indicates that in 2005, approximately 16 percent of the atmospheric mercury deposition in North Carolina comes from air emission sources located in North Carolina and by 2016 that fraction is expected to drop to 3 percent. Finally, based on the sensitivity run that removed mercury emissions from the boundary conditions from the 2005 modeling,

approximately 70 percent of the atmospheric mercury deposition in North Carolina originates from outside the central and eastern United States.

3.4 Atmospheric Deposition Monitoring Data

Mercury wet deposition involves the transfer of mercury from the atmosphere to land or water through precipitation. Several chemical species of mercury exist in ambient air as a result of both natural and man-made emissions, and the water-soluble form of mercury (oxidized mercury) may be scrubbed out of the atmosphere by cloud water or rain and snowfall. For many sensitive surface waters, atmospheric wet deposition constitutes a significant route of mercury input. Dry deposition of particles and gases occurs by complex processes such as settling, impaction, and adsorption. Dry deposition processes also contribute to the overall rate of atmospheric deposition. Together, these phenomena can contribute to raise methylmercury levels in fish in mercury-sensitive waters (http://daq.state.nc.us/toxics/studies/mercury/wet_dep.shtml).

Wet deposition of mercury is monitored regularly at sites across the United States by the National Atmospheric Deposition Program-Mercury Deposition Network (MDN). Rainfall is collected weekly in a Aerochem wet deposition sampler and sent to a laboratory for quantitative analysis. Mercury levels are measured using EPA Method 1631E for total mercury analysis and undergo full quality assurance/quality control procedures before being reported. Data collected from these stations are provided to the National Atmospheric Deposition Program Mercury Deposition Network (NADP-MDN: http://nadp.sws.uiuc.edu/MDN/) to aid in the identification of geographical and temporal trends in mercury deposition across the U.S.

While no monitoring data are available for dry deposition of mercury in North Carolina, MDN data are available for wet deposition through the collection and subsequent analysis of rainfall for total mercury concentration. The DAQ has operated two sites for measurement of mercury in rainfall since 1996. Both wet deposition monitoring sites are in the eastern part of the state near mercury-sensitive waters: one at Pettigrew State Park on the shores of Phelps Lake in Washington County (NC42), and the other at Waccamaw State Park in Columbus County (NC08). Data were also collected at Candor in Montgomery County (NC26) during a shorter period of time from November 2005 thru December 2007. Given its proximity, wet deposition data recorded at Great Smoky Mountains National Park-Elkmont in Sevier County, Tenn., (TN11, close to the border between Tennessee and North Carolina) were also considered. Locations of these four MDN sites are shown in Figure 3-9.

Data from these four MDN sites are presented in Figure 3-10 for the average annual mercury deposition in nanograms per square meter per day ($ng/m^2/day$) and for the average annual mercury concentration in nanograms per liter (ng/l). A close examination to the MDN data at these sites reveals that mercury wet deposition appears to be highest in western North Carolina (TN11, mountain area) and lowest in central North Carolina (NC26, piedmont area). These differences are due at least partly to differences in rainfall. However, the inter-annual variations of wet depositional fluxes of mercury are high, undermining the spatial pattern discerned from the data set (data are available at NC08 and NC42 after 1996; at NC26 during 2006-2007; at TN11 after 2002).

Assuming wet deposition of mercury over the entire state of North Carolina could be represented by the average condition of the existing three MDN monitoring stations (NC08, NC42 and

TN11), the total wet deposition within North Carolina was estimated to be around 1,530 kg (3,370 lbs) during the baseline year of 2002, slightly less than the long-term (2002-2008) average of the annual wet deposition in North Carolina (1,640 kg or, 3,610 lbs) and that during the year of 2005 (1,630 kg or, 3,590 lbs). The inter-annual difference in wet deposition is partly due to the differences in precipitation. The baseline year of 2002 is a relatively dry year according to its negative average annual 12-month standardized precipitation index (<-1.5) (http://www.nc-climate.ncsu.edu/).

Figure 3-9. Location of Mercury Deposition Network Monitoring Sites

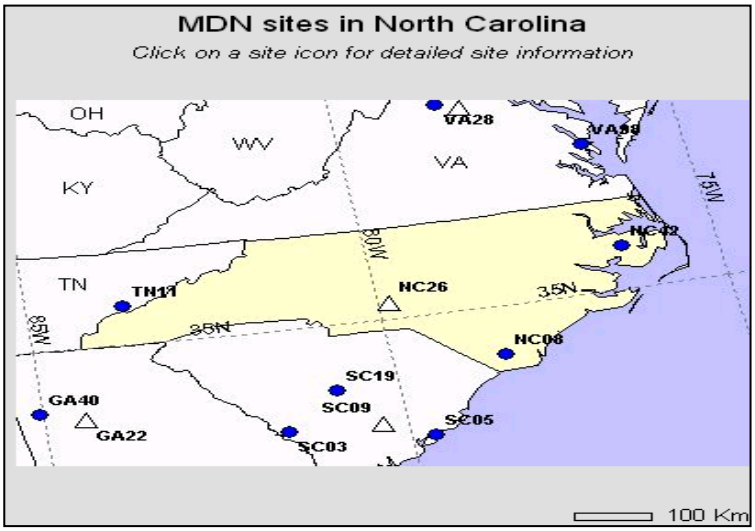
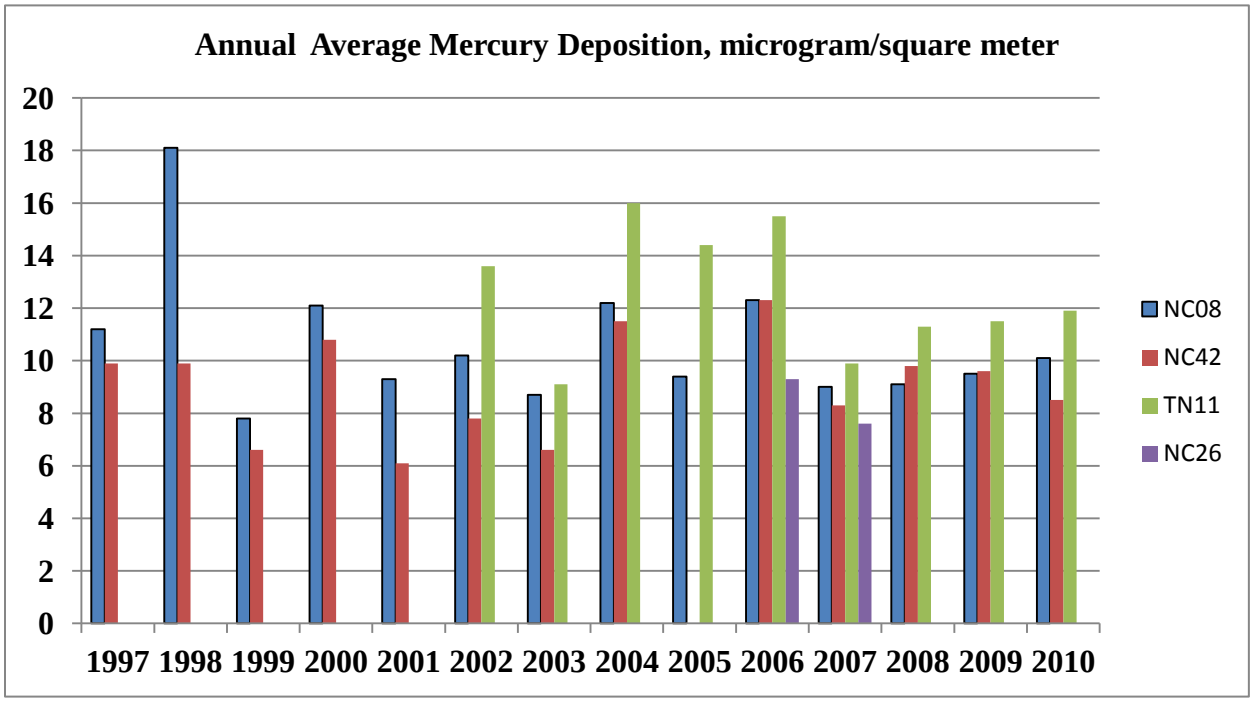


Figure 3-10. Annual Average Mercury Wet Deposition Trend for N.C. Monitoring Sites



Section 4. What are the projected mercury emissions for 2015, 2018, 2023 and 2025?

4.1 Definition

- "Projected mercury emissions" means calculated future annual airborne mercury released into the atmosphere from coal-fired electrical utility boilers located in North Carolina.

4.2 Projected Mercury Emissions

Table 4-1 presents estimated annual emissions with the required controls in place for the CSA, EPA EGU MATS Rule, and the Clean Air Interstate Rule (CAIR)/ CSAPR at the operating electric utility coal-fired boilers.

The projections reflect total mercury emissions from Duke Energy and Progress Energy coal-fired EGUs located in NC from the companies' analysis. These are only estimates of future emissions and should be regarded as such.

- Progress Energy's estimates include emissions from the boilers equipped with SCR, ESP and FGD controls on the Asheville, Mayo and Roxboro units. Year-to-year variations in emissions are largely due to the projected changes in load and dispatch. The remaining coal-fired boilers at Cape Fear, Lee, Sutton and Weatherspoon will be retired by 2015.
- Duke Energy's estimates are based on its projected total heat input (coal consumption) from the integrated resource planning model using the most recent official projections. Mercury is calculated assuming all facilities meet the mercury standard of 1.2 lbs/TBtu in the final EPA EGU MATS rule. Actual emissions from any given unit may be significantly less than the limit, but due to uncertainty on coal mercury content and long term variation in mercury performance Duke Energy cannot provide a more precise estimate at this time. Duke Energy's mercury emission estimates include:
    - SCR/Selective Non-Catalytic Reduction (SNCR), ESP and FGD controls on the Allen, Belews Creek and Marshall facilities along with Cliffside Unit 5; and
    - SCR, spray dryer, fabric filter and FGD controls on Cliffside Unit 6.

  Mercury emissions from the other coal-fired boilers at Cape Fear, Lee, Sutton and Weatherspoon were estimated to be zero, as they will be retired by 2015.

Table 4-1. Projected Future Mercury Emissions from North Carolina EGUs

Projected Total Mercury Emissions, lbs/yr				Percent Reduction from 2010 Emissions
Year	**Duke Energy**	**Progress Energy**	**Total**	**%**
2010	387	575	962	0
2015	481	267	748	22
2018	501	290	791	18
2023	383	198	581	40
2025	398	184	582	40

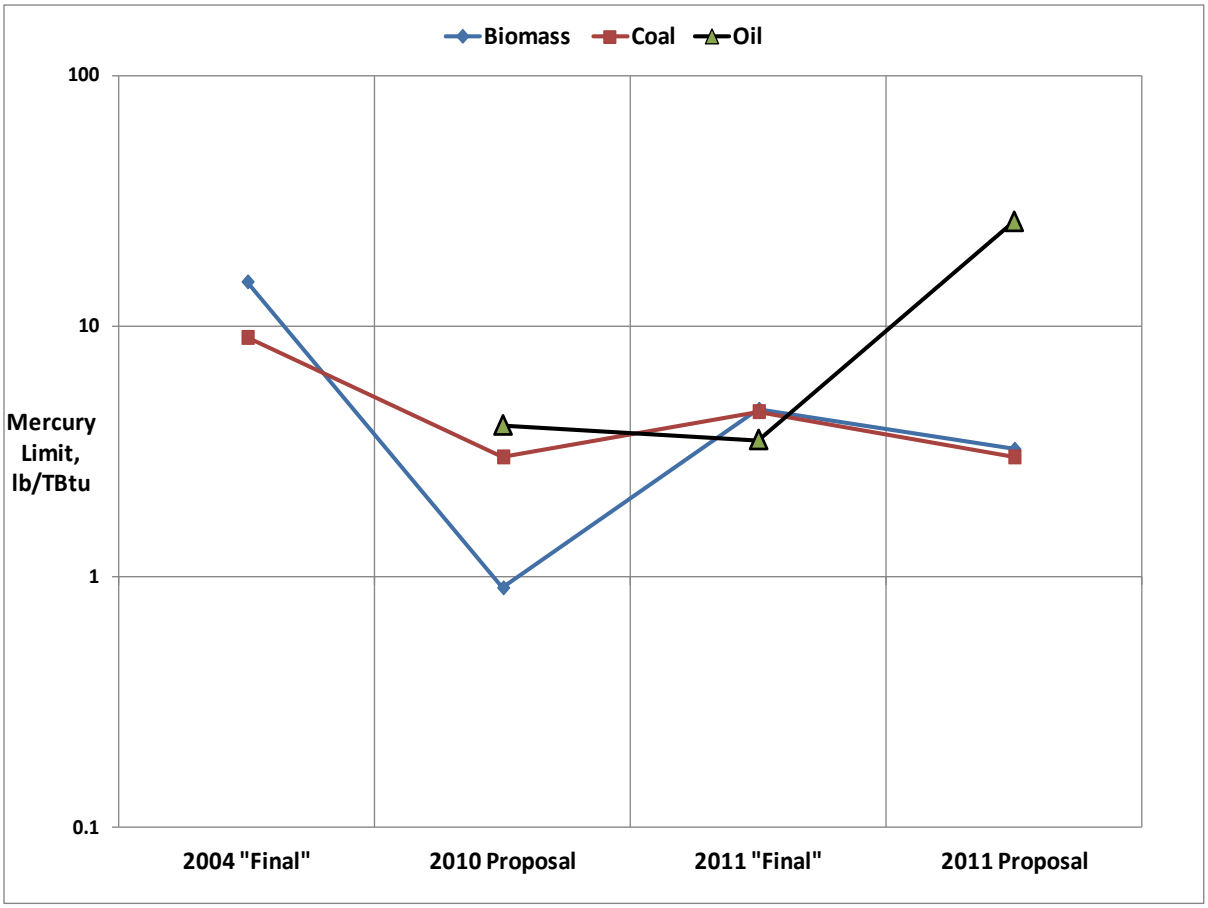
2010 NC EGU mercury emissions = 962 lbs/yr; see Table 1-1.

DAQ is not currently in a position to provide reliable projected future emissions for the eight non-EGU facilities designated as principal mercury emission sources. Projected emissions for

these manufacturing or waste incinerator facilities are dependent on a variety of parameters that are subject to variation beyond our capability to make reliable predictions. For example, several business activity factors (such as market, fuel, feedstock and unit cost conditions), usually drive their production levels. Given multiple industry sectors (paper, fertilizer, iron, chromium products, medical waste and municipal sewage waste), each with their own set of multiple business factors, the level of resources to predict reliable production levels are beyond the current capabilities and resources of DAQ.

Another factor limiting the ability of DAQ to project reliable future emissions for three of the principal non-EGU facilities with industrial boilers stems from the delayed schedule and uncertainty with the Industrial Boiler MACT rule. The Industrial Boiler MACT rule has a long history of delays since its initial proposal in 2004, as it was promulgated for the second time in March 2011, and then re-proposed for a third time in December 2011 under a "reconsideration." While EPA recently stated it plans to finalize its reconsideration of the Boiler MACT rules by spring of 2012, they have not yet revised the rule. Based on formal steps still to be taken, information sources close to the rulemaking expect the reconsidered Industrial Boiler MACT to be (re)finalized by summer of 2012. It is unknown at this time what the revised Industrial Boiler MACT numerical emission limits for mercury will be, since they change with each rule revision as shown in Figure 4-1.

Figure 4-1. Mercury Emission Limits for Various Industrial Boiler MACT Rules



Section 5. Discuss the amount of new source growth and projected new units growth through 2025.

5.1 Definitions:

- "New source growth" previously meant coal-fired units that used new source mercury allocations from the state's mercury allowance. These units would have been operating without the benefit of having a mercury allocation listed in Paragraph 15A NCAC 02D .2503(a). However, the above definition is outdated, given the previous EPA Clean Air Mercury Rule was vacated and replaced by the new EPA EGU MATS Rule, which does not provide for mercury allowances or mercury emission trading from one EGU facility to another.
- "Projected new unit growth" means new coal-fired utility boilers proposed by the utilities to the state's Utility Commission, to be built and operated to meet projected future increases in electric power demand.

Rather than build new units, Duke Energy and Progress Energy plan to retire 26 of their smaller coal-fired utility boilers by 2015, as presented in Table 5-1. Duke Energy Cliffside Unit 6 is currently the only new coal-fired electrical generating unit planned in North Carolina. Once Cliffside 6 comes on line in 2012, the facility will double the electricity generation from the retired Units 1-4 with much lower facility-wide emissions. Duke has committed to retiring the same number of megawatts from older coal-fired generation, thus making Unit 6 carbon neutral. Cliffside 6 is an 825-megawatt unit equipped with state-of-the-art SCR, a spray dry absorber (SDA) with fabric filter baghouse (FF), followed by a wet FGD scrubber intended to meet the recently established EPA EGU MATS limits. This SCR/SDA/FF/FGD configuration produces multi-pollutant control capability to remove emissions of mercury by 90 percent, SO_2 and acid gases by 99 percent, NOx by 90 percent and particulate matter (PM) by 99 percent.

Table 5-1. N.C. Coal-Fired Utility Boilers Retirement Schedule

		Size Rating	Retirement Schedule
Facility	**Units**	**Megawatts (MW) approx**	
Duke Energy			
Buck	3, 4	115	Mid 2011
Buck	5, 6	256	Jan 2015
Cliffside	1-4	200	Oct 2011
Dan River	1-3	470	April 2012
Riverbend	1-3	455	Jan 2015
Progress Energy			
Cape Fear	5, 6	320	Mid 2013
Lee	1-3	400	Fall 2012
L V Sutton	1-3	600	End 2013
Weatherspoon	1-3	170	Fall 2011

Section 6. What is the state of mercury control technology, including technological and economic feasibility?

This is a two-part question. The first part concerns the state of mercury emission control technology. The second part of the question concerns the feasibility with application of mercury capture technology to N.C. utility boilers in an economic manner. The response to the first part includes an explanation of how various coal-fired boiler control equipment operates together, along with the science that makes it work. The description of equipment used to control mercury is followed by a discussion on the technological and economic feasibility in North Carolina in response to the second part of the question.

The CSA requires reductions from coal-fired boiler of 77 percent in NOx emissions by 2009 and 73 percent in SO_2 emissions by 2013. Although the Act does not set mercury control requirements, it recognizes that the controls needed to meet the NOx and SO_2 emission caps will reduce mercury significantly; perhaps as much as 60-90 percent. In response to the CSA and in anticipation of the EPA EGU MATS rule, the two N.C. utility companies installed FGDs to control SO_2 and either SCR or SNCR systems to control NOx on 20 of their largest coal-fired units operating in North Carolina.

The EPA issued a federal rule in February 2012 with emission limits for MATS from EGUs to be met by 2015 or 2016.[24] Required in the EPA rule are 90+ percent reductions in mercury emissions along with similarly significant reductions in SO_2 and other acid gases, PM and other toxic metals. Such a rule requires application of holistic approaches of controlling mercury in tandem with other air toxic pollutants in a practical and cost-effective manner. Integration of mercury control along with multi-pollutant control is discussed below in response to both parts of the question to put the response in context of the current EPA MATS rule requirements. The emission limits for the three toxic pollutants or pollutant groups established in the EPA EGU MATS rule are presented in Table 6-1.

Table 6-1. Emission Limits for EPA EGU MATS Rule

Pollutant Group	**Mercury**	**Acid Gases**		**PM**
		SO_2	**Hydrogen Chloride**	
	lbs/TrillionBtu	**lbs/Million Btu**		
Coal-fired EGUs	1.2	0.2	0.002	0.03

6.1 State of Mercury Control Technology

The "state of mercury control technology" means the science, equipment and operating techniques used to reduce mercury emissions. Two general approaches for mercury control have proven capable of 90 percent removal for coal-fired boilers; one involves conventional technologies, while the other entails new technology. The two primary technologies that capture mercury emissions from EGUs are FGD scrubbers preceded by particulate controls and powder

[24] US EPA, "National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units," Federal Register, Vol. 77, No. 32, Feb 16, 2012, p. 9404.

activated carbon (PAC) injection followed by particulate controls. Both control technologies are used in conjunction with ESPs or baghouses as conventional technologies to effect mercury removal.

Prior to the CSA and the EPA EGU MATS rule, there were two emission control configurations on NC's coal-fired utility boilers. They were low NOx burners designed to reduce the formation of NOx emissions and an ESP. An ESP only removes particles (not gaseous pollutants) from the flue gas stream using an electric field to force charged particles to be collected on metal plate surfaces. In contrast to baghouses and certain scrubbers that apply energy to the whole gas stream, an ESP applies energy only to the particles and therefore, is more energy efficient. While most are referred to as cold-side (ESP-CS), some are referred to as hot-side ESPs (ESP-HS). The distinction between the two types of ESPs is that one is located downstream of the combustion air preheater (ESP-CS) and the other is upstream of the air preheater (ESP-HS). The difference in location accounts for a 400 F temperature dissimilarity in the flue gas as it enters the precipitator, which in turn affects ESP mercury control performance, as discussed later.

In response to past air quality rules for criteria air pollutants (CAPs), separate control technologies were used individually to reduce emission for each CAP. For example, ESPs were used for PM control, low-sulfur coal was burned for SO_2 control and SCRs units were used for NOx control. In response to the new EPA EGU rule for several toxic air pollutants, multi-pollutant emission controls on coal-fired boilers are needed in order to remove mercury (Hg), PM and non-mercury toxic metals (such as arsenic, cadmium, chromium), SO_2 and other acid gases. The new rule requires more than one technology operated in series, in order to achieve the high removal level necessary for the full array of hazardous air pollutants.

6.2 Conventional Mercury Control Technologies

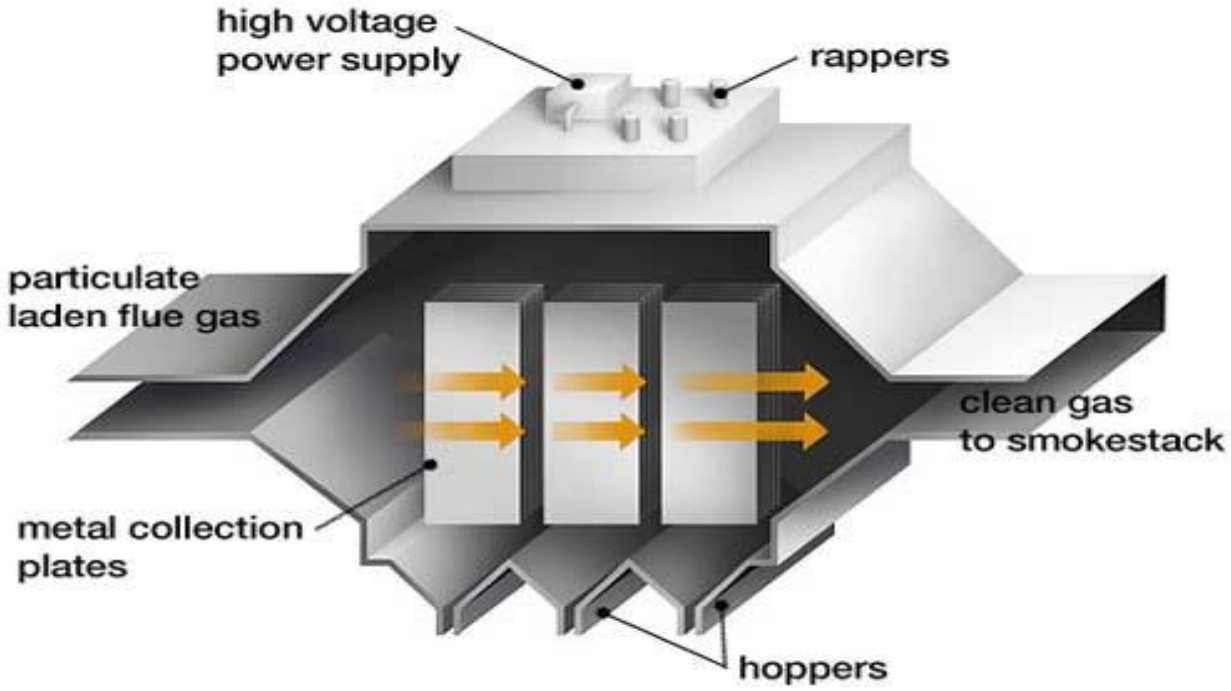
Bituminous coal is burned in N.C. utility boilers and typically contains mercury in the range of 0.08 to 0.10 parts per million (ppm)[25] or 7-9 lbs/TBtu.[26] When combusted in the furnace of utility boilers at 2,500 F, all the coal mercury is initially vaporized and exists as elemental mercury. As it leaves the boiler and cools, a portion of the elemental mercury becomes transformed into the other species of oxidized mercury and particle-bound mercury. The extent of this 'mercury speciation' or 'mercury oxidation' is primarily influenced by chlorine and sulfur content in the coal, flue gas temperature and other factors. The extent of mercury capture in most existing PM emission controls currently installed in North Carolina (ESPs and FGDs), depends on mercury speciation. More specifically, control performance of these two conventional technologies is largely conditional and proportional to the amount of oxidized and particle-bound mercury, present at the inlet to the control device. In contrast, control performance for elemental mercury for these two conventional technologies is virtually zero.

Bituminous coal-fired EGUs produce higher levels of oxidized and particle-bound mercury at the same gas temperatures than sub-bituminous and lignite coals. With 300 F temperatures typical of

[25] Pavlish, J.H. et al., "Status review of mercury control options for coal-fired power plants," Fuel Processing Technology, 82 (2003) pp. 89-165.
[26] U.S. EPA, "Control of mercury emissions from coal-fired electric utility boilers; Interim Report," EPA-600/R-01-109, April 2002.

ESP-CSs, the distribution of mercury speciation shifts with more of the elemental mercury converting to oxidized mercury and particle-bound mercury. This presents higher levels of the more collectible forms of mercury species to conventional emission controls, and accounts for why ESP-CS capture efficiency of total mercury is typically in the moderate range of 30-50 percent. At ESP-HS temperatures of 700 F, the percentage of elemental mercury remains relatively high, and low amounts of oxidized mercury and particle-bound mercury exist. This explains why ESP-HS capture efficiency resides in the low range of 10-20 percent of total mercury, given the low amounts of oxidized and PM-bound mercury present. Fabric filters operating near 300 F collect 90+ percent of total mercury and virtually all of the oxidized and particle-bound mercury present, as the flue gas passes through the filtered dust (PM) cake. Somewhat similarly, the combination of an FGD preceded by ESP-CS is capable of collecting 75-95 percent of total mercury and virtually all of the oxidized and particle-bound mercury. Figure 6-1 presents an illustration of an ESP.

Figure 6-1. Illustration of an Electrostatic Precipitator



Sub-bituminous coal-fired EGUs produce lower levels of oxidized and higher amounts of elemental mercury under similar conditions than bituminous coal. The contrast in mercury control performance between bituminous and sub-bituminous coals, presented in Table 6-2, illustrates the effect of coal parameters on mercury speciation and total mercury capture. With 300 F temperatures for ESP-CSs, the mercury speciation profile consists mostly of elemental mercury. This presents lower levels of the more collectible forms of mercury species to conventional emission controls, and accounts for why ESP-CS capture of total mercury is in the low range of 5-10 percent. At ESP-HS temperatures of 700 F, the percentage of elemental mercury remains relatively high, low amounts of oxidized mercury and PM-bound mercury are formed. This explains why ESP-HS capture efficiency resides in the very low range of 0-5 percent of total mercury, given the extremely low amounts of oxidized and PM-bound mercury

present. Fabric filters operating near 300 F collect 60-75 percent of total mercury, aided by unburned carbon in the flyash collecting oxidized and elemental mercury as the flue gas passes through the filtered dust-cake. Somewhat similarly, the combination of an FGD preceded by ESP-CS is capable of collecting 10-20 percent of total mercury because virtually all mercury remains in the elemental form that is uncollectable in most conventional emission controls.

Table 6-2. Total Mercury Removal Performance for Conventional Emission Controls[27]

Emission Controls for Pulverized Coal EGUs	Total Mercury Removal Percentage, %	
	Bituminous Coal	Sub-Bituminous Coal
ESP-CS	29	3
ESP-HS	11	0
FF Baghouse	89	73
ESP-CS & FGD	78	16
ESP-HS & FGD	39	0
SNCR ESP-CS	90	No data

Dry Sorbent Injection (DSI) consists of the injection of dry sorbent reagents that react with SO_2 and other acid gases with a downstream PM control device to capture the reaction products. The most common DSI reagent in use is trona, a naturally occurring mixture of sodium carbonate and sodium bicarbonate mined in some western states. Other reagents have also been used, such as sodium bicarbonate and hydrated lime. Sodium bicarbonate is capable of higher SO_2 removal efficiencies than Trona because it is more reactive. Trona can achieve SO_2 reductions up to 60 percent when injected upstream of an ESP, or up to 90 percent when injected upstream of a fabric filter. Since sulfur trioxide (SO_3) competes with mercury for adsorption sites on fly ash or injected activated carbon, even SO_3 at concentrations as low as a few parts per million is able to adversely affect mercury removal. By removing SO_3 with trona, the fly ash with high unburned carbon alone is able to remove over 90 percent of mercury.[28] DSI equipment is relatively simple and inexpensive and can be installed typically within 12 months. The basic injection system with storage silo costs around $20/kW, substantially less than $300-400/kW for a FGD.[29]

6.3 Emerging Mercury Control Technologies

PAC injection has the potential to achieve moderate to high levels of mercury control from 50-90 percent due to its ability to capture both elemental and oxidized mercury forms. The performance of activated carbon is related to its physical and chemical characteristics. Generally, the physical properties of interest are: surface area, pore size distribution and particle size distribution. The capacity for mercury capture generally increases with increasing surface area and pore volume.

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[27] EPA, Electrical Generating Utility Mercury Speciation Profiles for the Clean Air Mercury Rule," EPA-454/R-11-010, Nov 2011.

[28] Y. Kong et al., "Dry Sorbent Injection of Sodium Sorbents for SO_2, HCl and Mercury Mitigation," in Proceedings of 18th Annual North American Waste-to-Energy Conference, Orlando, Fl, May 2010 .

[29] Staudt, J.E. et al., Control Technologies to Reduce Conventional and Hazardous Air Pollutants from Coal-Fired Power Plants, prepared for Northeast States for Coordinated Air Use Management, March 2011 accessed May 2012 at http://www.nescaum.org/topics/mercury.

Carbon sorbent capacity is dependent on several flue gas parameters, including gas temperature, mercury concentration, SO_2 and SO_3 concentration, flue gas composition and other factors.

Sub-bituminous coals do not have adequate chlorine and other constituents present in the coal to produce sufficient levels of oxidized mercury for effective capture by conventional emission controls. For sub-bituminous coal-fired boilers, PAC injection offers the capability to collect mercury at levels required to meet the new EPA EGU MATS mercury emission limits. Injection of activated carbon could serve to meet the mercury standard and injection of a dry alkaline material (such as limestone or Trona), which would meet the acid gas standard while reducing the amount of carbon to meet the Hg standard.[30] However, use of one or both injection approaches would adversely impact the performance of the downstream PM collector, whether it is an ESP or baghouse. Either way, the ESP or baghouse would need to be upgraded to handle the additional PM from the injected material(s). Halogenated PAC sorbents have been developed to enhance performance of powdered activated carbon injection for mercury control. Under the same conditions, studies have shown the use of halogenated carbon to be considerably more effective at mercury capture than non-halogenated carbon. Relative to standard PAC, the use of halogenated powder activated carbon expands the usefulness of sorbent injection to situations where standard PAC may not be very cost-effective. These situations include using an ESP-CS to capture the PAC while improving the cost effectiveness of mercury capture by avoiding costly installation of a downstream fabric filter, while reducing PAC injection rates.

SCR uses a catalyst with ammonia gas injected to reduce the nitrogen oxides in the flue gas to molecular nitrogen and water. Ammonia gas is diluted with air or steam and this mixture is injected into the flue gas, upstream of a metallic catalyst bed composed of vanadium, titanium, platinum or zeolite. The SCR is located downstream of the boiler outlet. Recent data show SCRs promote additional mercury oxidation, thereby enhancing mercury removal with most control technologies. Eleven SCRs have been installed in North Carolina as a result of the CSA. Figure 6-2 presents an illustration of a SCR reactor.

Flue gas desulfurization scrubbers typically use limestone to remove 90-99 percent of sulfur dioxide in EGU flue gas. As a co-benefit, oxidized mercury is captured in the scrubber and typically removed at levels of 80-95 percent. Many of these FGD systems use limestone forced oxidation wet scrubbers,[31] as do most/all North Carolina EGUs equipped with FGDs. However, little to no elemental mercury is captured by a FGD. Such performance characteristics account for total mercury control performance ranging from 60-90 percent control, depending on the relative distribution of the mercury species. Studies show that FGD scrubbers following cold-side ESPs have higher performance and are more cost-effective in mercury removal than those following hot-side ESPs (see Table 6-2). Figure 6-3 presents a simplified illustration of a FGD system.

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[30] Environmental Elements, "Sorbent Injection," accessed April 3, 2010 at http://www.eec1.com/products/sorbent_injection.htm.

[31] Tom Higgins, "Demonstration Test of Iron Addition to an FGD Absorber to Enhance Flue Gas Mercury Removal," in proceedings of 2010 MEGA Symposium, Baltimore, MD, August 2010.

Figure 6-2. Illustration of Selective Catalytic Reduction Reactor

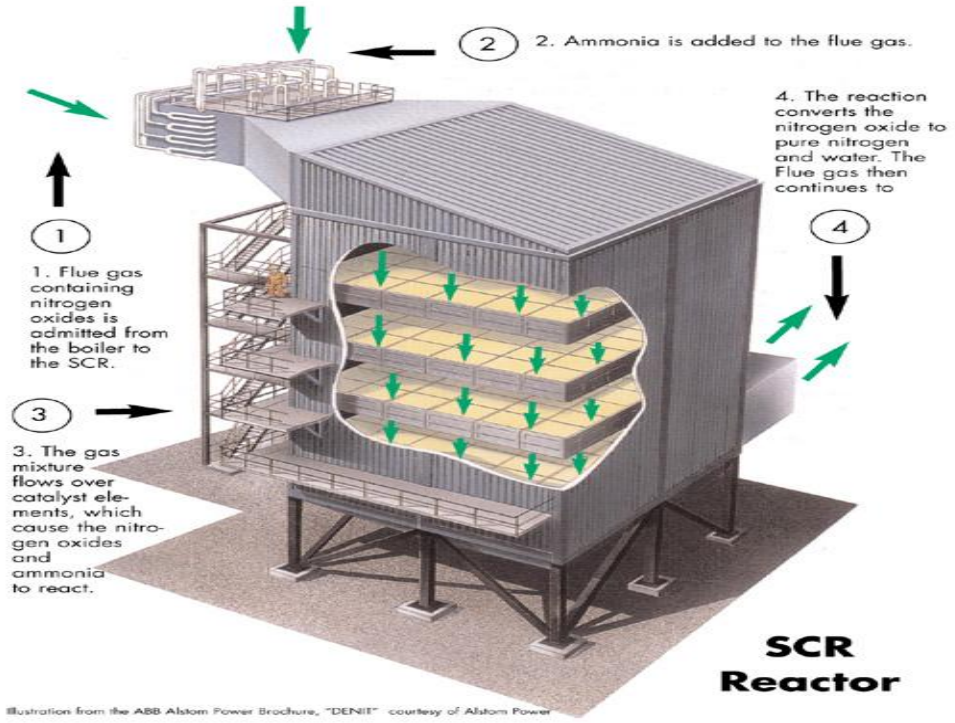
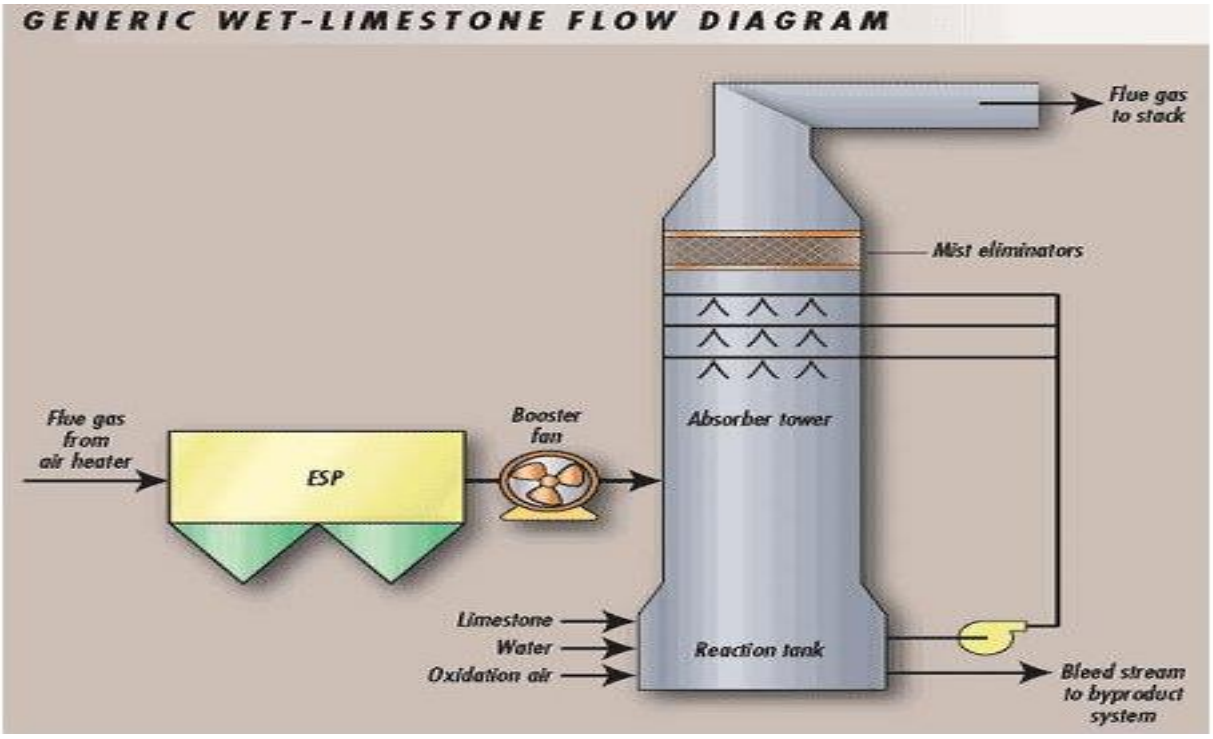


Figure 6-3. Illustration of Flue Gas Desulfurization System



An emerging issue being studied with many FGD units is re-emission of mercury previously captured. Typically 95 percent of oxidized mercury and no elemental mercury is captured in FGDs, meaning the same amount of elemental mercury enters and exits the FGD. Mercury re-emission occurs when soluble mercury is captured in the FGD liquid, reduced to elemental mercury, volatilized and emitted with the flue gas.[32] Re-emission is diagnosed by observing higher levels of elemental mercury at the FGD outlet than at the inlet. The general cause for re-emission is a reduction reaction in the liquid of initially-captured oxidized mercury to elemental mercury that volatilizes out of the liquid into the flue gas. Operational factors affecting mercury re-emission include fine particles, sulfite levels and the amount of oxidized mercury in the FGD liquid. Plants in the United States have reported FGD mercury re-emission occurring up to 50 percent of the time ranging from 15-50 percent of the inlet oxidized mercury.[33] Re-emission can vary from 0-40 percent for elemental mercury and significantly reduce total mercury collection performance.[34]

Options to resolve the FGD re-emission issue include injection of dry sorbents upstream of the ESP or baghouse to reduce the amount of mercury collected in the FGD. Another option demonstrated is use of various additive chemicals in the FGD scrubbing liquid to change the chemistry to be less favorable of the reduction reaction of oxidized to elemental mercury. Multiple materials suppliers have developed their own proprietary liquids shown to eliminate mercury re-emission and decrease mercury wastewater discharge.[35, 36] Facilities with FGDs can monitor scrubber liquid parameters for feedback control of the anti-re-emission additive injection rate. Additives typically form large insoluble solids by binding the liquid phase mercury and precipitating it into the scrubber solids that settle and are filterable leading to lower water effluent mercury discharge.

6.4 North Carolina Technical Applicability and Economic Feasibility

The second part of the question concerns the application of mercury capture technology to North Carolina's utility boilers in an economic manner. To meet the new EGU MACT rule in North Carolina, Duke Energy and Progress Energy plan to continue operating 20 of their largest capacity coal boilers equipped with SCR or SNCRs, ESPs and FGDs totaling roughly 10 gigawatts (GW) capacity (1GW=1,000 megawatts, MW). In addition, they have committed to close 26 of their smaller coal boilers not equipped with SCRs or SNCRs and FGDs totaling roughly 3 GW capacity in response to the CSA and EGU MATS. Current estimates of the utilities' environmental compliance costs for the CSA are $1.05 billion for Progress Energy and $1.84 billion for Duke Energy.[37]

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[32] Blythe, G. et al., "Field Testing of a Wet FGD Additive for Enhanced Mercury Control," Final Report for U.S. DOE-NETL Cooperative Agreement DE-FC26-04NT42309. March 2008.
[33] Siethoff, Eric, "Operational Factors Affecting Hg Re-Emission from a Wet Flue Gas Desulfurization System," in proceedings of Energy, Utility & Environmental Conference 2012, Phoenix, January 2012.
[34] Curie, J.F. et al., "Enhanced Mercury Control by Wet GFD Systems," in Proceedings of Air Quality VI Conference, Arlington, VA, September 2007.
[35] Keiser, Bruce, "Meeting Mercury Emission Regulations Through Control of Re-Emission Across Wet FGDs," in proceedings of Energy, Utility & Environmental Conference 2012, Phoenix, January 2012.
[36] Winter, Stephen, et al., "Results From a Two-Week Study to Mitigate Mercury Re-emissions From a Wet Scrubber," in Proceedings of 2010 MEGA Symposium, Baltimore, MD, Aug 2010.
[37] 2011 Clean Smokestack Act Final Report, June 2011 at http://daq.state.nc.us/news/leg/

Table 6-3 presents the current emission control configurations and the most recent emission performance levels for the Duke Energy and Progress Energy EGUs. As shown in Table 6-3, nearly all of the larger capacity North Carolina EGUs with an SCR or SNCR, ESP and FGD are meeting the future EGU MATS emission limits for mercury, PM and acid gases. According to the most recent emission inventory of 2010, only two facilities fully equipped with emission controls currently are not meeting (but nearly meeting) all three future EGU MATS emission limits. Those two are units at Mayo for PM and mercury emissions and at Roxboro for PM emissions only. Progress Energy expects to further improve performance at these facilities to comply with the future MATS limits. In contrast, the smaller capacity North Carolina EGUs equipped only with an ESP but not a SCR/SNCR and FGD, produce emission noticeably above the MATS emission limits for mercury, PM and acid gases. These smaller units with less emission controls either have been retired or are planned to be retired before the MATS compliance date in March 2015.

The 2010 performance levels shown in Table 6-3 reflect that the North Carolina EGUs are well positioned to meet the MATS emission limits by the 2015 compliance date. Such performance indicates that the state of mercury control technology for North Carolina EGUs is technologically and economically feasible to achieve more than 90 percent reductions in mercury emissions. The key issues facing Duke Energy and Progress Energy largely only include resolving the FGD mercury re-emission issue, and providing new forms of continuous emission monitoring for PM and mercury compliance.

Speciated mercury measurements were made on one of the fully-equipped emission controlled coal-fired EGUs to evaluate the performance of the control device separately and collectively. Measurements were made at the boiler exit/SCR inlet, ESP outlet and FGD outlet (stack) gas streams at the Roxboro Unit 2 burning high sulfur, bituminous coal in September 2008,[38] using the applicable EPA speciated mercury method.[39] Results of the measurements are presented in Figure 6-4 showing the concentrations of each species (oxidized, elemental, particle bound and total mercury) in units of the EGU MATS standard (lbs/TBtu) at the three locations discussed above. Figure 6-4 shows that:

- Elemental mercury concentration drops from nearly 2 lb/TBtu at the boiler exit/SCR inlet to less than 1 lb/TBtu at the FGD outlet; this reflects that while none of the elemental mercury gets captured as elemental mercury, about half of what exits the boiler gets converted and captured as oxidized mercury in the ESP and FGD.
- Oxidized mercury concentration starts at more than 5 lbs/TBtu at the boiler exit/SCR inlet and then drops to nearly zero at the FGD outlet; this reflects that while some of the elemental mercury gets converted to oxidized mercury in the SCR, nearly all gets collected before leaving the FGD.
- Particle-bound mercury concentration starts at more than 2 lbs/TBtu at the boiler exit/SCR inlet and then drops to nearly zero at the FGD outlet; this reflects that nearly all particle-bound mercury gets collected before leaving the FGD.

[38] Submitted to NC DAQ by Progress Energy. Performed for Babcock and Wilcox by CleanAir Engineering, "Report on Emission Testing at Semora, NC," March 2009.
[39] EPA Method 30B, Determination of total vapor phase mercury emissions from EGUs using carbon sorbent traps.

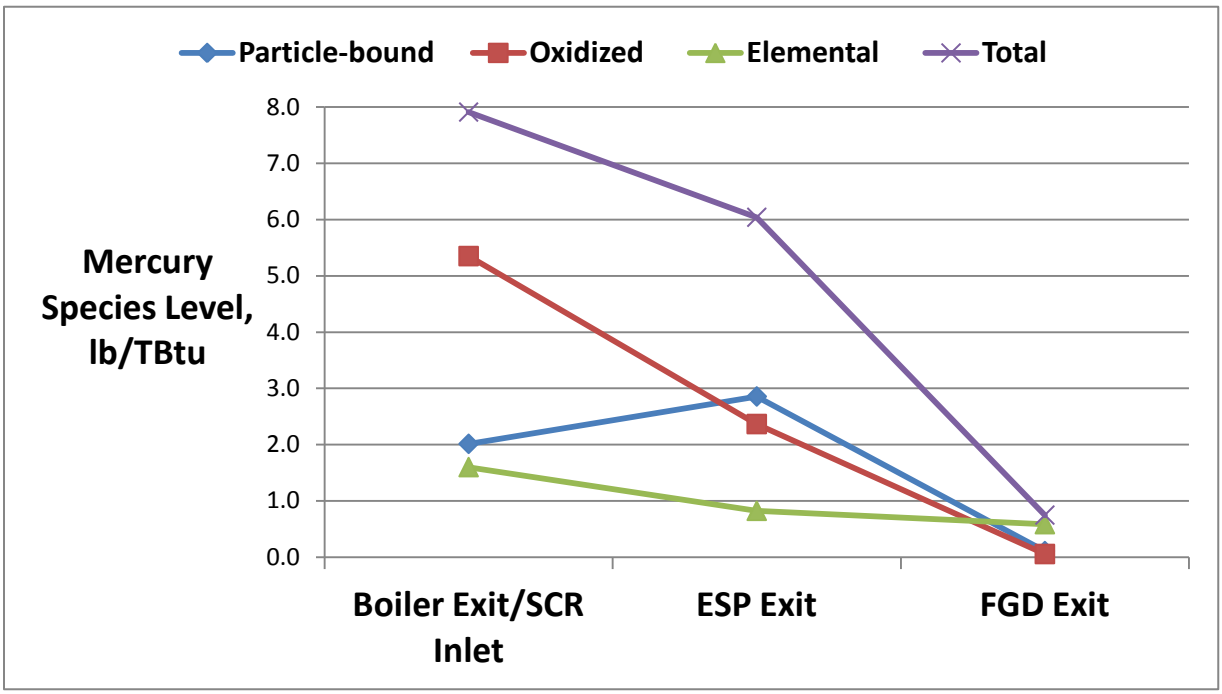
- Total mercury concentration in the coal is roughly 8 lbs/TBtu at the boiler exit/SCR inlet and remains at that level until 25+ percent is collected in the ESP, with an additional 65+ percent collected in the FGD for an overall removal of 90+ percent.

Table 6-3. NC Coal-Fired Utility Boilers 2010 Emission Performance

Facility	Units[1]	Size Rating, MW approx	Emission Controls			2010 Annual Emission Average			
			NOx	PM and Metals	SO_2/ HCl and Hg	PM	HCl or SO_2		Hg
						lb/MMBtu			lb/TBtu
Duke Energy						**0.03**	**0.002**	**0.2**	**1.2**
Allen	5	1,150	SNCR	ESP-CS	FGD	0.026	0.003	0.08	0.3
Belews Creek	2	2,500	SCR	ESP-CS	FGD	0.027	0.003	0.05	0.2
Buck*	5	330		ESP-HS		0.45	0.7	1.1	6.4
Cliffside*	4	210		ESP-HS		0.07	0.07	1.0	6.6
Cliffside	#5	570	SCR	ESP-CS	FGD				
Cliffside	#6	825	SCR	FF	FGD/ Spray Dryer	Start-up in 2012			
Dan River*	3	470		ESP-HS/CS		0.09	0.09	1.3	5.3
Marshall	4	2,000	SCR/ SNCR	ESP-CS	FGD	0.022	0.003	0.07	0.4
River-bend*	4	970	SNCR	ESP-HS		0.09		1.5	5.8
*** Will retire 16 small boilers totaling 2,000 MW with 125 MW average; will keep 12 large boilers and start one 825 MW boiler totaling 7,200 MW with 550 MW average**									
Progress Energy									
Asheville[2]	2	380	SCR	ESP-CS	FGD	0.02	0.0004	0.16	0.9
Cape Fear**	2	320		ESP-CS		0.05	0.08	1.4	4.2
Lee*	3	400		ESP-CS		0.05	0.08	1.3	4.8
Mayo	1	730	SCR	ESP-HS	FGD	0.034	0.0001	0.2	1.4
Roxboro	4	2,400	SCR	ESP-CS & HS	FGD	0.034	0.0001	0.2	0.9
Sutton**	3	600		ESP-HS		0.070	0.08	1.4	4.3
Weather-spoon**	3	170		ESP-CS		0.070	0.08	1.6	4.3
**** Will retire 11 small boilers totaling 1,500 MW with 135 MW average; will keep seven large boilers totaling 3,500 MW with 500 MW average**									

Footnotes: 1. All numbers in the 'Units' column indicate how many boilers are located at each facility, except for Cliffside #5 and #6, which reflect the specific unit.
2. Asheville 2010 data reported to local program, but not yet reported to DAQ
HCl = Hydrogen Chloride
MMBtu = Million British thermal units

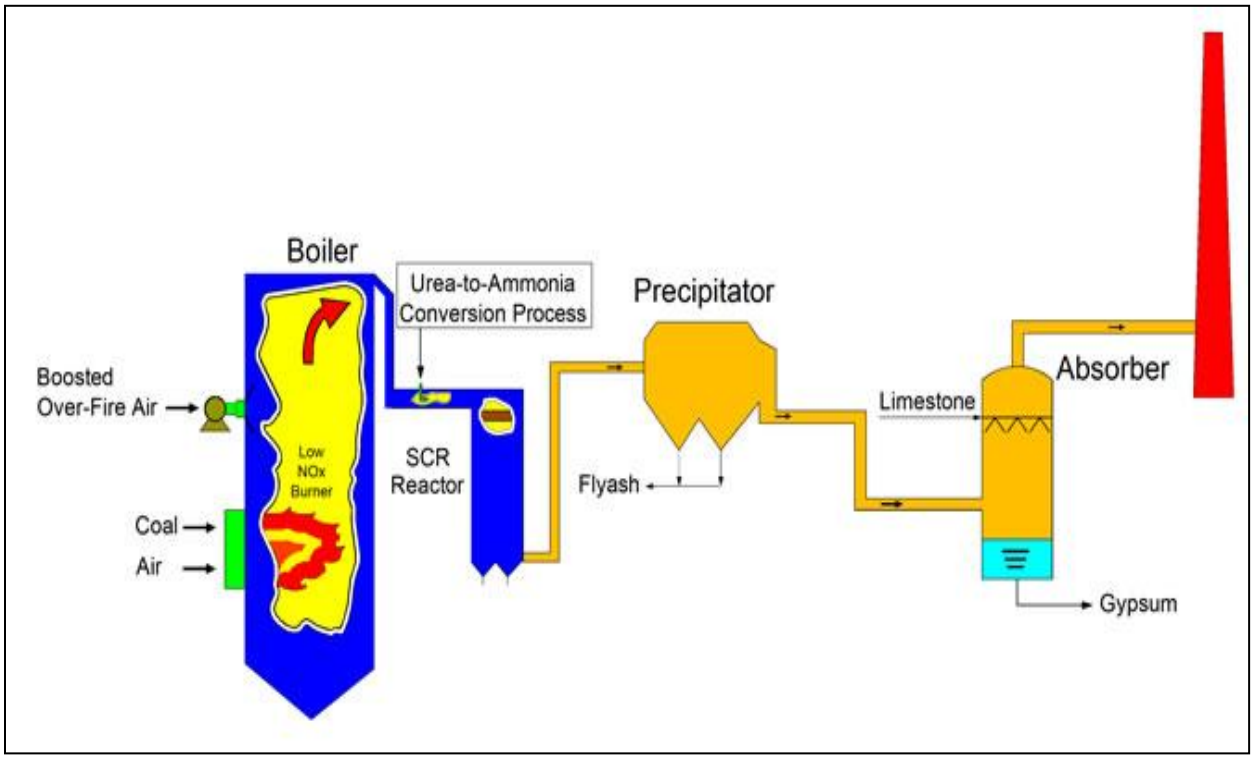
Figure 6-4. Mercury Speciation Profile for N.C. Coal-Fired Electrical Generating Units with SCR/ESP/FGD Emission Controls



Past experience indicates that adding a control technology to meet a new emission standard for one pollutant can have an adverse unintended consequence on continuing to meet emission standards for another pollutant. Most coal-fired EGUs in the United States currently do not meet one or more of the EGU MATS HAP emission limits. While a challenge to find a technology to meet one new stringent pollutant standard without unintended consequences, it is much more challenging to find the right combination of technologies to meet multiple new pollutant standards collectively. One such combination of technologies -- SCR, ESP and FGD -- is capable of meeting the EGU MATS emission limits for PM, mercury and acid gases. For this combination, each technology serves multiple purposes that supplement and complement the performance of the other technologies in terms of multiple pollutant emission reductions. Figure 6-5 presents the configuration for a SCR, ESP and FGD typical for most of the larger N.C. coal-fired EGUs to comply with the new MATS limits in the future. The following points characterize how this is achieved by these three technologies:

- The SCR reactor oxidizes nitrogen oxides into benign products (nitrogen and water) and converts elemental mercury into the collectible form of oxidized mercury for subsequent collection in the ESP and FGD.
- The ESP collects 99+ percent of the particulate (non-gaseous) pollutants, including ~25 percent of the oxidized and particle-bound mercury along with most of the other toxic metals. Removal and handling of most of the particulate in a dry form is advantageous relative to removal and handling it wet if it were collected in the scrubber.
- The FGD collects 99 percent of the SO_2 and other acid gaseous pollutants, nearly all of the remaining oxidized and particle-bound mercury (65+ percent of the total mercury), and 35 percent of the remaining particulate.

Figure 6-5. Emission Controls Configuration for Coal-Fired Electrical Generating Units with SCR/ESP/FGD



Section 7. Assessment of cost and performance of mercury control technology as it may be applied to uncontrolled sources of mercury in North Carolina, including both coal-fired electric steam generating units and other sources that emit mercury, and including an assessment of technology used to satisfy requirements of the CSA (G.S. 143-215.107D), and other requirements for controlling nitrogen oxide and sulfur dioxide emissions.

The first part of this assessment requires a listing of any uncontrolled coal-fired boilers and other principal sources that emit mercury and then an assessment of the cost and performance of mercury control technology that these sources might reasonably use to reduce their mercury emissions. The second part of the assessment requires an evaluation of the performance and cost of emission control equipment installed, as presented to the two North Carolina's utility companies to meet the requirements of the CSA, EGU MATS and the CSAPR/CAIR rules through the reduction of NOx and SO_2.

Listed below in Table 7-1 are the facilities emitting one percent or more of the statewide total amount of mercury on the order of 1,800 lbs per year, meaning those facilities with mercury emissions greater than 18 lbs/yr. Estimated mercury emissions listed in the table are from the most recent 2010 DAQ inventory as reported by the facilities.

The largest EGU facilities *with* mercury controls are listed in the first group in Table 7-1. These are Duke Energy's Belews Creek, Cliffside, Marshall and Allen facilities; and Progress Energy's Roxboro, Mayo and Asheville facilities. Documentation provided under the CSA shows the net overall environmental compliance costs for emission controls for Duke Energy of $1.84 billion and for Progress Energy of $1.05 billion, for a combined total of $2.89 billion in capital costs.[40]

Identified in the second group in Table 7-1 are the smaller EGU facilities *without* mercury controls. These are Duke Energy's Buck, Cliffside (Units 1-4), Dan River and Riverbend facilities; and Progress Energy's Cape Fear, Lee, Sutton and Weatherspoon facilities. These uncontrolled facilities have been or will be retired by 2015.

The third group in Table 7-1 contains three facilities with high efficiency mercury control systems already installed. These facilities include PCS Phosphate, Nucor Steel and Stericycle.

- The majority of mercury emissions from PCS Phosphate stem from six identical coal-fired calciners. Since 2006, the company has installed wet ESPs on each calciner to supplement the duplex cyclones exhausting to Venturi scrubbers. Wet ESPs reduced mercury emissions in 2006 from 246 lbs/yr to 25 lbs/yr in 2010. This additional 90 percent reduction in mercury emission control from wet ESPs renders this facility well-controlled.
- Nucor Steel operates an electric arc furnace to convert scrap metal into steel slabs with a 2,190,000 ton/year annual capacity controlled by a baghouse. Much of the scrap steel comes from used vehicles, with most of the mercury contained in switches. Prior to the N.C. mercury switch removal program, Nucor's mercury emissions were 680 lbs/yr in

[40] 2011 Clean Smokestack Act Report pp. 5-6, accessed at http://daq.state.nc.us/news/leg/, April 2012.

2002. From 2006-2009 its mercury emissions dropped to an average of 142 lbs/yr, but rose to 294 lbs/yr in 2010. DAQ is investigating the recent increase.

- Stericycle operates a medical waste incinerator controlled by an absorber/venturi scrubber system. Like Nucor, Stericycle operates a high performance control system, but their mercury emissions are also vulnerable to higher-than-normal mercury levels in the feedstock/feedstream to the process. The revised EPA medical waste incinerator rule will require Stericycle to further reduce mercury emissions for which it plans to install a carbon bed absorber by July 2013.[41]

The fourth group in Table 7-1 consists of three paper mill facilities with coal- and/or oil-fired boilers without mercury control systems. These facilities include International Paper in Riegelwood, Kapstone in Roanoke Rapids and Blue Ridge Paper in Canton. It is expected the new Boiler MACT mercury limit will effect emission reduction by installing new emission controls and/or from fuel switching to natural gas. The two other paper mills in North Carolina are switching from coal and/or oil to natural gas for their industrial boilers instead of installing controls for continued coal- and/or oil-firing. EPA envisions that most coal- or oil-fired boilers would need a dry lime injection system with a baghouse to meet the proposed MACT emission limits for mercury, PM and hydrogen chloride with capital costs of more than $1 million.

The last group in Table 7-1 consists of two other facilities – city of Greensboro sewage sludge incinerator and Elementis Chromium in Castle Hayne – as principal mercury emission sources.

- The Greensboro sludge facility was recently rebuilt as a new fluidized bed incinerator with a new high efficiency scrubber with an absorber utilizing sodium hydroxide scrubber water for PM, acid gas and mercury control. Tests in 2011 showed mercury emissions of 17 lbs/yr, meeting the new EPA emission limit for this category and representing a significant drop from the 54 lbs/yr mercury emissions in 2010.
- Elementis Chromium produces chromium products from ore heated in kilns controlled with quench tanks and wet ESPs. In 2011 the company switched from oil to natural gas, which is expected to reduce future mercury emissions.

In summary, 19 facilities designated as the principal sources of mercury emissions either:

- Have recently installed effective mercury controls and conducted emission tests showing their effectiveness (seven largest EGUs, PCS, Nucor Steel and Greensboro Osborne);
- Are required to install effective mercury controls and to conduct tests showing their effectiveness to meet a more stringent EPA mercury emission limit (Stericycle);
- Have switched fuel that will reduce mercury emissions (Elementis Chromium); or
- Will be retired by 2015 (the 7 smaller EGUs).

The three paper mills with industrial boilers are considered the only uncontrolled principal sources of mercury emissions. For these facilities, it is envisioned that their coal- or oil-fired boilers could switch to natural gas or could need a dry lime/baghouse with capital costs of more than $1 million to meet the mercury emission limits in the March 2011 final Boiler MACT or in the December 2011 reconsidered Boiler MACT (see Figure 4-1). However, it is currently

[41] Revised Hospital, infectious, medical waste incinerator NSPS 40 CFR 60 Subpart Ce mercury emission limits.

unknown whether the proposed limits will remain in the reconsidered Boiler MACT rule expected to be finalized in summer of 2012. Since these three facilities have 112(j) boiler permits, their expected compliance date with the Boiler MACT will be in 2018.

TABLE 7-1. MERCURY EMISSION CONTROL PERFORMANCE OF SIGNIFICANT NORTH CAROLINA SOURCES

	Source	201 Mercury Emissions (lb/y)	Industry sector, Major emission source	Mercury Control Comments/ Characterization
Group 1. EGUs with high efficiency mercury controls installed				
1	Progress - Roxboro	14	EGUs with coal-fired boilers	90% mercury control on average required by EPA MATS rule effective in 2015; new controls already installed cost $2.9 billion.
2	Progress - Mayo	6		
3	Duke - Marshall	5		
4	Progress - Asheville	2		
5	Duke - Belews Creek	2		
6	Duke - Allen	1		
7	Duke – Cliffside Units 5-6	9		
	Duke – Cliffside Units 1-4			Retired Oct 2011
Group 2. EGUs already retired or planned to be retired, currently without mercury emission controls				
8	Progress - Sutton	11	EGUs with coal-fired boilers	Retire end 2013
9	Progress - Le	11		Retire fall 2012
1	Duke - Riverbend	8		Retire Jan 2015
1	Duke - Buck	8		Retired mid 2011
1	Progress - Cape Fear	7		Retire mid 2013
1	Duke - Dan River	3		Retired April 2012
1	Progress - Weatherspoon	3		Retired fall 2011
Group 3. Facilities with high efficiency controls already installed				
1	PCS Phosphate - Aurora	2	Fertilizer, coal calciners	High efficiency controls installed recently.
1	Nucor Steel - Hertford	29	Steel, electric arc furnace	High efficiency controls with variable mercury feed levels; expect lower future emissions from vehicle mercury switch removal program.
1	Stericycle – Haw River	1	Waste, medical waste incinerator	High efficiency controls with variable mercury feed levels.
Group 4. Industrial boilers expected to install mercury controls in response to EPA MACT rule				
1	International Paper - Riegelwood	12	Paper industry, coal-fired boilers	Currently without mercury controls; expect Boiler MACT mercury limit to reduce future emissions from new controls and/or fuel switching.
1	Blue Ridge Paper - Canton	4		
2	Kapstone Kraft Paper – Roanoke Rapids	2		
Group 5. Other facilities with principal mercury emission sources				
2	Greensboro – Osborne POTW	5	Government, sewage sludge incinerator	Effective new controls installed in 2010; 2011 Hg emissions = 17 lb/yr, meeting new EPA rule emission limit for this category
2	Elementis Chromium	2	Chromium products, #6 oil fired kilns	Switched fuel from oil to gas in 2011 and expect to reduce mercury emissions.

Section 8. Provide a recommendation of mercury control technology, including the cost and expected reductions in mercury emissions

By Jan. 1, 2013, both Duke Energy and Progress Energy will be required to submit mercury control plans identifying the technology for use at each unit.[42] The objective is to achieve maximum reduction in mercury emissions that is technically and economically feasible without relying on mercury allowances obtained through any trading system. Their installed controls and cost were reported in Section 7, along with their intention to retire uncontrolled units. Section 8 discusses any needs for additional mercury control scenarios with cost considerations.

The SO_2 and NOx controls, which were installed under CSA, have achieved their respective emission reduction targets prior to their respective compliance dates. These emission reductions also appear to be sufficient to meet the CSAPR emission budgets without the use of purchased allowances. The EPA MATS establishes emission rate limits (1.2 lb/TBtu) for mercury, likewise to be met without the use of purchased allowances or emissions trading. In contrast, the now vacated Clean Air Mercury Rule (CAMR) allowed compliance through a cap and trade budget. The intent under CSA, has been to restrict the sale of SO_2 and NOx allowances to others and to surrender to the state those allowances that were not used to offset emissions. This question regarding the ability of the companies to reach the CAMR budgets without trading disappears due to the current regulatory approach under MATS. The combined controls installed on CSA units appear to comply with the MATS mercury emission rate limits, eliminating the need for additional expensive pollution control equipment.

According to the information presented in Section 7, the remaining three non-EGU units that may need additional mercury emission controls are in the process of being regulated under new federal regulations. They will have requirements to achieve compliance with either appropriate emission controls, or fuel switching to natural gas. Closure of these non-EGUs does not appear to be likely as they seem to be capable of achieving compliance.

In conclusion, DAQ finds that currently there is no need for further mercury reductions from the coal fired electrical generating units that did not install controls specifically for mercury under CSA. In some cases, factors related to relative fuel costs and resultant emission reductions have caused the companies to replace their generation capacity by switching to natural gas. In combination with the companies' plans to shut down all remaining coal fired units, the question of any remaining costs is no longer relevant.

[42] 15 NCAC 15A NCAC 02D .2511(b).

Section 9. Results of studies and monitoring on mercury in fish in North Carolina, including an evaluation of the impact of reduced mercury emissions from coal-fired power plants on the level of mercury observed in fish tissue

"Mercury and its species" means all compounds or forms of mercury that are routinely analyzed for in fish tissue bioassays. Fish tissue samples collected in North Carolina are typically analyzed for total mercury, which exists almost entirely (95-100 percent) as methylmercury.

9.1 Executive Summary

A primary objective of the DWQ fish tissue-monitoring program is to provide state health officials with information about mercury concentrations among game-fish populations for the protection of North Carolina's citizens who consume them. This goal has been met with small datasets from locations throughout North Carolina, which have routinely shown fish-mercury contamination at various levels among most waterbodies. Routine statewide monitoring of total mercury among one of the state's most popular and abundant sport fish, Largemouth Bass (*Micropterous salmoides*), has resulted in a statewide consumption advisory for this top predator species.

The rate and degree to which mercury bioaccumulates within fish and other aquatic biota is dependent on a host of environmental and biotic factors including a waterbody's productivity, food chain length and rates of mercury methylation, which are all in part defined by geographical, physical and chemical characteristics. Waterbodies located in the state's coastal plain ecoregions (generally east of I-95) are known to be particularly susceptible to mercury contamination and bioaccumulation in fish because of their specific environmental conditions. Relative to the piedmont and mountain areas of the state, the coastal plain's low-lying fresh water systems include wetlands and slow-moving streams that are typically characterized by warm, low pH waters with high concentrations of dissolved organic carbon. Notwithstanding these principal environmental characteristics and their influences on fish mercury concentrations in the eastern part of the state, a comprehensive understanding of mercury transport and cycling in freshwater ecosystems is still vaguely understood.

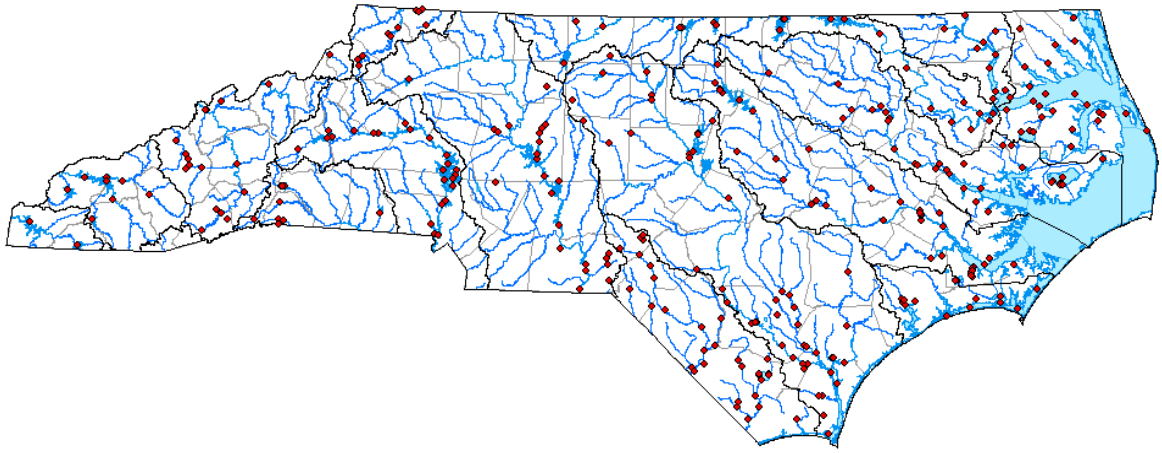
In response to the current schedule of mercury emission reductions from North Carolina's coal-fired electricity generating facilities per 15A NCAC 2D .2509, 13 statewide monitoring stations were established by DWQ in 2008 for long-term fish mercury analysis. Using linear regressions of Largemouth Bass mercury concentrations, no statistically significant linear trends have been observed at these monitoring stations. Given that the current and future mercury emission reductions from coal-fired boiler units operating in North Carolina make up a small amount of the total mercury deposition in North Carolina, it is possible that statistically significant trends of decreasing fish mercury levels will not become clear any time soon.

9.2 North Carolina's Fish Mercury Database

DWQ's fish tissue results for total mercury (roughly equivalent to methylmercury) are used as indicators of human and wildlife health concerns related to fish consumption. From 1990 to 2011, DWQ has processed and analyzed approximately 7,600 fish tissue samples for total mercury from approximately 330 statewide locations (Figure 9-1). This data set represents an average of 23 fish tissue samples per collection site.

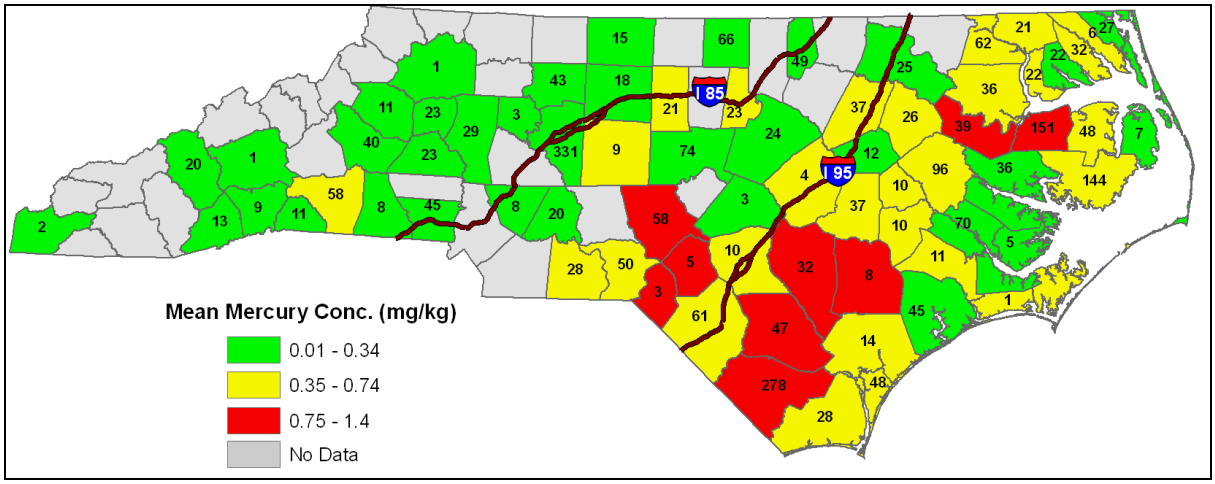
A majority of the records in the DWQ mercury database are associated with the following five fish species: Largemouth Bass (*Micropterus salmoides)*, Bowfin (*Amia calva*), Bluegill (*Lepomis macrochirus*), Redear Sunfish (*Lepomis microlophus)* and Channel Catfish (*Ictalurus punctatus*). Collective records for these species represent 58 percent of the DWQ fish tissue mercury data collected from 1990 to 2011. Six of the most common fish species included in the DWQ mercury database (i.e. Largemouth Bass, Bowfin, Chain Pickerel, Warmouth, Yellow Perch, and Spotted Sucker) are characterized by mercury data that meets or exceeds the state's fish consumption advisory action level of 0.4 milligram (mg)/kg in greater than half of their respective records. This list is represented by either top predator or bottom-feeding species in which mercury bioaccumulation is most pronounced.

Figure 9-1. 1990 – 2011 DWQ statewide fish mercury sampling station locations. Note: many overlapping sites are not visible at this resolution.



Largemouth Bass embody the largest data subset within the DWQ fish mercury database, representing 2,528 or 33 percent of the 7,615 records. Most of the elevated mercury concentrations in Largemouth Bass occur within the Coastal Plain ecoregion, which is effectively equivalent to locations found east of I-95 (Figure 9-2). However, mercury concentrations in Largemouth Bass that exceed the state's fish consumption advisory action level of 0.4 mg/kg occur statewide. The highest mercury burdens of Largemouth Bass have been found in the southernmost part of the state in the Waccamaw River watershed, with mercury concentrations reaching a maximum of 3.6 mg/kg. The Sandhills Ecoregion, which includes the upper reaches of the Lumber River Basin in Scotland, Richmond, Hoke and Moore counties, also holds numerous Largemouth Bass samples that are well above the state's fish consumption advisory action level.

Figure 9-2. 1990-2011 DWQ Largemouth Bass Mercury Concentrations.



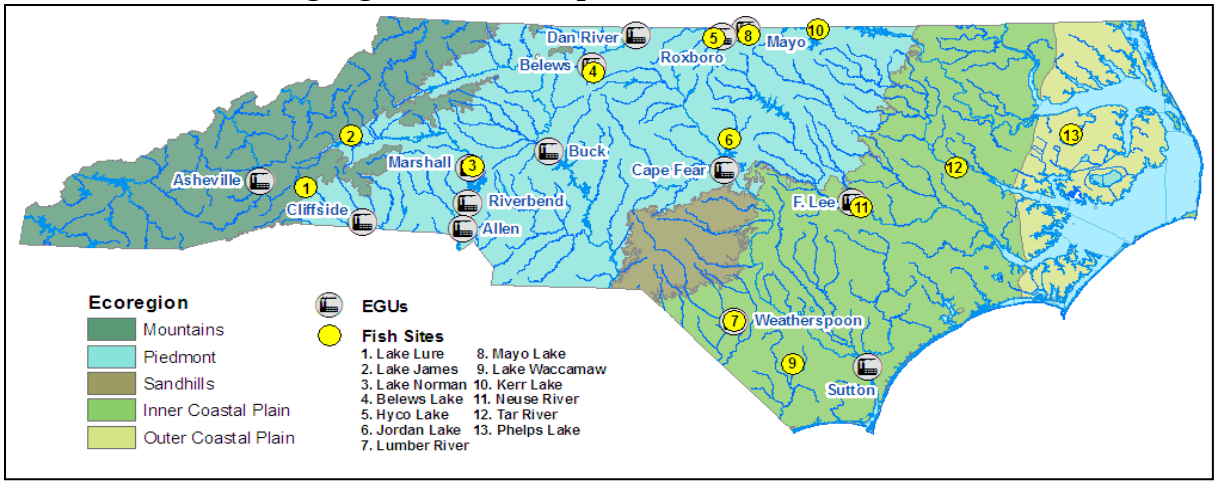
Values indicate the number of samples analyzed in each county. Categories were established to facilitate rounding-up based on a 0.4 mg/kg fish consumption advisory action level.

9.3 Current Fish Mercury Monitoring Sites Related to 15A NCAC 2D .2509

Thirteen fish tissue collection sites across the state have been sampled annually since 2008 (Figure 9-3). These locations will be sampled for 10 consecutive years:

- 4 sites (# 3, 4, 5, and 8) are located in lakes next to N.C.'s largest coal boiler facilities currently controlled with scrubbers (Marshall, Belews Creek, Roxboro and Mayo).
- 3 sites (# 1, 6, and 10) are located in lakes within 20 miles of coal boiler facilities with scrubbers (Asheville and Mayo), or soon to be retired (Cape Fear).
- 1 site (# 2) is located in a lake within 50 miles of a EGU currently with scrubbers (Asheville).
- 3 sites (# 7, 11, and 12) are located within North Carolina's main rivers.
- 2 sites (# 9 and 13) are located in lakes where DAQ has greater than 10 years of mercury deposition network monitoring data.

Figure 9-3. Annual fish-mercury monitoring sites related to 15A NCAC 2D.2509. Names of EGUs are highlighted on the map.



9.4 Mercury trend analysis for Largemouth Bass at 13 statewide monitoring sites

Linear regressions of normalized-length Largemouth Bass mercury concentrations were plotted for fish-mercury at each of the 13 fish monitoring sites (Table 9-1). A length of 14 inches was used to normalize mercury concentrations, representing the most common minimum harvest size allowed for Largemouth Bass in inland waterbodies across North Carolina.[43] Temporal sampling ranges plotted for the 13 sites are from three to 10 years, depending on the availability of historic largemouth bass mercury data, and the total number of fish collected during each annual sampling trip (i.e., a mercury concentration normalized to 14 inches could not be calculated for sampling trips with fewer than three individuals collected). Although additional fish species were collected for supplemental trend analysis, adequate numbers of collected individuals only exist for Largemouth Bass; therefore, annual trend analyses of other fish species was not performed.

Largemouth Bass mercury concentrations are highly variable between sampling years at each site (Table 9-1). Linear regression analysis of mercury concentrations at the sampling sites did not show any statistically significant trends of decreasing or increasing mercury levels in Largemouth Bass over the period of 1990 to 2011. In a previous North Carolina fish-mercury study of the Abbotts Creek Arm of High Rock Lake, significant temporal responses to the removal of an aquatic point source took approximately a decade to occur. Moreover, it is possible that the current and planned emission reductions in North Carolina will be offset by non-point deposition from regional and global atmospheric pools of mercury.

[43] NCWRC, "North Carolina inland fishing, hunting and trapping regulations digest," Effective Aug. 1, 2011 to July 31, 2012. http://www.ncwildlife.org/Portals/0/Regs/Documents/2011-12/2011-12_RegsDigest.pdf.

Table 9-1. Largemouth Bass Mercury Concentrations (mg/kg) at 13 Monitoring Sites across N.C. by Year [1].

Site No. [2]	Sample Location	Year																		
		Collected prior to 15A NCAC 2D.2509															Related to 15A NCAC 2D.2509 [3]			
		1990	1992	1993	1994	1995	1996	1997	1998	1999	2000	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	Lake Lure	-	-	-	-	**0.40**	-	-	-	-	-	-	-	-	-	-	0.36	0.39	**0.45**	0.37
2	Lake James	-	-	-	-	-	-	-	-	-	-	-	-	0.27	-	-	0.22	0.20	0.31	0.24
3	Lake Norman	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	-	-	0.21	0.19	0.12
4	Belews Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	-	0.15	0.20
5	Hyco Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.16	0.19	0.13
6	Lake Jordan	0.14	-	-	-	-	-	-	0.27	-	-	-	-	-	-	-	0.23	0.34	0.18	0.10
7	Lumber River	-	-	**0.52**	-	-	-	-	-	-	-	-	-	-	-	-	**0.57**	**0.61**	**0.74**	**0.73**
8	Mayo Lake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27	0.21	0.25
9	Lake Waccamaw	-	**0.47**	**0.95**	-	-	**0.93**	-	-	-	-	**0.84**	-	-	-	-	**0.80**	**1.07**	**0.83**	**1.18**
10	Kerr Lake	-	-	-	-	-	-	-	-	**0.43**	-	-	-	-	-	-	0.35	0.23	0.34	0.32
11	Neuse River	-	-	-	**0.48**	-	-	-	-	-	**0.53**	-	-	-	-	-	**0.40**	-	0.20	0.33
12	Tar River	-	**0.51**	**-**	-	-	-	**0.58**	-	-	**0.66**	-	-	-	-	-	-	0.29	**0.51**	**0.43**
13	Phelps Lake	-	-	-	**0.66**	**0.91**	-	-	-	-	-	**0.83**	**0.70**	-	**0.94**	**0.74**	**0.72**	**0.49**	**0.70**	**0.60**

[1] All mercury concentrations were normalized to a total fish length of 14 inches (minimum harvest size allowed for Largemouth Bass in most inland waters of NC (NCWRC 2011)).

No statistically significant linear trends in mercury concentrations were found at any of the 13 monitoring sites.

Bold numbers either meet or exceed the 0.4 mg/kg fish consumption advisory action level set by the N.C. Department of Health and Human Services.

[2] Site numbers correspond to the map numbers shown in Figure 10-3.

[3] DWQ began sampling fish tissues related to15A NCAC 2D .2509 in 2008.

Some mercury concentrations could not be normalized to 14 inches in 2008 and 2009 because less than three individuals of Largemouth Bass were collected at that site.

9.5 Historic DWQ Mercury Studies

DWQ Eastern Regional Mercury Study and Mercury Study Extension

The Eastern Regional Mercury Study (ERMS) was conducted from November 2002 to July 2003 to determine low level mercury concentrations in surface waters and sediments at 11 sites in eastern North Carolina.[44] In 2004, the study was extended to include additional sampling at three of the 2002-2003 sites and at eight new sites (Mercury Study Extension).[45] The study was expanded to include waters in the central and western portions of the state. Quarterly (fall, winter, spring and summer) sampling was conducted during both studies to address seasonal variations at the study sites. Parameters collected at the sites included total and monomethyl mercury, sediment mercury, sulfate, dissolved organic carbon, nutrients and physical parameters. The majority of the total mercury concentrations measured at the study sites are below the North Carolina surface water quality standard of 12 ng/l. Total mercury and methylmercury concentrations in North Carolina waters do not appear to be significantly different than those observed in other areas of EPA Region IV.

9.6 Fish Mercury Research in North Carolina

The following research projects at North Carolina State University (NCSU) and the University of North Carolina at Chapel Hill (UNC-CH) were principally funded by the Water Resources Research Institute of the University of North Carolina (WRRI).

NCSU

Scientists at N.C. State University have completed several WRRI funded studies investigating fish mercury levels in N.C.'s aquatic ecosystems. The principal objectives were to gain a better understanding of mercury dynamics in N.C. waterbodies for the development of predictive models for fish mercury risk assessment. This research was conducted by Dr. Dana Sackett while she was a Doctor of Philosophy (Ph.D.) student at NCSU under the primary direction of Drs. Derek Aday and James Rice of the Department of Zoology. The publications summarized below were incorporated as chapters into Dr. Sackett's Ph.D., dissertation titled: *Evaluating mercury dynamics and trophic transfer in aquatic ecosystems.*[46]

A statewide assessment of mercury dynamics in North Carolina waterbodies and fish.[47]

Using existing and available data sets compiled by DWQ and others from 1990 to 2006, their initial study examined the relationships between fish mercury concentrations and a suite of physical, chemical, and biological factors that are relatively easy to measure. Multivariate tests were conducted to create predictive statistical models that relate these environmental drivers of mercury transport in aquatic ecosystems to fish mercury concentrations in North Carolina

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[44] NCDWQ, "2002-2003 NC Eastern Regional Mercury Study," 2003. http://portal.ncdenr.org/c/document_library/get_file?uuid=0693129f-56b9-4b36-ab05-2a85de3dd784&groupId=38364

[45] NCDWQ "Mercury Study Extension Data, 2005-2006," 2007, http://portal.ncdenr.org/c/document_library/get_file?uuid=f5914e77-00b0-4169-b74e-08b7503ebed8&groupId=38364

[46] Sackett, D. K. "Evaluating mercury dynamics and trophic transfer in aquatic ecosystems" (NCSU Ph.D. dissertation). ProQuest document ID: 898334097: ISBN:9781124923277, 2011.

[47] Sackett, D. K., Aday, D. D., Rice, J. A., and Cope, W. G. "A statewide assessment of mercury dynamics in North Carolina water bodies and fish," TAFS 138:1328-1341, 2009.

waterbodies. Their study showed that 81 percent of the variability in fish tissue mercury levels can be explained by fish trophic status, ecoregion and pH. By examining the relative importance of many biotic and abiotic variables over a wide range of ecosystems and fish species found throughout North Carolina, their study serves as a template for future investigations and should help state policymakers with risk assessment decisions.

Does proximity to coal-fired power plants influence fish tissue mercury?[48]
The second phase of fish-mercury research at NCSU examined the relative importance of proximity to coal-fired power plants on fish mercury concentrations in two fish species of different trophic positions (Largemouth Bass, and Bluegill). Using seven lakes considered to be near coal fired power plants (<10km) and seven lakes considered to be far (>30km), their study tested if higher deposition levels near power plants would also translate into higher fish mercury levels. In addition to confirming that mercury concentrations in fish are driven by biotic characteristics (e.g., trophic position, age, total length) and waterbody characteristics (e.g., pH, dissolved organic carbon and sulfate), they found that significantly less fish-mercury bioaccumulation occurs in lakes near coal fired power plants. This means that differences in fish-mercury levels in lakes near power plants appear to be lower because selenium reduces the methylation of mercury.

The third phase of fish mercury research at NCSU is focusing on fish body size and fisheries management, with an objective of understanding if current harvest regulations are encouraging anglers in North Carolina to consume fish with unsafe mercury levels. A journal paper covering this research is currently in review for publication.

UNC-CH
Scientists at UNC-CH recently completed a WRRI funded study titled: *Space/time estimation of fish tissue mercury along unsampled streams in eastern North Carolina.*[49] This research was conducted by Dr. Marc Serre and Dr. Eric Money while Dr. Money was a Ph.D. student at the School of Public Health Department of Environmental Sciences and Engineering, and in collaboration with two scientists at NCSU (Dana Sackett and Derek Aday). This work was also published as a journal article titled: *Using river distance and existing hydrography data can improve the geostatistical estimation of fish tissue mercury at unsampled locations.*[50]

Using a subset of mercury data for the Lumber and Cape Fear River basins, their study examined a combination of data sources that may improve the estimation of fish tissue mercury concentrations in waterbodies with impairments or data deficiencies. Estimation maps were produced that were on average 16 percent more accurate when accounting for river distance and

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[48] Sackett, D. K., Aday, D. D., Rice, J. A., Cope, W. G., and Buchwalter, D. "Does proximity to coal-fired power plants influence fish tissue mercury?," Ecotoxicology 19:8:1601-1611, 2010.
[49] Money and Serre, "Space/time estimation of fish tissue mercury along unsampled streams in eastern North Carolina," WRRI report No. 393, 2010. http://repository.lib.ncsu.edu/dr/bitstream/1840.4/8102/1/NC-WRRI-393.pdf
[50] Money, E. S, Sackett, D. K., Aday, D. D., and Serre, M. L. "Using river distance and existing hydrography data can improve the geostatistical estimation of fish tissue mercury at unsampled locations," Environ Science & Technology, 2011, 45:7746-7753.

the secondary variables pH and water column total mercury. Both secondary variables contributed to an overall decrease in estimation error, albeit small due to the limited amount of data points available for these variables. The use of the river-Bayesian Maximum Entropy method in this study contributed 13 percent of the reduction in estimation error and provides a good framework for further decreases in estimation error with the addition of other secondary factors in future work.

This research demonstrates that water column total mercury data can provide a valuable alternate source of information to estimate fish tissue mercury levels. Furthermore, incorporating additional information about species type and habitat patterns could result in even more accurate maps. Overall, the framework developed in this research is a good starting point and can aid environmental managers in identifying important bioaccumulation factors and areas where sampling and advisory resources can be targeted.

9.7 Evaluation of the Impact of Reduced Mercury Emissions from Coal-fired Power Plants on the Levels of Mercury Observed in Fish Tissue.

The results of studies and monitoring on mercury and its species in fish in North Carolina discussed above shows no statistically significant change in spatial or temporal trends in the levels of mercury observed in fish tissue over recent years. Despite the considerable mercury emission reductions from N.C. coal-fired electricity generating units, the finding of no significant change in mercury fish levels is consistent with the results of the deposition modeling presented in Section 3. The deposition modeling results indicate that mercury deposition in North Carolina is largely attributed to mercury emission sources distant from North Carolina. While emissions from in-state and other U.S. states have been and will be reduced, mercury emissions from Mexico, Canada and other countries worldwide are expected by EPA to be unchanged in the future from those used in 2005.

Section 10. A summary of mercury-related health problems in NC, including accumulation of mercury in humans, toxicity, and mercury exposure from non-air emitting sources.

In 2008 two goals were established in the Statement of Work submitted to the Environmental Management Commission (EMC) for the Interim Report.
GOAL 1: to undertake to update the Secretary's Science Advisory Board (SAB) on Toxic Air Pollutants 2000 report, "Mercury in the Environment."
GOAL 2: report on the mercury-related health problems existing before installation of mercury controls on EGUs.

GOAL 1
In 2008 the SAB reviewed its 2000 report, "Mercury in the Environment," and determined that the information was current and no changes were indicated.

GOAL 2
In August 2006, the Centers for Disease Control and Prevention (CDC) and the N.C. Department of Health and Human Services (DHHS) conducted a pilot study[51] to identify a cohort of people who consumed at least six ounces of locally caught fish twice per week (defined as a "large amount") and had measurable concentrations of serum mercury. Specifically, the objectives of this study were:

- To determine whether there were persons with elevated mercury concentrations living in areas identified by the EPA to have high mercury emissions and deposition.
- To assess the feasibility of identifying, recruiting and enrolling these persons.
- To create sampling procedures for establishing baseline mercury concentrations in a highly exposed population and subsequently monitoring future trends in the same geographical areas.
- To determine the public health impact of high levels of mercury emission and deposition in the environment by collecting blood mercury data from subsistence fishermen who routinely consume fish from these areas.

If successful, this pilot project would be used to evaluate a larger cohort over time (as long as a decade) across multiple N.C. locations. In this way, the benefits to human health of regulatory efforts to reduce mercury emissions, as measured by reduced levels of serum mercury, may be observed in those whose diets consist of the consumption of a "large amount" of locally caught fish.

Columbus and Brunswick counties were selected for this study because: (1) EPA determined that there was elevated mercury deposition in these counties; (2) environmental conditions were such that the conversion of mercury to methylmercury was efficient; (3) fish tissue was elevated with respect to mercury; and (4) subsistence fishing was common. In addition, a 1993 DHHS study of methylmercury concentrations in blood samples from a sample of subsistence fishermen and their families indicated elevated levels (mean = 7.5 micrograms per liter, μg/L).

[51] Blood Mercury Levels Among Fish Consumers Residing in Areas with High Environmental Burden of Mercury. Report submitted to North Carolina Department of Health and Human Services, April 2007.

The cohort of this pilot study consisted of English and/or Spanish-speaking subsistence fisherman and family members, 18 years of age or older at the time of the study, who consumed at least six ounces of fish at least twice per week, caught from Big Swamp, the Lumber River and/or the Waccamaw River. Pregnant women were excluded from the study. One hundred seventeen participants were enrolled in the study. Of this, blood samples were drawn from 100 enrollees and analyzed for total and organic mercury. Organic mercury is indicative of methylmercury intake from fish and shellfish.

The mean age of the 73 male and 27 female study participants was 50 years. Eighty-eight percent were from Columbus County and 12 percent were from Brunswick County. Of these participants, 98 percent were Caucasian, 4 percent were Latino, 1 percent American Indian and 1 percent other.

In response to a questionnaire completed by each participant, the mean number of servings of locally caught fish (at least 6 oz. serving size) was 2.7 (range 2-8) and the mean number of servings (at least 6 oz. serving size) of any fish was 4.7 (range 2-15). Ninety percent of these participants ate fish caught from the Waccamaw River, 32 percent from Big Swamp and 32 percent from the Lumber River. Twenty-one percent ate fish from other local fishing sites. Blackfish, bowfin, catfish and largemouth bass were the most popular species consumed, whose tissues tend to be high in mercury concentration. Eighty-eight percent of participants reported that other fish species were also eaten during the previous month: brim, flounder, crappie, perch and whiting.

Analysis of blood samples taken from the study participants yielded the following information:

- The geometric mean serum mercury level = 2.0 µg/L (95 percent Confidence interval: 1.5, 2.8).
- Females: mean serum mercury level = 0.8 µg/L (95 percent Confidence interval: 0.5, 1.4)
- Females of childbearing age (18-49 years): mean serum mercury level = 0.4 µg/L (95 percent Confidence interval: 0.2, 0.6). *No females of child-bearing age had a mercury level greater than the Reference Level of 3.5 µg/L.*
- Males: mean serum mercury level = 2.8 µg/L (95 percent Confidence interval: 2.1, 3.7)
- Latinos had significantly higher mercury levels (mean = 6.2 µg/L, 95 percent Confidence interval: 2.3, 62) compared to non-Latinos (mean = 1.9 µg/L, 95 percent Confidence interval: 0.9, 3.4)
- The range of serum mercury levels was less than limit of detection (LOD= 0.33 µg/L) to 44 µg/L.
- 7 percent of participants had levels greater than 20 µg/L (warning level for elevated mercury exposure).
- No statistically significant differences in mean serum mercury levels were detected in those whose drinking water source was a well and those who had a municipal source.
- No statistically significant differences in mean serum mercury levels were detected among those who ate fish caught from the Waccamaw River, Big Swamp, or the Lumber River.
- No correlation was found in serum mercury levels and number of fish servings eaten per week.

- Serum mercury levels were compared between the study population and a national reference level for the United States.

Source	50th percentile mean (95 percent Confidence interval) (µg/L)	95th percentile mean (95 percent Confidence interval) (µg/L)
NHANES*	0.9 (0.8, 1.0)	6.0 (5.1, 10.7)
NC Cohort	71 percent had levels greater than 0.9	23 percent had levels greater than 6.0

* NHANES (National Health and Nutrition Examination Survey, 1999-2002); only includes females 16-49 years of age.

- No significant difference in the number of total servings consumed per week were observed between those with exposures greater than the NHANES 95th percentile (6.0 µg/L) and those with exposure less than the NHANES 95th percentile.
- Inorganic mercury contributed in a minor way to total serum mercury concentrations (median = 7 percent contribution). The geometric mean of organic mercury was 0.3 µg/L (95 percent Confidence interval: 0.2, 0.6) and the range was from less than the limit of detection (LOD = 0.35 µg/L) to 42 µg/L.

This pilot study suffered from the following design flaws:

- The former Holtrachem facility (that was closed in 2001), located in the general area of the Waccamaw River, was a chlor-alkali plant that used large quantities of metallic mercury as a catalyst in its production process. Substantial quantities of mercury leaked into the ground from plant operations and contaminated Lake Waccamaw. Thus, the body burdens of mercury found in this study attributable to emissions from coal-fired plants are confounded by the contribution of Holtrachem.
- As a consequence of the ongoing Holtrachem contribution, reductions in mercury emissions from coal-fired power plants may not be observed either in fish tissue or human serum in this region.
- Conclusions drawn from this study may not be representative of subsistence fisherman throughout the state. It is unknown, because of sample size and confounders, if these conclusions are even attributable to subsistence fishermen in Columbus and Brunswick counties.
- The contribution to the total body burden of mercury from freshwater fish vs. saltwater fish is unknown in the population consuming both types.
- No data were collected on the consumption of canned or bagged tuna, as there were no fresh tuna caught for this study. Canned tuna is known to contain elevated levels of mercury.

One of the major difficulties with following-on to this pilot study is that this kind of health study is beyond the mission of DAQ. DHHS and CDC conducted the pilot study, and health-based studies requiring sampling of human tissues are in the purview of DHHS. DAQ has been informed by DHHS that funding will be required if a follow-on work effort is to be performed.

At this time, the follow-on project that would have been used to evaluate a larger cohort over time (as long as a decade) across multiple N.C. locations has not been attempted because of funding

constraints.[52] Therefore, the benefits to human health of regulatory efforts to reduce mercury emissions, as measured by reduced levels of serum mercury, have not been analyzed for those whose diets consist of the consumption of a "large amount" of locally caught fish on a larger scale.

A study similar to the proposed follow-on study including populations from Maryland and South Dakota was recently published by Wolkin *et.al.* (2012).[53] Results indicate study populations had blood mercury levels greater than the national average; however, the number of servings of fish consumed was not found to be associated with blood mercury levels. The authors also reported that identifying and monitoring these populations over time would be challenging.

Additionally, a recent human-health assessment was conducted to estimate exposure using modeled mercury emissions data for the coal and oil - fired EGU source category on a national scale to support the new MATS rule.[54] Comparatively, the results of the risk assessment for EGUs also indicate that mercury deposition from other sources was not considered and from 22 – 29 percent of the watersheds included in the assessment could be considered to have "at-risk" populations (e.g. mercury levels in fish tissue above health thresholds[55]). Second, the fish mercury concentration data for watersheds located in areas with elevated EGU-related mercury deposition is limited. Therefore, watersheds with "at-risk" populations could be substantially larger than estimated. Third, even with no additional mercury deposition, the total mercury exposure would exceed established health thresholds for watersheds with "at-risk" populations. Reductions in mercury deposition from EGUs would reduce the magnitude of the risk even though total exposure and risk would remain. Lastly, the study found no strong correlation between mercury fish tissue levels and total mercury deposition because of differences in methylation potential in individual watersheds. Evidence does support a steady-state linear relationship between changes in mercury deposition and changes in fish tissue mercury concentrations given all the sources of mercury deposition are taken into account.

Overall, the state of the science regarding the toxicology of mercury health effects has not advanced significantly since the late 1990s. Biological changes in humans from ingestion of mercury-contaminated fish tissue can occur over a lifetime of exposure. Conclusions correlating reductions in mercury emissions with reductions in adverse human health effects based on ingestion of contaminated fish cannot be definitively made until new scientific evidence is found. Reductions in mercury emissions will reduce the amount of mercury entering the ecosystem, but how those reductions impact those living in that ecosystem remains to be seen.

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[52] Personal Communication, Dr. Ken Rudo, NC DHHS, January 12, 2012.

[53] Amy Wolkin, Danielle Hunt, Colleen Martin, Kathleen L. Caldwell, Michael A. McGeehin. 2012. Blood mercury levels among fish consumers residing in areas with high environmental burden. Chemosphere, Volume 86, Issue 9, March 2012, Pages 967–971.

[54] EPA. 2011. National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-fuel-fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units. EPA-HQ-OAR-2009-0234 and EPA-HQ-OAR-2011-0044.

[55] Mercury Reference Dose (RfD) = 0.1 µg/kg body weight/day

Section 11. Report on "results of studies on mercury deposition, applying monitoring techniques, back trajectory analysis, source attribution methodology, and any other relevant methodologies to assess the role of coal-fired units in North Carolina deposition."

The proposed effort for a monitoring and analysis study with contracted services consistent with Task 11 was described to the Air Quality Committee in 2008. The study was intended to assess the role of coal-fired power plants on mercury deposition during periods before and after a FGD scrubber installation in North Carolina. The plan was to collect a broad set of monitoring data consisting of the three ambient air mercury species, wet and dry mercury deposition and several criteria pollutants near a coal-fired EGU. The proposed effort would have included back trajectory analysis from the multi-year study and modeling outputs to show deposition patterns.

In the July 2008 Mercury Report presentation, DAQ staff informed Air Quality Committee (AQC) members that the proposed Task 11 study could not be implemented without additional funding. The contractual effort to complete such a study would have cost several hundred thousand dollars. The AQC was informed DAQ would be unable to support such costs unless the AQC/EMC arranged an appropriation for the full amount of the study from the General Assembly. Given the appropriation was not secured, the study was not conducted. In lieu of conducting the study, DAQ considered including similar and/or related EGU deposition study results performed by other states or organization. However, similar studies performed by other organizations were not found. The following discussion addressed several underlining points driving the need for a study and related issues on mercury in North Carolina.

11.1 Comprehensive Monitoring and Analysis Study in Steubenville, Ohio[56]

In late 2002 an enhanced air monitoring site was established in Steubenville, Ohio, as part of a multi-year comprehensive mercury monitoring and source apportionment study to investigate the impact of local and regional coal combustion sources on atmospheric mercury deposition in the Ohio River Valley. This study deployed advanced monitoring instrumentation, utilized innovative analytical techniques and applied state-of-the-art statistical receptor models. EPA and University of Michigan researchers have refined tools used to trace mercury by using a combination of advanced methods that include precipitation monitoring and computer models. The study included wet deposition data and source apportionment modeling results from daily event precipitation samples collected during the calendar years 2003-2004. The volume-weighted mean mercury concentrations for 2003 and 2004 were 14.0 and 13.5 nanograms per liter (ng/L), respectively, and total annual mercury wet deposition was 13.5 and 19.7 micrograms per square meter (ug/m^2), respectively. Two new EPA implemented multivariate statistical models, positive matrix factorization and Unmix, were applied to the data set and six sources were identified. The results indicated that approximately 70 percent of the mercury *wet* deposition was found by both models to be contributed from coal combustion and a majority of the *wet* deposition was due to local and regional sources in Steubenville, Ohio. The results found on the relationship between EGU emissions and the extent of mercury wet deposition in the Ohio River Valley may or may not apply in North Carolina.

[56] Keeler, G.J., Landis, M. "*Sources of Mercury Wet Deposition in Eastern Ohio," Environmental Science and Technology,* Sept 8, 2006, summary accessed at http://www.epa.gov/mercury/science.htm *in May 2012.*

11.2 Mercury Deposition Modeling for North Carolina EGUs

Recent estimates of annual global mercury emissions from all sources are in the range of 10 million to 16 million lbs/yr.[57] Some of the mercury released from sources deposit nearby while the remainder can travel thousands of miles in the atmosphere before it is eventually deposited in rainfall (wet deposition) or in dry gaseous form (dry deposition). The suspended mercury traveling such great distances is referred to as the global pool of mercury circulating around the world. The amount deposited depends on the form of mercury released, mercury emission rate and stack height and exit velocity. Mercury exists in the atmosphere in three forms or species:

- Elemental gaseous mercury, non-reactive and generally deposits far away from release;
- Oxidized mercury, highly reactive and generally deposits near its release; and
- Particle-bound mercury, which also generally deposits near its release.

Wet deposition involves the transfer of mercury from the atmosphere to land or water through precipitation. The water-soluble forms of mercury may be scrubbed out of the atmosphere by cloud water or rain and snowfall. For many sensitive surface waters, atmospheric wet deposition constitutes a significant route of mercury input. Dry deposition of particles and gases occurs by complex processes such as settling, impaction and adsorption. Dry deposition processes also contribute to the overall rate of atmospheric deposition. Together, these phenomena can contribute to raise methylmercury levels in fish in mercury-sensitive waters (http://daq.state.nc.us/toxics/studies/mercury/wet_dep.shtml).

Mercury atmospheric deposition is assessed using the EPA CMAQ model. The CMAQ model, the emissions data and the meteorological simulations for the entire year of 2005 were provided by EPA. Model runs were performed by DAQ to estimate nonpoint source (air deposition) loading of total mercury from in-state, regional and global sources. The CMAQ model was designed to simulate various chemical and physical processes that are important for understanding atmospheric trace gas transformations and distributions.

DAQ conducted modeling to estimate the amount of mercury deposition across North Carolina, respectively with the following results:

- For 2005, roughly 9,900 lbs of mercury are deposited in North Carolina relative to 4,300 lbs of in-state emissions.
- For 2016 compared to 2005, mercury deposited in North Carolina is reduced by 10 percent to roughly 8,900 lbs relative to 750 lbs emissions of in-state emissions.
- Removing all EGU mercury emissions in 2016 reduces the total deposited to 8,700 lbs.

11.3 Highlights from this report

Four earlier DAQ reports during 2003-2008 provided data showing coal-fired EGUs were responsible for the majority of mercury emission in North Carolina. This 2012 report provides similar and updated information from the earlier reports on the same issues related to the control

[57] United Nations Environment Program Global Atmospheric Mercury Assessment: Sources, Emissions and Transport, accessed at http://www.epa.gov/international/toxics/mercury/mercury_context.html#worldwide in May 2012.

of mercury emissions from coal-fired EGUs and from other principal sources of mercury. The key findings of this report include the following points.

Emissions of mercury

- In 2010 1,850 lbs of airborne mercury was released from largely the same facilities designated as the principal sources of mercury in the state since 2002. There are 22 principal sources of mercury accounting for 98 percent of the states' emissions, including 14 coal-fired EGUs and eight other industrial facilities.
- Fifty-two percent of current N.C. mercury emissions come from coal-fired EGUs. New controls with 90+ percent mercury removal were installed during 2005-2010 on seven of the largest EGU facilities.
- The other 48 percent of emissions (~890 lbs/yr) come from two metal industry facilities, industrial boilers at paper mills, waste incinerators and numerous small sources. Several industry sources have installed controls effective at mercury removal and several are switching to natural gas that will reduce their mercury emissions.
- Figure 11-1 and Table 11-1 presents the actual and projected EGU and non-EGU mercury emissions from 2002 to 2025 with statewide reductions reaching more than 80 percent from 2002 levels. The estimates show that mercury emissions from 2002 to 2025 are projected to decline for EGU facilities from 3,500 lbs to 580 lbs for a 83 percent reduction and for non-EGU facilities from 1,950 lbs to 800 lbs for a nearly 60 percent reduction. The figure reflects that past EGU reductions were achieved from new CSA-required controls, and future EGU reductions will be largely due to retiring the smaller coal-fired EGUs and burning less coal.

Figure 11-1. Actual and Projected EGU and Non-EGU Mercury Emissions from 2002 to 2025.

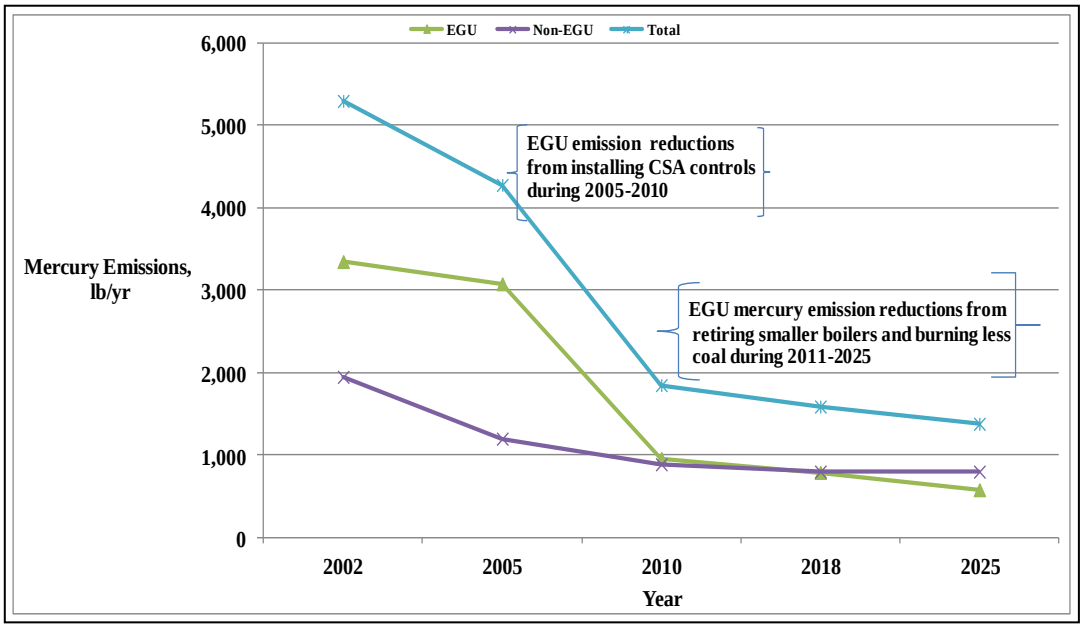

Table 11-1. Actual and Projected EGU and Non-EGU Mercury Emissions from 2002 to 2025.

Year	2002	2010	2018	2025
	Mercury emissions, lb/yr			
EGU	3,350	960	790	580
Non-EGU	1,950	890	800	800
Total	5,300	1,850	1,590	1,380
% EGU Decline from 2002		71%	76%	83%
% Non- EGU Decline from 2002		54%	59%	59%
% Total Decline from 2002		65%	70%	74%

- The 2012 EPA Mercury and Air Toxics Standards Rule for EGUs require stringent mercury emission control as verified by continuous monitors. Assessment of the installed controls on the largest North Carolina EGUs indicate 90 percent capture of total mercury and 95 percent of the mercury species prone to deposit near their release. The emission control combination of a SCR or SNCR, ESP and FGD on eastern bituminous coal-fired utility boilers in North Carolina achieves high collection performance not only for mercury, but also for particulate, metals and acid gases. Relatively minor performance improvements with costs well below CSA costs are being evaluated at the largest EGUs to comply with new EPA MATS continuous emission limits.

Effects of mercury emissions and emission control in North Carolina

- Atmospheric deposition modeling indicates only 15 percent of the mercury deposited in North Carolina comes from sources inside North Carolina, while the majority comes from sources outside of North Carolina. This means for every seven pounds of emission reduction, there would be one pound less of mercury deposition.
- Routine statewide monitoring of mercury-in-fish tissue for largemouth bass has resulted in a statewide fish advisory. Results indicate no changes in mercury-in-fish tissue levels at 13 sites near EGU facilities over recent years. These mercury-in-fish results are consistent with the modeling deposition findings that indicate global mercury emissions are unchanged and the majority of deposition in the state stem from global emissions.
- In a pilot study for a small group whose diet consist of eating locally caught fish, no correlation was found between blood mercury levels and the number of fish servings eaten.

Given the above findings, we conclude additional controls to further reduce mercury emissions from coal-fired EGUs beyond those required by the CSA and EPA offer:

- Limited opportunity given EGUs are/will capture 90 percent of total mercury and 95 percent of the mercury species prone to deposit near their release, *and*
- Limited benefit given the majority of deposition in the state stem from global emissions.

A future report similar in scope to this 2012 report is recommended to see whether the above state-of-the-science findings and trends continue.

Section 12. Recommendations, if any, on rule revisions.

12.1 Regulatory Background

The EPA conducted the studies required by Clean Air Act (CAA) section 112(n)(1) concerning utility HAP emissions, and completed both the Utility Study and the Mercury Study by 1998. On December 20, 2000, the EPA issued a finding pursuant to CAA section 112(n)(1)(A) that it was appropriate and necessary to regulate coal and oil-fired EGUs under CAA section 112 and added such units to the list of source categories subject to regulation under CAA section 112(d). In making that finding, the EPA considered the Utility Study, the Mercury Study, the NAS Study and certain additional information, including information about mercury emissions from coal-fired units.

Shortly after issuance of the December 2000 finding, an industry group challenged that finding in the Court of Appeals for the D.C. Circuit (D.C. Circuit). *Utility Air Regulatory Group (UARG)* v. *EPA*, 2001 WL 936363, No. 01–1074 (D.C. Cir. July 26, 2001). The D.C. Circuit dismissed the lawsuit holding that it did not have jurisdiction because CAA section 112(e)(4) provides, in pertinent part, that ''no action of the Administrator * * * listing a source category or subcategory under subsection (c) of this section *shall be a final agency action subject to judicial review*, except that any such action may be reviewed under section 7607 of (the CAA) when the Administrator issues emission standards for such pollutant or category.''

Pursuant to a settlement agreement, the deadline for issuing emission standards was March 15, 2005. However, instead of issuing emission standards pursuant to CAA section 112(d), on March 29, 2005, the EPA issued the Section 112(n) Revision Rule (2005 Action). That action delisted EGUs after finding that it was neither appropriate nor necessary to regulate such units under CAA section 112. In addition, on May 18, 2005, the EPA issued the CAMR. That rule established standards of performance for emissions of mercury from new and existing coal-fired EGUs pursuant to CAA section 111. Environmental groups, states and tribes challenged the 2005 Action and CAMR. Among other things, the environmental and state petitioners argued that the EPA could not remove EGUs from the CAA section 112(c) source category list without following the requirements of CAA section 112(c)(9).

On Feb. 8, 2008, the D.C. Circuit vacated both the 2005 Action and CAMR. The D.C. Circuit held that the EPA failed to comply with the requirements of CAA section 112(c)(9) for delisting source categories. Specifically, the D.C. Circuit held that CAA section 112(c)(9) applies to the removal of ''any source category'' from the CAA section 112(c) list, including EGUs. The D.C. Circuit found that, by enacting CAA section 112(c)(9), Congress limited the EPA's discretion to reverse itself and remove source categories from the CAA section 112(c) list. The D.C. Circuit found that the EPA's contrary position would ''nullify § 112(c)(9) altogether.''

The D.C. Circuit did not reach the merits of petitioners' arguments on CAMR, but vacated CAMR for existing sources because coal-fired EGUs were already listed sources under CAA section 112. The D.C. Circuit reasoned that even under the EPA's own interpretation of the CAA, regulation of existing sources' mercury emissions under CAA section 111 was prohibited if those sources were a listed source category under CAA section 112.6 *Id.* The D.C. Circuit vacated and remanded CAMR for new sources because it concluded that the assumptions the

EPA made when issuing CAMR for new sources were no longer accurate (*i.e.*, that there would be no CAA section 112 regulation of EGUs and that the CAA section 111 standards would be accompanied by standards for existing sources). Thus, CAMR and the 2005 Action became null and void.

On Dec. 18, 2008, several environmental and public health organizations filed a complaint in the U.S. District Court for the District of Columbia. They alleged that the Agency had failed to perform a nondiscretionary duty under CAA section 304(a)(2), by failing to promulgate final CAA section 112(d) standards for HAP from coal- and oil fired EGUs by the statutorily-mandated deadline, Dec. 20, 2002, two years after such sources were listed under CAA section 112(c). The EPA settled that litigation. The consent decree resolving the case required the EPA to sign a notice of proposed rulemaking setting forth the EPA's proposed CAA section 112(d) emission standards for coal- and oil-fired EGUs by March 16, 2011, and a notice of final rulemaking by Dec. 16, 2011.

In September 2009 the DAQ Director issued a memorandum clarifying the "Application of Rule 15A NCAC 02D .2500, Mercury Rules for Electric Generators." The memorandum stated: "The CAMR vactur by the Court has resulted in making all but two of the Section 02D .2500 rules deficient and impractical. However, 15A NCAC 02D .2509 and 02D .2511 are state-only rules and are not affected by the Court's vacatur of CAMR. They remain in effect and enforceable."[58]

The EMC approved Section 15A NCAC 02D .2500, *Mercury Rules for Electric Generators*, and those 11 mercury rules became effective on Jan. 1, 2007. North Carolina has two state mercury rules that are not included as a part of N.C.'s "Mercury Plan" that was submitted to the EPA for compliance with CAMR. CAMR is now null and void, so eventually the remaining nine rules will need to be repealed. This should occur when DAQ is sure that the replacement rule (MATS) has withstood any legal challenges. The two remaining state rules 02D .2509, *Periodic Review and Reallocations*, and .2511, *Mercury Emission Limits*, could remain intact. However, these rules may not be needed given the evolving regulatory framework regarding mercury emission limits and the conclusions included in this report.

Under 02D .2509, *Periodic Review and Reallocations*, DAQ will have reported to the Commission on the regulation of mercury emissions in 2008 and 2012. Based on this 2012 report, the Commission will review the state of mercury technology and decide if any rule changes are needed. Remaining requirements state that in 2018 and 2023 the Director is required to report to the Commission on the state of mercury control technology, the costs of installation and operation and changes in fish tissue mercury concentrations in the state.

Under 02D .2511, *Mercury Emission Limits*, Duke Energy and Progress Energy shall submit a Mercury control plan to the Director by Jan. 1, 2013. Each plan must identify the technology proposed for use at each unit, the schedule for installation and operation of mercury controls at each unit, and the identity of units that will be shut down. Any unit that does not have mercury

[58] Overcash, K., "Memorandum: Application of Rule 15A NCAC 02D .2500, Mercury Rules for Electric Generators," September 15, 2009, NC DAQ.

controls installed by the end of 2017 is required to be shut down by Dec. 31, 2017. The Director will review the mercury control plans submitted and make recommendations to the Commission. The Commission will approve a mercury control plan if it finds that the plan achieves the maximum level of reductions in mercury emissions at each unit that is technically and economically feasible. Duke Energy and Progress Energy are to complete their control installations required under the CSA. Additionally, each utility will provide DAQ with mercury emission reduction data collected at four boilers before and after the installation of SCRs and scrubbers. New sources are required to install the best available control technology with an emissions limitation, based on the maximum degree of reduction of mercury from coal-fired electric steam generating units that is achievable for such units taking into account energy, environmental and economic impacts and other costs.

Although CAMR is null and void, reductions of mercury emission in North Carolina remain on schedule. Emission controls needed to comply with CSA, plus federal regulations including MATS and CAIR (or CSAPR) have provided significant co-benefits in the form of mercury emission reductions. The CSA has reduced mercury emissions from sources within the state, and federal regulations will provide similar mercury reductions from our border states, thus further reducing mercury deposition in North Carolina.

Regarding further need for rule revisions, N.C.'s approved State Implementation Plan (SIP) currently contains rules in 15A NCAC 02D .1111, *Maximum Achievable Control Technology*, that apply to sources subject to national emission standards for hazardous air pollutants for source categories promulgated in 40 CFR Part 63. Sources shall comply with applicable emission standards, monitoring and reporting requirements, maintenance requirements, notification and record keeping requirements, performance test requirements, test method and procedural provisions, and any other provisions, as required therein, rather than with any otherwise applicable rule in Section .0500 of this Subchapter that would be in conflict therewith. No additional rulemaking action is needed as the MATS rule for EGU, including applicability to the subset of CSA units, will proceed on a federal compliance schedule.

On Dec. 16, 2011, the Environmental Protection Agency (EPA) finalized the first-ever national standards to reduce mercury and other toxic air pollution from coal and oil-fired power plants. The MATS rule (plus subsequent revisions), are in effect in for EGUs in NC. EPA's MATS finalize standards to reduce air pollution from coal and oil-fired power plants under sections 111 (new source performance standards) and 112 (toxics program). Emissions standards set under the toxics program are federal air pollution limits that individual facilities must meet by a set date. EPA must set emission standards for existing sources in the category that are at least as stringent as the emission reductions achieved by the average of the top 12 percent best controlled sources.

Those EPA MATS rules set technology-based emissions limitation standards for mercury, PM and acid gases, reflecting levels achieved by the best-performing sources currently in operation. The final rule sets standards for all HAPs emitted by coal- and oil-fired EGUs with a capacity of 25 megawatts or greater. All regulated EGUs are considered major under the final rule. EPA did not identify any size, design or engineering distinction between major and area sources.

Existing sources generally will have up to four years if they need it to comply with MATS. This includes the three years provided to all sources by the Clean Air Act. EPA's analysis continues to demonstrate that this will be sufficient time for most, if not all, sources to comply. Under the Clean Air Act, state permitting authorities can also grant an additional year as needed for technology installation. EPA expects this option to be broadly available. However, DAQ does not anticipate the need to delay compliance, based on analysis that currently shows compliance. MACT standards for non-EGU sources' emission standards are also likely to reduce mercury and other hazardous air pollutant emissions.

Included in the MATS rule are stringent continuous emission monitoring requirements for mercury, PM and acid gases. Unlike the vacated Clean Air Mercury Rule, the MATS rule does not allow any mercury emission trading, and does not contain provisions for any emission allowances or new source growth. Because of requirements in the Clean Smokestacks Act, most of the largest 20 N.C. coal-fired EGUs equipped with new emission controls are currently meeting the MATS emission limits on a *short-term basis* as shown in Table 6-3 in Section 6. However in meeting the MATS limits, performance levels must be sustained on a *long-term basis* as validated by continuous emission monitoring systems (CEMS). Options for relatively minor performance improvements with costs well below CSA costs are being evaluated at some of the largest North Carolina EGUs to assure continuous compliance with new EPA limits by 2015.

Compliance with the MATS emission limits must be demonstrated by using all valid CEMS hourly data collected during each successive 30-boiler operating day period. The 26 smaller North Carolina EGUs not equipped with new controls cannot meet the MATS limits, and have been or will be retired by 2015. Given the stringent MATS limits requiring 90+ percent continuous mercury control performance, there is limited opportunity for a N.C. rule to further reduce emissions from coal-fired EGUs. If the MATS emission limits were less stringent by requiring for example only 60 percent continuous mercury control, there would be more opportunity for a N.C. rule to further reduce emissions from EGUs.

Starting in 2016, EPA estimates the national health benefits associated with meeting the MATS rule are $37 billion to $90 billion and the N.C. health benefits are $1.6 billion to $3.9 billion. EPA estimates the total national annualized cost of this rule will be $9.6 billion. Cost information contained in the 2011 CSA reports indicates the N.C. utility companies have spent $2.9 billion in capital costs on emission controls, corresponding to roughly $0.5 billion in annualized cost. Table 12-1 presents the estimated benefits the MATS rules would avoid in terms of adverse health condition for effects nationwide and in North Carolina.

However, regarding rule litigation, at least 24 states have filed petitions for review challenging the EGU MATS rule on several issues. This is in addition to a number of industries and industry groups including the American Public Power Association, the National Mining Association, the United Mine Workers of America and the Utility Air Regulatory Group. At least 14 states have filed to intervene on the behalf of EPA, including North Carolina. They are joined by a number of environmental groups including the Natural Resources Defense Council, the Sierra Club and the American Academy of Pediatrics. The National Mining Association and the American Public Power Association have also filed a petition for reconsideration. It is likely that EPA will ask the

court to hold the litigation in abeyance to give EPA time to respond to the petitions for reconsideration before moving forward with the litigation.

Table 12-1. Adverse Health Condition Effects Avoided by the MATS Rule

Adverse health condition cases	Effect Nationally	Effect in North Carolina
Premature deaths	4,200 to 11,000	190 to 480
Chronic bronchitis	2,800	112
Heart attacks	4,700	188
Aggravated asthma	130,000	5,200
Acute bronchitis	6,300	252
Respiratory symptoms	140,000	5,600
Hospital and emergency room visits	5,700	288
Miss work person-days	540,000	21,600
Restricted activities person-days	3,200,000	128,000

Given the findings in this 2012 Mercury Report, DAQ concludes that additional controls – beyond those required by the CSA and EPA – offer limited opportunities and benefits to further reduce mercury emissions from coal-fired EGUs and other existing industrial facilities in North Carolina at this time. A future report similar in scope to this 2012 report is required in 2018 and 2023 under current rules [15A NCAC 02D .2509(e)] to see whether the above state-of-the-science findings and trends continue and whether the EPA EGU MATS Rule withstands the litigation challenging it.