MEMORANDUM

SUBJECT: Non-Hg Case Study Chronic Inhalation Risk Assessment for the Utility MACT Appropriate and Necessary Analysis

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To estimate the potential for human health impacts from current emissions of HAPs other than mercury from coal- and oil-fired electric utility steam generating units (EGUs), several facilities were selected as case studies for a chronic inhalation risk assessment, and this memo documents the methods and results of the assessment for these case studies. The assessment was performed in support of the appropriate and necessary analysis for coal- and oil-fired EGUs.

1. Case Study Selection

An initial set of eight case study facilities was selected based on several factors. First, we considered facilities with the highest estimated cancer and non-cancer risks using the 2005 National Emissions Inventory (NEI) data and the Human Exposure Model (HEM-3)[1]. The 2005 NEI data were used because the initial set of case study facilities was selected before we received the bulk of the emissions data from the "Information Collection Effort for New and Existing Coal- and Oil-fired Electric Utility Steam Generating Units" (EPA ICR No. 2362.01; OMB Control Number 2060-0631). The criteria considered in the selection of the initial set of case study facilities are given below:

- Focused on the highest risk facilities based upon previous studies. We identified the top facilities in terms of total inhalation cancer and non-cancer risk based on the 2005 NEI and the use of HEM-3, following the same approach used for risk assessments performed for section 112(f) of the Clean Air Act.
- Screened the top facilities to exclude those that (a) were not power generating facilities that contribute to the grid, (b) for which ICR facility data were not available, and (c) installed emissions control equipment, suggested that the 2005 NEI may not reflect current conditions at those facilities (and, therefore, may have significantly lower risks).
- Provided coverage, to the extent possible, for the different cancer and non-cancer risk drivers identified in risk modeling for the top EGUs in each category.
- Provided coverage for different regions of the country, including those believed to have higher US EGU mercury impacts (e.g., eastern portion of the country, primarily NE and SE).
- Visually inspected aerial images of each EGU location to verify that there are potential residential locations located nearby and, consequently, possible near-field inhalation impacts.

[1] http://www.epa.gov/ttn/fera/hem_download.html

Based on application of these criteria, the initial set of case study facilities included: Xcel Bayfront, SC&E Canadys, Dominion Chesapeake Energy Center, Exelon Cromby Generating Station, Spruance Genco, PSI Energy – Wabash River, Heco Waiau, and Dominion – Yorktown.

After the receipt of more data through the ICR, additional case study facilities were selected, based on the magnitude of emissions, heat input values (throughput), and level of emission control. For the initial set of case study facilities, emissions were estimated for all HAPs included in the available ICR data. Because dispersion modeling and risk estimates were performed for the initial set of case study facilities before the selection of the additional facilities, the results of the initial set were used to focus the assessment of the additional facilities. The results for the initial set indicated that nickel, hexavalent chromium, and arsenic were the cancer risk drivers, and that non-cancer risks were not significant. Although the non-cancer risks were low (the maximum chronic hazard index was 0.4), they were driven by emissions of nickel, arsenic and hydrogen chloride. For these reasons, the selection of additional case study facilities focused on nickel, hexavalent chromium, and arsenic. The following criteria were used to select the additional case study facilities:

- Considered the potential emissions of EGUs based on generating capacity (> 300 MW).
- Focused on coal-fired EGUs with the highest emission rates of chromium and arsenic from test data. We computed an approximate emission rate using 2008 heat input data from the Clean Air Markets data and maps[2], a unit-specific emission factor estimated from the ICR data, and average capacity utilization based on 2007-2009 data provided in the ICR data.
- Focused on untested EGUs with the highest throughput and minimal emission controls. For throughput, we used 2008 heat input data.

An additional eight case study facilities were selected using these criteria: Cambria Cogen, Conesville, TVA Gallatin, City Utilities of Springfield -James River, Amerenue-Labadie, PSHNH –Merrimack, Monticello Steam Electric Plant, and OG&E –Muskogee. Considering both sets of case study facilities, there were a total of sixteen facilities, fifteen that use coal as fuel, and one that uses oil. The locations of the case study facilities are shown in Figure 1.

It is important to note that the case study facilities likely do not represent the highest-emitting (and highest-risk) sources. Although facility selection criteria included high estimated cancer and non-cancer risks using the 2005 NEI data, high throughput, and minimal emission control, another necessary criterion was the availability of ICR data for the EGUs at those facilities (or for similar EGUs at other facilities). Because the ICR data were collected for the purpose of developing the MACT standards, the ICR was targeted towards better performing sources, with a smaller set of random recipients. Therefore, facilities for which ICR data were available may not represent the highest-emitting sources.

[2] http://camddataandmaps.epa.gov/gdm/

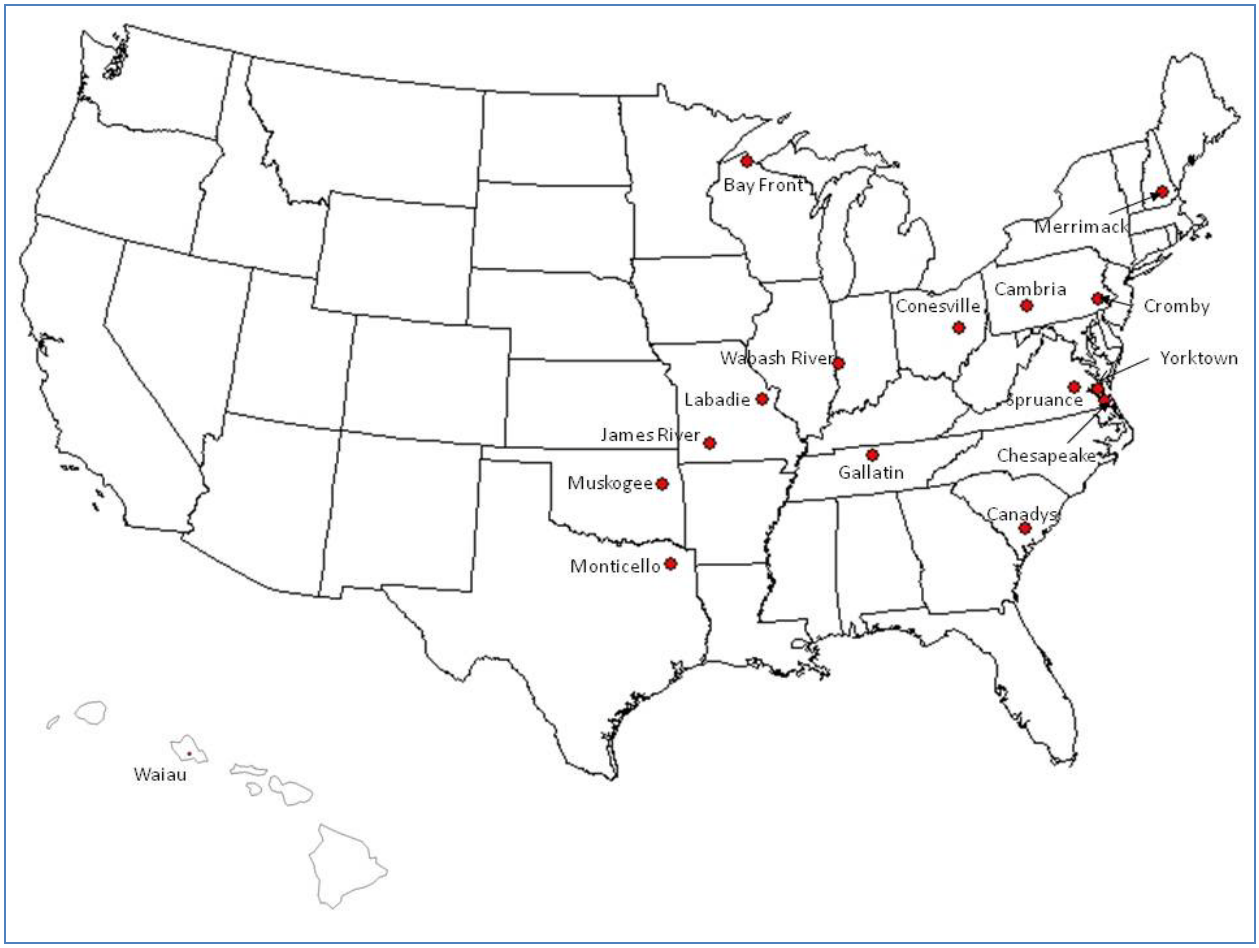

Figure 1. Location of Case Study Sites.

2. Methods

This section describes the methods used to estimate emissions for the case study facilities, and the dispersion modeling and risk estimation methods used.

2.1 Emissions Estimation

For the initial set of case study facilities, emissions were estimated using ICR data for metals, HCl, and several organic compounds, such as ethylene dibromide, polycyclic aromatic hydrocarbons, and naphthalene. However, because the ICR emission rate estimates of organic HAP emissions were based on minimum detectable levels, they were not used in the assessment of any of the case study facilities. As discussed above, only emissions of nickel, hexavalent chromium, and arsenic were estimated for the additional set of case study facilities.

For all case study facilities, emissions were developed using the data from Part III of the ICR. Emission factors, in lbs of pollutant per million BTU, were developed directly from the test data, where available. Where test data were not available for a specific unit, emission factors were derived from similarly configured units at the facility (site-average across tested units) or from similarly configured units from other facilities tested (average across tested units with

similar configuration). Only EGUs were considered in the assessment; other emitting processes located at the facilities were not considered.

Speciated chromium emissions data were not available from the ICR. Speciated chromium emissions data are available from existing test data on four coal-fired boilers and seven oil-fired boilers. These test data indicate that hexavalent chromium is on average twelve percent and eighteen percent of the emissions from coal- and oil-fired boilers, respectively, and we applied these values to the total chromium emissions estimates to estimate hexavalent chromium emissions.

"Actual" annual emissions were computed with the following equation:

$$\frac{\text{annual emission rate}\ \frac{t}{yr}}{} = \frac{\text{emission factor}\ \frac{lb}{MMBtu}}{} * \frac{\text{heat input}\ \frac{MMBtu}{hr}}{} * \frac{8760\ \frac{hr}{yr}}{} * \frac{\text{capacity factor}\ \%}{100} * \frac{}{2000\ \frac{t}{lb}}$$

In the above equation, the annual emission rate was computed in tons per year using an emission factor in lb/MMBtu and the maximum heat input in MMBtu/hr. The capacity factor was taken as the boiler-specific 3-year average capacity factor provided by ICR respondents of Part I of the ICR. If a respondent did not provide a 3-year average capacity factor for a boiler, a default value of 100 percent was used. For the set of additional case study facilities, potential emissions were computed using a 100 percent average capacity factor.

Hourly emissions for each hour in years 2005-2009 were generated from the actual annual emissions by using hourly heat input as a temporalization factor. That is, the hourly heat input divided by the annual heat input was multiplied by the annual emissions to get hourly emissions for each pollutant. The same annual emissions value was used for all 5 years. Hourly heat input values were obtained from Clean Air Markets continuous emission monitoring (CEM) data. Where data were missing for several months for a specific year, the data for the same period of a different year were used. In situations where hourly heat inputs were unavailable for the entire year, a State average temporalization for the year 2005 was used for all years. The State average data were readily available from national scale modeling efforts. For the Heco Waiau case study, neither unit nor State average data were available, so we used facilities with CEM data from Broward and Miami-Dade Counties as a surrogate for Hawaii CEM heat input for each of the five years. Hourly emissions derived from the potential emissions were created assuming the same emissions for each hour.

Table 1 provides facility and unit location, and stack parameter data for all units in the case studies. Table 2 provides estimates of actual and potential emissions.

Table 1. Unit Locations and Stack Parameters.

Facility	Location	Unit Type	Unit ID	Lat	Long	Stack Height (m)	Stack Temperature (K)	Stack Velocity (m/s)	Stack Diameter (m)
Xcel Bayfront	Ashland, WI	1 coal	5	46.5872	-90.9018	59.44	371.48	13.05	1.86
Cambria Cogen	Ebensburg, PA	2 coal	B1	40.4748	-78.703	70.10	466.48	27.83	2.29
			B2	40.4748	-78.703	70.10	466.48	27.83	2.29
SC&E Canadys	Canadys, SC	3 coal	CAN001	33.0646	-80.6235	60.96	415.37	11.00	4.88
			CAN002	33.0653	-80.6232	60.96	412.04	12.62	4.88
			CAN003	33.065	-80.6218	60.96	413.71	19.93	4.88
Dominion Chesapeake Energy Center	Chesapeake, VA	4 coal	Unit 1	36.7705	-76.3012	53.34	414.26	17.68	3.96
			Unit 2	36.7706	-76.3011	53.34	412.59	18.25	3.96
			Unit 3	36.7709	-76.3009	60.96	413.15	21.29	3.66
			Unit 4	36.7712	-76.3008	60.96	382.04	21.45	4.27
Conesville	Conesville, OH	4 coal	3	40.1648	-81.9044	137.16	416.48	12.19	5.33
			4	40.1862	-81.8787	243.84	416.48	25.36	7.92
			5	40.1856	-81.8798	243.84	324.82	23.92	7.92
			6	40.1856	-81.8798	243.84	324.82	23.92	7.92
Exelon Cromby Generating Station	Phoenixville, PA	coal (unit 1) oil (unit 2)	Unit 1	40.1524	-75.5303	91.44	388.71	17.92	4.27
			Unit 2	40.152	-75.5304	91.44	388.71	17.11	4.27
TVA Gallatin	Gallatin, TN	4 coal	1	36.3156	-86.4005	152.86	408.15	21.76	7.62
			2	36.3156	-86.4005	152.86	408.15	21.76	7.62
			3	36.3151	-86.4009	152.86	408.15	24.57	7.62
			4	36.3151	-86.4009	152.86	408.15	24.57	7.62
City Utilities of Springfield - James River	Springfield, MO	3 coal	3	37.1084	-93.2602	60.96	422.04	4.57	3.66
			4	37.1084	-93.2598	60.96	422.04	5.70	3.66
			5	37.1084	-93.2605	106.68	422.04	14.72	2.53
Amerenue-Labadie	Labadie, MO	4 coal	1	38.5626	-90.8381	213.36	444.26	28.04	6.25
			2	38.5621	-90.8377	213.36	444.26	28.04	6.25
			3	38.5614	-90.8371	213.36	444.26	28.04	8.84
			4	38.5614	-90.8371	213.36	444.26	28.04	8.84
PSHNH -Merrimack	Bow, NH	2 coal	1	43.142	-71.4685	69.19	433.15	45.42	2.59

Facility	Location	Unit Type	Unit ID	Lat	Long	Stack Height (m)	Stack Temperature (K)	Stack Velocity (m/s)	Stack Diameter (m)
			2	43.1418	-71.4682	97.23	449.82	31.09	4.42
Monticello Steam Electric Plant	Mount Pleasant, TX	3 coal	1	33.0907	-95.0375	121.92	453.15	24.69	6.55
			2	33.0914	-95.038	121.92	453.15	24.69	6.55
			3	33.0923	-95.0378	140.21	354.26	26.52	2.44
OG&E -Muskogee	Fort Gibson, OK	3 coal	4	35.7618	-95.2886	106.68	402.04	17.13	7.32
			5	35.7619	-95.288	106.68	402.04	17.13	7.32
			6	35.7621	-95.2872	152.40	402.04	24.84	6.55
Spruance Genco	Richmond, VA	8 coal	GEN1	37.4552	-77.4312	76.20	355.37	17.03	2.62128
			GEN2	37.4555	-77.4309	76.20	355.37	17.03	2.62128
			GEN3	37.4557	-77.4307	76.20	355.37	17.03	2.62128
			GEN4	37.4559	-77.4304	76.20	355.37	17.03	2.62128
PSI Energy – Wabash River	West Terre Haute, IN	1 coal-gas (unit 1) 2 coal (units 4&6)	PG7221FA	39.5303	-87.4256	68.58	452.59	19.17	5.49
			4	39.5274	-87.4232	137.16	410.93	34.26	7.62
			6	39.5274	-87.4232	137.16	410.93	34.26	7.62
Heco Waiau	Waiau, HI	6 oil	W3	21.3891	-157.9615	42.09	469.26	12.25	3.05
			W4	21.389	-157.9613	42.09	469.26	12.25	3.05
			W5	21.3888	-157.9612	41.91	414.26	12.25	2.74
			W6	21.3887	-157.961	41.91	414.26	12.25	2.74
			W7	21.3885	-157.9606	41.91	392.04	16.12	3.2
			W8	21.3884	-157.9603	41.91	392.04	16.12	3.2
Dominion - Yorktown	Yorktown, VA	2 coal (units 1&2) 1 oil (unit 3)	Units 1&2	37.2154	-76.4622	98.76	402.04	32.77	5.18
			Unit 3	37.2152	-76.4612	149.05	415.93	33.52	6.86

Table 2. Unit Emissions Estimates.

Facility	Location	Unit Type	Unit ID	As (TPY) actual	As (TPY) potential	Cr^{+6} (TPY)* actual	Cr^{+6} (TPY)* potential	Nickel (TPY) actual	Nickel (TPY) potential	HCl (TPY) actual	Basis of Emissions Factor (lbs/MMBtu) **
Xcel Bayfront	Ashland, WI	1 coal	5	n/a		n/a		n/a		40	similar config
Cambria Cogen	Ebensburg, PA	2 coal	B1	used potential	1.0E-03	used potential	3.6E-02	used potential	2.2E-01	not modeled	test
			B2		1.1E-03		7.8E-03		7.2E-02		test
SC&E Canadys	Canadys, SC	3 coal	CAN001	5.1E-02	not modeled	1.9E-02	not modeled	1.3E-01	not modeled	114	similar config
			CAN002	4.9E-02		1.8E-02		1.3E-01		111	similar config
			CAN003	2.2E-02		2.4E-03		9.6E-02		4.8	test (except HCl)
Dominion Chesapeake Energy Center	Chesapeake, VA	4 coal	Unit 1	5.1E-02	not modeled	1.9E-02	not modeled	1.3E-01	not modeled	113	similar config
			Unit 2	5.6E-02		2.1E-02		1.4E-01		125	similar config
			Unit 3	1.0E-01		3.8E-02		2.7E-01		232	similar config
			Unit 4	1.4E-01		5.0E-02		3.5E-01		304	similar config
Conesville	Conesville, OH	4 coal	3	9.1E-02	1.2E-01	6.6E-01	8.5E-01	3.5E+00	4.5E+00	not modeled	test
			4	1.0E-01	1.6E-01	8.1E-03	1.3E-02	1.9E-01	3.0E-01		similar config
			5	6.8E-02	8.2E-02	5.3E-03	6.5E-03	1.2E-01	1.5E-01		similar config
			6	6.5E-02	8.2E-02	5.1E-03	6.5E-03	1.2E-01	1.5E-01		similar config
Exelon Cromby Generating Station	Phoenixville, PA	coal (unit 1) oil (unit 2)	Unit 1	6.6E-02	not modeled	3.0E-03	not modeled	1.8E-02	not modeled	5.7	similar config
			Unit 2	2.4E-03		6.0E-04		3.4E-01		0.97	test for arsenic only
TVA Gallatin	Gallatin, TN	4 coal	1	3.3E-03	4.8E-03	2.6E-01	3.8E-01	1.2E+00	1.8E+00	not modeled	site average
			2	3.3E-03	4.8E-03	2.7E-01	3.8E-01	1.2E+00	1.8E+00		test
			3	3.8E-03	5.3E-03	3.0E-01	4.2E-01	1.4E+00	2.0E+00		site average
			4	3.8E-03	5.3E-03	3.1E-01	4.2E-01	1.4E+00	2.0E+00		site average
City Utilities of Springfield - James River	Springfield, MO	3 coal	3	4.1E-03	5.1E-03	1.1E-01	1.3E-01	6.6E-01	8.1E-01	not modeled	site average
			4	4.6E-03	5.4E-03	4.1E-02	4.9E-02	4.5E-01	5.4E-01		test
			5	9.1E-03	1.1E-02	3.5E-01	4.4E-01	1.9E+00	2.4E+00		test
Amerenue-Labadie	Labadie, MO	4 coal	1	3.9E-01	5.4E-01	1.3E-01	1.8E-01	9.5E-01	1.3E+00	not modeled	similar config
			2	4.3E-01	5.4E-01	1.5E-01	1.8E-01	1.1E+00	1.3E+00		similar config
			3	4.4E-01	5.4E-01	1.5E-01	1.8E-01	1.1E+00	1.3E+00		similar config
			4	4.6E-01	5.4E-01	1.5E-01	1.8E-01	1.1E+00	1.3E+00		similar config
PSHNH -	Bow, NH	2 coal	1	8.2E-02	9.4E-02	2.7E-02	3.2E-02	2.0E-01	2.3E-01	not	similar config

Facility	Location	Unit Type	Unit ID	As (TPY) actual	As (TPY) potential	Cr^{+6} (TPY)* actual	Cr^{+6} (TPY)* potential	Nickel (TPY) actual	Nickel (TPY) potential	HCl (TPY) actual	Basis of Emissions Factor (lbs/MMBtu) **
Merrimack			2	1.5E-01	2.1E-01	2.0E-02	2.9E-02	8.5E-02	1.2E-01	modeled	test
Monticello Steam Electric Plant	Mount Pleasant, TX	3 coal	1	6.1E-02	6.7E-02	1.16E-01	1.26E-01	4.1E-01	4.5E-01	not modeled	site average
			2	6.2E-02	6.7E-02	1.17E-01	1.26E-01	4.1E-01	4.5E-01		test
			3	1.1E-01	1.2E-01	1.98E-02	2.09E-02	1.7E-01	1.8E-01		similar config
OG&E - Muskogee	Fort Gibson, OK	3 coal	4	3.1E-01	4.7E-01	1.0E-01	1.6E-01	7.5E-01	1.2E+00	not modeled	similar config
			5	2.8E-01	4.7E-01	9.5E-02	1.6E-01	6.9E-01	1.2E+00		similar config
			6	3.2E-01	4.6E-01	1.1E-01	1.5E-01	7.9E-01	1.1E+00		similar config
Spruance Genco	Richmond, VA	8 coal	GEN1	8.4E-04	not modeled	3.1E-04	not modeled	2.4E-03		4.5	test
			GEN2	9.0E-04		3.2E-04		8.3E-03		0.0	test
			GEN3	3.5E-03		5.6E-04		6.2E-03		0.0	test
			GEN4	2.4E-03		3.6E-04		4.1E-03		0.1	test
PSI Energy – Wabash River	West Terre Haute, IN	1 coal-gas (unit 1) 2 coal (units 4&6)	PG7221FA	1.3E-03	not modeled	7.5E-04	not modeled	5.0E-03	not modeled	1.1	test
			4	1.1E-01		4.5E-03		4.1E-02		43.6	test
			6	3.3E-01		1.4E-02		1.2E-01		131.0	test
Heco Waiau	Waiau, HI	6 oil	W3	1.4E-03	not modeled	7.7E-05	not modeled	2.1E-01	not modeled	0.2	site average
			W4	1.6E-03		8.7E-05		2.4E-01		0.2	site average
			W5	2.0E-03		1.1E-04		3.0E-01		0.2	site average
			W6	2.0E-03		1.1E-04		3.1E-01		0.2	site average
			W7	8.3E-03		1.2E-03		1.3E+00		0.3	tested
			W8	9.3E-03		1.3E-03		1.5E+00		0.4	tested
Dominion - Yorktown	Yorktown, VA	2 coal (units 1&2) 1 oil (unit 3)	Units 1&2	1.9E-01	not modeled	6.8E-02	not modeled	4.8E-01	not modeled	415.5	similar config
			Unit 3	2.4E-02		3.6E-01		1.8E+01		1.6	tested

* hexavalent chromium was assumed to be 12 percent of total chromium for coal fired units (same value used in the EPRI report) and 18 percent for oil fired units. Coal gas speciation was assigned the coal speciation (12 percent).

** Emission factors were based on unit-specific test data ("test"), data from the average of tested similar units at the same facility ("site average"), or units that had similar boiler / control configurations ("similar config")

2.2 Dispersion Modeling

Dispersion modeling for the case study facilities was done using AERMOD[3], EPA's preferred model for near-field dispersion. The AERMOD modeling system has two input data processors that are regulatory components of the system: AERMET, a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS digital elevation data. Other nonregulatory components of the AERMOD system include AERSURFACE, a surface characteristics preprocessor, and the Building Profile Input Program for PRIME (BPIPPRM), a processor that calculates building parameters (e.g., height and projected building width) for use in building downwash algorithms within AERMOD.

For each facility listed in Table 1, each boiler or combination of boilers (e.g., Yorktown Units 1 and 2) was modeled as an individual emission point. Sources were modeled with a unit emission rate of 1 g/s. Annual and hourly emissions were used in post-processing to calculate concentrations for all modeled HAPs. The EGU location coordinates and stack parameters used in the modeling are given in Table 1. When stack parameters such as stack height and diameter differed among the boilers, plane view and aerial photos were used to assign the correct source identifier to the stacks. Source locations (in UTM coordinates) were entered into AERMAP to calculate source elevations. Census block centroids within 20 km of each facility were used as model receptors. Receptor coordinates (in UTM coordinates) were entered into AERMAP to calculate receptor elevations.

Because data were not readily available for building parameters, building downwash was ignored except for Waiau, Cambria, and Yorktown. Photos of these facilities revealed that downwash may play a role in dispersion. Building parameters were generated using aerial and plane view photos. Later analysis revealed that downwash may not play a role in Cambria and Yorktown. Table 3 summarizes the use of downwash for each facility.

The urban/rural classification for each facility was based on methodologies listed in Section 7.2.3 of the Guideline on Air Quality Models[4]. These methodologies are a landuse method and a population density based method. With both methods, a circle with 3 km radius is centered on the source. If 50 percent of the area within the circle is commercial, industrial, or high intensity residential landuse, the source is considered urban. If the population density within the circle is 750 people per sq. km or more, the source is considered urban. Also, if a source is near an urban area but not considered urban based on the above methods, it was still modeled as urban. Based on these methods, three facilities, Dominion Chesapeake, Spruance Genco, and Heco Waiau were considered urban. Urban populations were based on nearby city populations. All others were modeled as rural sources.

Five years of meteorological data were used as input for the modeling. The most recent five complete years (2005 through 2009) were chosen. Integrated Surface Hourly (ISH)

[3] http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod
[4] U.S. EPA, 2005. *Guideline on Air Quality Models*. 40 CFR Part 51 Appendix W. http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf.

meteorological data and upper air data were processed through a beta version of AERMET which includes the input of hourly averaged winds from a beta preprocessor (AERMINUTE) that processes two-minute wind speeds for Automated Surface Observing Stations (ASOS). Surface characteristics were processed using AERSURFACE. For each station, the most representative National Weather Service surface and upper air stations were chosen. This was often the closest station or station with the least amount of missing data when multiple stations were considered. A list of selected stations for each facility is shown in Table 3, along with urban/rural classification and whether downwash effects were modeled.

Table 3. Model Scenario Information.

Facility	Downwash	Urban/rural (population)	Surface station	Upper air station
Xcel Bayfront	No	Rural	Ashland Kennedy Memorial Airport, WI	Minneapolis, MN
Cambria Cogen	Yes	Rural	Johnstown Cambria County Airport, PA	Pittsburgh, PA
SC&E Canadys	No	Rural	Charleston Intl. Airport, SC	Charleston Intl. Airport, SC
Dominion Chesapeake Energy Center	No	Urban (200,000)	Norfolk Intl. Airport, VA	Washington Dulles, VA
Conesville	No	Rural	Zanesville Municipal Airport, OH	Wilmington, OH
Exelon Cromby Generating Station	No	Rural	Philadelphia Intl. Airport, PA	Washington Dulles, VA
TVA Gallatin	No	Rural	Nashville Intl. Airport, TN	Nashville Intl. Airport, TN
City Utilities of Springfield -James River	No	Rural	Springfield Regional Airport, MO	Springfield Regional Airport, MO
Amerenue-Labadie	No	Rural	St. Louis Lambert Intl. Airport, MO	Lincoln, IL
PSHNH -Merrimack	No	Rural	Concord Municipal Airport, NH	Albany, NY
Monticello Steam Electric Plant	No	Rural	Tyler Pounds Field, TX	Shreveport, LA
OG&E -Muskogee	No	Rural	Muskogee Davis Field, OK	Norman, OK
Spruance Genco	No	Urban (200,000)	Richmond Intl. Airport, VA	Washington Dulles, VA
PSI Energy – Wabash River	No	Rural	Terre Haute Hulman Regional Airport ,IN	Wilmington, OH
Heco Waiau	Yes	Urban (300,000)	Honolulu Intl Airport, HI	Lihue, HI
Dominion - Yorktown	Yes	Rural	Newport News Intl. Airport, VA	Washington Dulles, VA

AERSURFACE was used to process 1992 land cover data to calculate the following surface characteristics at the surface meteorological stations: albedo, Bowen ratio and surface roughness. All variables were allowed to vary seasonally. Bowen ratio was also allowed to vary seasonally and by year, as it is affected by the moisture conditions at the station (average, dry, or wet) based on precipitation amounts. Precipitation was calculated for each season for each year from 2005 to 2009. For stations that do not use default month-season assignments (e.g., March may not be considered spring at some locations), AERSURFACE output was varied monthly but precipitation used to define whether the location experienced dry, wet, or average moisture conditions was based on seasonal totals. A season was considered average if the seasonal precipitation was within 25 percent of the seasonal normal. A season was dry if the seasonal precipitation was less than 75 percent of the seasonal normal and a season was wet if the season exceeded 125 percent of the seasonal normal. Surface roughness also varied spatially at a location, based on aerial photos and analysis of the 1992 land cover data. Surface roughness may vary spatially around a station because of the proximity of vegetation and structures around the meteorological tower.

A potential concern related to the use of NWS meteorological data for dispersion modeling is the often high incidence of calms and variable wind conditions reported for the ASOS stations in use at most NWS stations since the mid-1990's. In the METAR[5] coding used to report surface observations beginning July 1996, a calm wind is defined as a wind speed less than 3 knots and is assigned a value of 0 knots. The METAR code also introduced the variable wind observation that may include wind speeds up to 6 knots, but the wind direction is reported as missing if the wind direction varies more than 60 degrees during the 2-minute averaging period for the observation. The AERMOD model currently cannot simulate dispersion under calm or missing wind conditions. To reduce the number of calms and missing winds in the surface data, archived 1-minute winds for the ASOS stations can be used to calculate hourly average wind speed and directions, which are used to supplement the standard archive of hourly observed winds processed in AERMET.

Recently, the National Climatic Data Center (NCDC) began archiving the 2-minute average wind speeds for each minute of the hour for most ASOS stations for public access. These 2-minute values have not been subjected to the METAR coding for calm and variable winds, but have also been subjected to only limited quality control measures. The 1-minute ASOS wind data consists of running 2-minute average winds, reported every minute, for commissioned ASOS stations. The 1-minute ASOS wind data can be obtained without cost through the National Climatic Data Center (NCDC) website (ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/). AERMINUTE reads the one minute data files and calculates hourly average winds for each hour from available minutes. In AERMET processing, the hourly average winds supersede the winds from the standard observations also processed by AERMET.

For actual emissions, AERMOD hourly concentrations were output at each receptor for each boiler at a facility for the period 2005-2009. For example, if a facility had three boilers, each receptor would have an hourly concentration contribution from each boiler. A unit

[5] METAR literally translates to Météorologique Aviation Régulière. The Federal Aviation Administration defines the report as the aviation routine weather report.

emission rate of 1 g/s for each boiler was modeled in AERMOD. The resulting modeled concentration at each receptor was scaled by the hourly emissions of each HAP to calculate an hourly concentration for each HAP. A 5-year concentration for each HAP was calculated by averaging the hourly values (that were not calm or missing hours) for the 2005-2009 period. The methodology for estimating concentrations due to potential emissions was similar, except the potential emissions were uniformly distributed throughout a year (i.e., no hourly variability).

2.3 Chronic Inhalation Risk Assessment

In the risk assessment for chronic inhalation exposures, we used the 5-year average ambient concentrations of HAP estimated from the refined dispersion modeling. The estimated ambient concentration at each nearby census block centroid was used as a surrogate for the chronic inhalation exposure concentration for all the people who reside in that census block. We calculated the maximum individual risk, or MIR, for each facility as the cancer risk associated with a continuous lifetime (24 hours per day, 7 days per week, and 52 weeks per year for a 70-year period) exposure to the maximum concentration at the centroid of an inhabited census block. Individual cancer risks were calculated by multiplying the estimated lifetime exposure to the ambient concentration of each carcinogenic HAP (in micrograms per cubic meter) by its cancer unit risk estimate (URE), which is an upper bound estimate of an individual's probability of contracting cancer over a lifetime of exposure to a concentration of 1 microgram of the pollutant per cubic meter of air. We used URE values for arsenic and hexavalent chromium from EPA's Integrated Risk Information System (IRIS), which is a human health assessment program that evaluates quantitative and qualitative risk information on effects that may result from exposure to environmental contaminants. Unit risk estimates in IRIS have undergone both internal and external peer review.

The IRIS URE for nickel subsulfide was derived from evidence of the carcinogenic effects of insoluble nickel compounds in crystalline form. Soluble nickel species such as nickel sulfate, and insoluble species in amorphous form, do not appear to produce genotoxic effects by the same toxic mode of action as insoluble crystalline nickel, although other agencies, including the International Agency on Research in Cancer[6] and the Danish EPA[7] for example, have determined that nickel sulfate, specifically, and nickel compounds, in general, are carcinogenic. Although there is some discussion of how risk varies with different combinations of nickel compounds, the collection of epidemiology studies provides strong evidence of carcinogenicity specifically with respect to soluble nickel (nickel sulfate). In 2009, the National Toxicology Program (NTP)[8] noted that "The combined results of epidemiological studies, mechanistic studies, and carcinogenesis studies in rodents support the concept that nickel compounds generate nickel ions in target cells at sites critical for carcinogenesis, thus allowing consideration and evaluation of these compounds as a single group." Nickel speciation information for large combustion sources (including oil combustion, coal combustion, and others) suggests that at least

[6] World Health Organization International Agency for Research on Cancer, 1997. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 49, Chromium, Nickel and Welding. http://monographs.iarc.fr/ENG/Monographs/vol49/volume49.pdf

[7] Danish Environmental Protection Agency, 2008. European Union Risk Assessment Report, Nickel and Nickel Compounds.

[8] Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

35% of total nickel emissions may be soluble compounds, while the remaining insoluble nickel emissions are not well-characterized. More recent data specifically from oil combustion suggest that the nickel emissions can be 85-100% nickel sulfate. EPA does not have an inhalation unit risk estimate for nickel sulfate and is not aware of any other organization that has developed one. However, the EPA does have a unit risk for one of the insoluble nickel compounds, nickel subsulfide. This unit risk is 4.8 X 10-4 per ug/m3. A draft assessment from Texas Commission on Environmental Quality (May 2009) derives a unit risk for total nickel which is between 3.9 X 10-4 and 9.0 X 10-4 per ug/m3 (these are upper bound estimates, where the range corresponds to different adjustment procedures in the modeling). This estimate is roughly similar to the IRIS unit risk for nickel subsulfide. For the purposes of this assessment, we have assumed that 65% of emitted nickel is insoluble, that all insoluble nickel is crystalline, and that the URE for nickel subsulfide can be applied to this fraction. On this basis, the URE for nickel subsulfide (representing pure insoluble crystalline nickel) was multiplied by 0.65 and applied to all nickel compounds.[9] We note that this approach, while attempting to account for potential differences in toxicity between the soluble and insoluble forms of nickel, is not completely consistent with the NTP suggestion that all forms of nickel can be considered as a single group, and, therefore, this approach may result in an underestimation of the health risks from nickel emissions from EGUs.

To assess the risk of non-cancer health effects from chronic exposures, following the approach recommended in EPA's Mixtures Guidelines[10,11], we summed the hazard quotients (HQ) for all HAPs that affect a common target organ system to obtain the HI for that target organ system (target-organ-specific HI, or TOSHI). The HQ for chronic exposures is the estimated chronic exposure (again, based on the estimated 5-year average ambient concentration at each nearby census block centroid) divided by the chronic non-cancer reference level, which is usually the EPA Reference Concentration (RfC), defined as ``an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." In cases where an IRIS RfC is not available, EPA utilizes the following prioritized sources for chronic dose-response values: (1) The Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Level (MRL), which is defined as ``an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (other than cancer) over a specified duration of exposure"; and (2) the California Environmental Protection Agency chronic Reference Exposure Level (REL), which is defined as ``the concentration level at or below which no adverse health effects are anticipated for a specified exposure duration." In this assessment, we used the IRIS RfC values for hexavalent chromium and hydrogen chloride, the ATSDR MRL for nickel compounds, and the California Environmental Protection Agency REL for arsenic.

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[9] Recent data from industry have attempted to further characterize the insoluble nickel. While these data show that the insoluble nickel is primarily in a spinel form, they do not attempt to characterize the toxicity of that form, noting only that it is not in the insoluble crystalline form. As such, it does not provide us with a better means for characterizing the risks than the approach described above.

[10] US EPA, 1986, Guidelines for the Health Risk Assessment of Chemical Mixtures, EPA-630-R-98-002. http://www.epa.gov/NCEA/raf/pdfs/chem_mix/chemmix_1986.pdf.

[11] US EPA, 2000. Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures. EPA-630/R-00-002. http://www.epa.gov/ncea/raf/pdfs/chem_mix/chem_mix_08_2001.pdf.

The health reference values used in the assessment are given in Table 4.

Table 4. Health Reference Values Used in the Assessment.

Pollutant	CAS Number	URE (1/µg/m3)	Source	RfC (mg/m^3)	Source
Arsenic	7440382	4.3E-03	IRIS	0.000015	CalEPA
Chromium (VI)	18540299	0.012	IRIS	0.0001	IRIS
Nickel	7440020	0.000312	IRIS	0.00009	CalEPA
HCl	7647010			0.02	IRIS

3. Results

The results of the assessment are given in Table 5. Based on actual emissions, the highest estimated lifetime cancer risk from any of the sixteen case study facilities was 10 in a million, driven by nickel emissions from the one case study facility with oil-fired EGUs. For the facilities with coal-fired EGUs, there were three with maximum cancer risks greater than 1 in a million (the highest was 8 in a million), all driven by hexavalent chromium, and there were four with cancer risks at 1 in a million. All of the facilities had non-cancer TOSHI values less than one, with a maximum TOSHI value of 0.4 (also driven by nickel emissions from the one case study facility with oil-fired EGUs).

The cancer risk estimates from this assessment indicate that the EGU source category would not be eligible for delisting under section 112(c)(9)(B)(i) of the CAA, which specifies that a category may be delisted only when the Administrator determines "… that no source in the category (or group of sources in the case of area sources) emits such hazardous air pollutants in quantities which may cause a lifetime risk of cancer greater than one in one million to the individual in the population who is most exposed to emissions of such pollutants from the source…." We note that, since these case studies do not cover all facilities in the category, and since our assessment does not include the potential for impacts from different EGU facilities to overlap one another (i.e., these case studies only look at facilities in isolation), the maximum risk estimates from the case studies may underestimate true maximum risks.

Table 5. Chronic Inhalation Risk Assessment Results.

Facility	Actual emissions				Potential emissions			
	Max Risk	Risk Driver	Max HI	HI Driver	Max risk	Risk Driver	Max HI	HI Driver
Xcel Bayfront	$4.0x10^{-9}$	Formaldehyde	0.005	HCl	N/A	N/A	N/A	N/A
Cambria Cogen	$5.0x10^{-7}$	Chromium VI	0.003	Nickel	$5.0x10^{-7}$	Chromium VI	0.003	Nickel
SC&E Canadys	$6.0x10^{-7}$	Arsenic	0.009	HCl	N/A	N/A	N/A	N/A
Dominion Chesapeake Energy Center	$3.0x10^{-6}$	Chromium VI	0.05	HCl	N/A	N/A	N/A	N/A
Conesville	$3.0x10^{-6}$	Chromium VI	0.01	Nickel	$3.0x10^{-6}$	Chromium VI	0.01	Nickel
Exelon Cromby Generating Station	$3.0x10^{-7}$	Arsenic	0.008	Nickel	N/A	N/A	N/A	N/A
TVA Gallatin	$1.0x10^{-6}$	Chromium VI	0.006	Nickel	$1.0x10^{-6}$	Chromium VI	0.005	Nickel
City Utilities of Springfield -James River	$8.0x10^{-6}$	Chromium VI	0.04	Nickel	$9.0x10^{-6}$	Chromium VI	0.05	Nickel
Amerenue-Labadie	$8.0x10^{-7}$	Arsenic	0.006	Arsenic	$9.0x10^{-7}$	Arsenic	0.007	Arsenic
PSHNH -Merrimack	$1.0x10^{-6}$	Arsenic	0.01	Arsenic	$2.0x10^{-6}$	Arsenic	0.01	Arsenic
Monticello Steam Electric Plant	$6.0x10^{-7}$	Chromium VI	0.003	Arsenic	$7.0x10^{-7}$	Chromium VI	0.003	Arsenic
OG&E -Muskogee	$1.0x10^{-6}$	Arsenic	0.01	Arsenic	$2.0x10^{-6}$	Arsenic	0.01	Arsenic
Spruance Genco	$8.0x10^{-8}$	Arsenic	0.007	HCl	N/A	N/A	N/A	N/A
PSI Energy – Wabash River	$1.0x10^{-7}$	Arsenic	0.001	Arsenic	N/A	N/A	N/A	N/A
Heco Waiau	$1.0x10^{-5}$	Nickel	0.4	Nickel	N/A	N/A	N/A	N/A
Dominion - Yorktown	$1.0x10^{-6}$	Chromium VI	0.02	Nickel	N/A	N/A	N/A	N/A