September 21, 2018

Via e-mail

Mr. Randy Mosier
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Air and Radiation Administration
Department of the Environment
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RE: Public Comments on Proposed Action on Regulation for Incinerator NOx Limits, COMAR 26.11.08

Dear Mr. Mosier:

The Environmental Integrity Project ("EIP") and the Chesapeake Bay Foundation ("CBF") (collectively, "Commenters") respectfully submit these comments on the Maryland Department of the Environment's ("MDE's") Notice of Proposed Action for revising its air quality regulations at COMAR 26.11.08 (Control of Incinerators), as published in the Maryland Register on August 17, 2018.[1]

Commenters are appreciative of the effort that MDE has put into this rulemaking and the relatively transparent nature of the public stakeholder process. However, we do not believe that the proposed regulation lives up to MDE's statement to the Baltimore Sun, as reported in July of 2017, that MDE would issue a "'very tough, aggressive' rule [for the Wheelabrator incinerator in Baltimore] that [will] force the plant to invest in technology to clean up its exhaust."[2] The NOx limits that take effect in 2019 and 2020 for this incinerator, also known as "BRESCO," are based on optimizing its existing pollution control technology, and, as explained more fully in Section I below, Commenters think that the facility could achieve lower NOx limits than those proposed just by further optimizing the existing system. In addition, neither MDE nor Wheelabrator has

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[1] 45:17 Md. R. 809-814 (Aug. 17, 2018).

[2] Dance, Scott, *Maryland moving to cut emissions from BRESCO trash incinerator*, Baltimore Sun (July 5, 2017), available at http://www.baltimoresun.com/news/maryland/environment/bs-md-bresco-pollution-20170630-story.html.

performed a thorough analysis of the potential to install new NOx pollution controls on the BRESCO facility.

More importantly, however, the proposed regulation lacks sufficient specificity regarding what is supposed to be the most important piece of the next step toward a stronger NOx limit. Commenters have repeatedly noted to MDE the importance of a meaningful and specific feasibility analysis for additional NOx controls. However, the section of the proposed rule describing the feasibility analysis appears tailored to allow Wheelabrator to exclude the most effective NOx pollution controls in its assessment. In addition, the preamble to the rule lacks any statement about MDE's intent to use the feasibility analysis as the basis for a separate rulemaking to commence in 2020. MDE staff expressly represented to its air regulatory advisory council, the Air Quality Control Advisory Council ("AQCAC"), that such a statement would be in the preamble. Commenters also believe that MDE must clarify certain matters with respect to the startup and shutdown limits, and we remain concerned, as we have expressed repeatedly, about MDE's failure to require the use of a continuous emissions monitoring system ("CEMS") for ammonia at BRESCO.

I. Further NOx Reductions are Achievable at BRESCO.

The NOx emission limits for the BRESCO incinerator set in the proposed rule represent a step forward. However, the public stakeholder process for this rulemaking, in which Commenters have engaged extensively, has not unearthed evidence that it is infeasible to install more effective pollution controls on this incinerator. In addition, our expert's review of information submitted by Wheelabrator during the stakeholder process found that the BRESCO incinerator can meet lower pollution limits today just by using its existing NOx control system. While Commenters understand that MDE will likely finalize the NOx limits set forth in the proposed rule, the fact that that Wheelabrator can almost certainly do far better at controlling its emissions means that MDE must set much stronger NOx limits for this plant in the future. This is particularly important because 2017 emissions data (discussed in more detail below) confirms that Wheelabrator is unlikely to voluntarily reduce its NOx emissions in the absence of a legal mandate compelling it to do so.

MDE's proposed rule sets a 150 parts per million dry volume at 7% oxygen (hereinafter "ppm") limit on a 24-hour average for the facility, which takes effect in 2019, and a 145 ppm limit on a 30-day average, which takes effect in 2020. Commenters recognize that this represents a more aggressive standard when compared with Reasonably Available Control Technology ("RACT") standards currently in effect or proposed in other states.[3] However, we note that New York State has announced that it is considering a 150 ppm limit on a 24-hour basis for its incinerators.[4] The Virginia Department of Environmental Quality ("VDEQ") concluded in September 2017 that Reasonably Available Control Technology ("RACT") for a Covanta-operated incinerator in Lorton, Virginia requires that facility to meet NOx limits of 110 ppm on a

[3]Connecticut and New Jersey have 150 ppm RACT limits for similar incinerators and Massachusetts has proposed such a limit. Pennsylvania has submitted a limit of 180 ppm to EPA as RACT.
[4] New York State Department of Environmental Conservation letter to stakeholders, March 26, 2018.

daily average, 90 ppm on an annual average, and 233 tons per year.[5] In addition, all of these limits allow far greater emissions than the NOx limit required for new incinerators in Maryland, which is 45 ppm on a 24-hour basis.[6]

Commenters believe that, with additional controls, Wheelabrator can greatly reduce its NOx emissions and reduce the health burden of its pollution on Baltimoreans. MDE clearly has the legal authority to require additional reductions at this very large source of NOx emissions and it should exercise this authority to reduce the human health and environmental impacts of ozone levels that exceed federal standards. EPA has stated that "a state has discretion to require beyond-RACT reductions from any source, and has an obligation to demonstrate attainment as expeditiously as practicable. Thus, states may require . . . NOx reductions that are 'beyond RACT' if such reductions are needed . . . to provide for timely attainment of the ozone NAAQS." [7]

A. Wheelabrator should be required to install the most effective pollution controls available for NOx.

Commenters submit the attached report of Dr. Ranajit Sahu, [8] who has reached several salient conclusions after reviewing information that Commenters obtained following AQCAC's December 2017 meeting, including the report on the optimization study performed in June 2017 by Fuel Tech, Inc.[9] and the 2017 1-hour CEMS data from the datasets made available on MDE's website. [10]

Dr. Sahu has concluded that he sees "no technical impediments to the implementation of the [most effective] NOx-reducing technologies, such as SCR (or hybrid SNCR/SCR), in the appropriate locations along the gas paths at each of the [Wheelabrator Baltimore] boilers."[11] Dr. Sahu has reviewed numerous materials relating to the Wheelabrator Baltimore incinerator,[12] including the reports for both optimization studies performed at the facility (one in 2016 and one

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[5] Letter from Thomas J. Faha, Regional Director, VDEQ, to Frank N. Capibianco, Covanta Facility Manager (September 29, 2017), available at https://www.epa.gov/sites/production/files/2017-10/documents/2017updatecaroline.11cfi_nox_ract.pdf.

[6] A 45 ppm NOx limit on a 24-hour average was set forth in the permit for the proposed Energy Answers incinerator in Baltimore City and Frederick/Carroll Renewable Waste-to-Energy Facility in Frederick County. Both facilities received their air quality permits but neither facility was constructed.

[7] EPA, Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements, 80 Fed. Reg. 12264, 12279 (March 6, 2015).

[8] Expert Report on NOx Emissions from the Wheelabrator Baltimore Municipal Waste Incinerator in Baltimore, owned and operated by Wheelabrator Baltimore, L.P. by Dr. Ranajit (Ron) Sahu, Consultant, dated May 10, 2018 (hereinafter "May 2018 Sahu Report"). Attached hereto as Attachment A.

[9] Bisnett, M. "NOx Optimization Project Wheelabrator Baltimore Inc." Fuel Tech Project 459S, June 5-9, 2017 (hereinafter "June 2017 Fuel Tech Study"), p. 5. Technical Support Document p. 427.

[10] MDE, Air & Radiation Administration, Research and Special Studies, Wheelabrator Annual CEM Data Reports, at http://mde.maryland.gov/programs/Air/Pages/ARAResearch.aspx.

[11] May 2018 Sahu Report, p. 10.

[12] Expert Report on NOx Emissions from the Wheelabrator Baltimore Municipal Waste Incinerator in Baltimore City, owned and operated by Wheelabrator Baltimore, L.P. ("Wheelabrator") By Dr. Ranajit (Ron) Sahu, Consultant, May 5, 2017 (hereinafter "May 2017 Sahu Report"), p. 1., Attachment B to May 9, 2017 comments of CBF. Technical Support Document Appendix B.

in 2017), the 1-hour averaged NOx CEMS data collected at the three boilers during 2017,[13] and the Wheelabrator NOx RACT PowerPoint presentation made at the January 2017 stakeholder meeting.

Thus, any objection to using the most effective NOx pollution controls available at BRESCO appears to be solely financial. This is a particularly troubling position when taken by a company that, according to the Baltimore Sun, has been rewarded approximately $10 million over the past six years for being a renewable, and ostensibly green and environmentally friendly, source of energy in Maryland.[14] In the case of hybrid SNCR/SCR, the financial concerns are reduced as this technology is typically much less expensive than SCR. Commenters note that we have no record of Wheelabrator ever providing more than a cursory response to our recommendation that it analyze the feasibility of using hybrid SNCR/SCR[15] or Regenerative Selective Catalytic Reduction ("RSCR"), the technology that would have been installed on the proposed Energy Answers incinerator in Baltimore City and was touted in project materials as more cost-effective than SCR while achieving an 80% reduction efficiency.

As Dr. Sahu notes in his report, installation of SCR would likely allow Wheelabrator to achieve levels around 50 ppm on a 24-hour average at BRESCO, assuming roughly 75% NOx reduction efficiency, which he notes is a lenient target for this technology.[16] This would cut approximately 803 tons of NOx per year from the incinerator's 2016 annual emissions, reducing the annual number from 1141 tons to 338 tons.[17]

Commenters continue to feel strongly that a presumptive limit should have been included in the rule requiring that BRESCO achieve SCR-level reductions of NOx and requiring a demonstration by Wheelabrator that it cannot meet this limit if the company wishes to avoid it. Our concerns about the lack of such a limit are only heightened by the inadequacy of the section of the proposed regulation on the feasibility analysis, which we believe must be revised.

B. Wheelabrator can achieve NOx limits lower than those proposed simply by using its current pollution controls.

In addition, Dr. Sahu concludes, based on his review of 2017 1-hour CEMS data and the June 2017 Fuel Tech Study that Wheelabrator can meet NOx limits lower than the 150 ppm and

[13] May 2018 Sahu Report, p. 1.
[14] Dance, Scott, *Power struggle: How a trash incinerator – Baltimore's biggest polluter – became 'green' energy*, Baltimore Sun, Dec. 15, 2017, at
http://www.baltimoresun.com/news/maryland/environment/bs-md-trash-incineration-20171107-story.html
[15] At the September 22, 2017 stakeholder meeting, Wheelabrator Representative Tim Porter gave brief feedback on in-duct hybrid SNCR/SCR technology, stating his concerns about catalyst interference and poisoning at the Wheelabrator Baltimore facility. In Commenters' October 6, 2017 comments, we recommended additional engineering analysis and the collection of gas composition data needed to assess the validity of these concerns and to identify potential ways to address any potential poisoning or interference. As expressed below in Section II relating to the feasibility analysis, Commenters still consider it critical that MDE obtain this data in order to evaluate the feasibility of installing hybrid SCR/SNCR on the BRESCO incinerator.
[16] May 2018 Sahu Report, p. 10.
[17] Potential NOx emission reductions were calculated by applying the proportion of average 24-hour concentrations (50 ppm to 169 ppm in 2016) to the 2016 annual NOx emissions of 1141 tons, effectively calculating the emission rate assuming effluent stack flow and oxygen percentage remain constant.

145 ppm limits proposed using its existing control technology, solely through further optimization of those controls.[18] Specifically, Dr. Sahu states in his report that Wheelabrator can achieve a 24-hour limit of 135 ppm on a 24-hour basis and 130 ppm on a 30-day basis as demonstrated by the hourly CEMS data during the optimization tests and the failure to use more effective testing approaches during the optimization runs.[19] Adoption of a 135 ppm limit on a 24-hour basis would reduce 230 tons of NOx per year from the incinerator, using 2016 annual emissions as a baseline, reducing annual emissions to 911 tons.[20]

Given Maryland's action against the U.S. EPA under Clean Air Act Section 126 seeking an order that requires coal plants in other states to run their controls more effectively, we do not understand why MDE is not requiring Wheelabrator to run its existing controls in the most effective way possible.[21] Requiring the most reduced emissions rate for this source category would be consistent with Maryland's statements in its Clean Air Act 126 and 176a Petitions.

C. Wheelabrator did not maintain the same emissions reductions that it achieved during 2017 optimization testing in the following months.

Even given Wheelabrator's failure to use approaches during optimization that could have reduced its NOx levels further during those tests, CEMS data shows that Wheelabrator did not maintain the NOx reductions achieved during optimization in the following months.[22] Instead it allowed its emissions to increase again. This is likely because Wheelabrator had no legal incentive to do so as the limits in MDE's draft rule have not yet taken effect. Commenters are troubled that Wheelabrator has not voluntarily maintained the lower levels of NOx that achieved at the BRESCO incinerator in June 2017, especially, as stated above, since it is treated as a source of environmentally friendly energy under the state's Renewable Portfolio Standard. This also further demonstrates the need for MDE to set a very strong NOx limit for this plant following MDE's receipt of the feasibility analysis by the end of 2019.

As described in Dr. Sahu's report and shown in the tables below - reproduced, using a slightly altered form, from Dr. Sahu's report - NOx emissions increased again at each unit following the optimization tests. For unit 2, Wheelabrator achieved an hourly average of 148.1 ppm during optimization testing and its NOx levels increased to an hourly average of 165.1 ppm after the optimization tests (though this was lower than pre-optimization average of 168.6 ppm). For unit 3, NOx levels of 144.9 ppm were achieved during testing but increased to 165.1 ppm in the following months. Again, however, this was lower than pre-optimization levels, which measured at 167.6 ppm. Finally, at unit 1, optimization testing achieved levels of 147.1 ppm and levels increased in the following months to 164.8 ppm, which was actually higher than pre-optimization levels of 158.1 ppm.

[18] May 2018 Sahu Report, pp. 3-8
[19] *Id.* at 8.
[20] Potential NOx emissions reductions were calculated using the same methodology as described in note 17, *supra*.
[21] As stated above, Commenters could have raised this earlier in the stakeholder process had we received the 2017 Fuel Tech Report earlier and hourly CEMS data earlier.
[22] May 2018 Sahu Report, p. 9.

UNIT 1		
Time Period Relative to Optimization Test	**Dates**	**NOx emissions in ppm (average hourly)**
Before Optimization	January 1 - June 6, 2017	158.1
During Optimization	June 7, June 12-14, June 20-29, 2017	147.1
After Optimization	June 30 - December 31, 2017	164.8

UNIT 2		
Time Period Relative to Optimization Test	**Dates**	**NOx emissions in ppm (average hourly)**
Before Optimization	January 1 - June 7, 2017	168.6
During Optimization	June 8, June 12-14, June 20-29, 2017	148.1
After Optimization	June 30 - December 31, 2017	165.1

UNIT 3		
Time Period Relative to Optimization Test	**Dates**	**NOx emissions in ppm (average hourly)**
Before Optimization	January 1 - June 5, 2017	167.6
During Optimization	June 6, June 12-14, June 20-29, 2017	144.9
After Optimization	June 30 - December 31, 2017	165.1

II. MDE Must Revise the Proposed Regulation to Ensure That The Feasibility Analysis Addresses the Potential to Install the Most Effective NOx Control Technology on the Baltimore Incinerator.

Proposed COMAR 26.11.08.10(E) sets forth the requirements for the feasibility analysis that Wheelabrator is required to submit by January 1, 2020 in order to assess whether additional NOx reductions can be obtained at BRESCO. Commenters have repeatedly noted that this section of the regulation needs serious improvements and have recommended specific improvements to prior drafts that are not reflected in the current proposed regulation.[23] The feasibility analysis is meaningless if it does not include an assessment of whether the most

[23] *See* Commenters' October 6, 2017 and May 11, 2018 comments. Commenters also attempted to share the specific changes that we consider necessary to the feasibility study section of the November 2017 draft of the rule at the December 11, 2017 AQCAC meeting.

effective NOx controls can be technically implemented on the Baltimore incinerator. MDE must revise this section of the proposed regulation in order to ensure that Wheelabrator does not exclude from the analysis any type of NOx control on the basis that it has not been used on another retrofit.

On September 17, 2018, the Baltimore City Council adopted Resolution 18-0101R, which calls on MDE to require that Wheelabrator's analysis evaluates the technical feasibility of installing the most effective pollution controls that exist for NOx on the Baltimore incinerator and the potential for boiler modification and replacement.[24] Put simply, it is completely unacceptable to Commenters and to the general public[25] for Wheelabrator to be allowed to submit an analysis that fails to assess whether the most effective control technology for NOx can be installed on its Baltimore incinerator. Such an analysis would also be contrary to the express statements made by MDE's own advisory board, AQCAC, which clearly intended for MDE to require that Wheelabrator analyze the potential to meet NOx limits down to 45 ppm on a 24-hour average, which is the limit that would have to be met by a new incinerator in Maryland.[26]

A. Minimum Requirements for the Feasibility Analysis.

As Commenters have previously stated to MDE in their joint letter dated October 6, 2017, the analysis submitted to MDE by Wheelabrator should, *at minimum*, address the feasibility of installing the following at the BRESCO incinerator:

- Optimized SNCR, including analysis of ammonia versus urea injection
- Flue Gas Recirculation
- Fuel nitrogen content reduction strategy
- In-duct Hybrid SNCR/SCR
- Regenerative SCR (RSCR)
- Advanced Natural Gas Injection
- Injection or Combustion Optimization
  - Additional temperature and flow profiling to inform injector height, positions, injection rates, and injector technology
  - Additional flow modeling (in boiler and ducts) and optimization of combustion practices
- Replacement of electrostatic precipitator (ESP) with Baghouses
- Boiler modification to accommodate Covanta Low-NO_x or similar technology
- Boiler replacement

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[24] Baltimore City Council, Resolution 18-0101R, details available at https://baltimore.legistar.com/LegislationDetail.aspx?ID=3678576&GUID=35FB7815-0A94-4195-8820-AB5256B6AEE1&Options=ID|Text|&Search=. City Council Resolution 18-0101R is attached as Attachment B.

[25] In addition to the Baltimore City Council's statement on this matter, Commenters are aware that at least 156 individual comments from residents of Baltimore City, Baltimore County, or Anne Arundel County (counties in the Baltimore ozone nonattainment area) have been submitted to MDE calling for a thorough evaluation of the potential to install new controls on the BRESCO incinerator.

[26] A 45 ppm NOx limit on a 24-hour average was set forth in the permit for the proposed Energy Answers incinerator in Baltimore City and Frederick/Carroll Renewable Waste-to-Energy Facility in Frederick County. Both facilities received their air quality permits but neither facility was constructed.

In addition, MDE should collect the following data from Wheelabrator now or as soon as possible in order to evaluate the feasibility study.

- Detailed temperature profile and computational fluid dynamics modeling of gas flow path, including vertical profiling within boiler and along the gas path after it leaves the boiler to the stack.
- Ammonia[27] CEMS data reported on a 1-hour average, provided electronically by Wheelabrator on a semiannual basis.
- Temporal Fuel/waste composition data, provided in a quarterly report.[28]
- Quarterly gas composition sample[29] collected as a 12-hour integrated sample at the first practical location after leaving the boiler. Sample shall be sent to accredited lab and will be analyzed for:
    - O_2, CO, CO_2, NO, NO_2, NH_3, SO_2 and total reduced sulfur.
    - Organics and toxics included within EPA Method TO-15
    - Alkaline Metals (sodium, potassium)
    - Heavy Metals
    - Arsenic

B. MDE Must Revise Subparagraphs E1(b) and (c) in Proposed COMAR 26.11.08.10 to prevent Wheelabrator from excluding the most effective NOx controls from the analysis.

Subparagraphs E(1)(b) and (c) of proposed COMAR 26.11.08.10 are drafted in such a way that Wheelabrator will likely exclude pollution control technology in the first step of the analysis if the technology has not been used in a retrofit on a similar existing incinerator. While Commenters consider it acceptable for Wheelabrator to conclude, after consideration and if supported with an explanation, that a certain technology cannot feasibly be installed on the incinerator, it is completely unacceptable for Wheelabrator to rule it out in the first step of the assessment.

Wheelabrator must be required to analyze the feasibility of installing all of the most effective NOx controls. MDE is fully authorized to craft a regulation ensuring that Wheelabrator submits such a report. Such an analysis would still afford Wheelabrator the option of explaining that it is technically infeasible to install these controls on the incinerator or why Wheelabrator considers said technology cost prohibitive. However, it should not be allowed to rule these technologies out in the first step of the analysis. At bare minimum, MDE must remove the language shown in strike-out below from subparagraph E(1)(b) if it is going to limit the rest of the analysis to the technologies identified in that paragraph.

(b) A written narrative and schematics detailing various

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[27]Commenters recognizes that ammonia monitoring is not currently required at the facility, but it should be required.
[28] At the September 22, 2017 stakeholder meeting, Tim Porter stated that Wheelabrator had conducted a study regarding fuel NO_x going back to regulation development in the mid-90's, and found that there was limiting yard waste had no measurable effect on NO_x reductions. Commenters have never received any follow-up communication from Wheelabrator or MDE about this study.
[29] As stated above, Wheelabrator has raised concerns about catalyst poisoning in the past. Gas sampling will show whether catalyst poisoning is a valid concern, and, if so, identify potential ways to work around it.

state-of-the-art NOx control technologies for achieving additional NOx emission reductions ~~from existing MWCs~~, including technologies capable of achieving NOx emission levels comparable to those for a new source ~~in consideration of the overall facility design at Wheelabrator Baltimore Inc.;~~

(c) An analysis of whether each state-of-the-art control technology identified under §E(1)(b) of this regulation could technically be implemented at the Wheelabrator Baltimore Inc. facility;

C. MDE Should Revise Subparagraph E(2) in Proposed COMAR 26.11.08.10 to require that additional information be provided within a defined time frame.

Subparagraph E(2) of Proposed COMAR 26.11.08.10 requires that Wheelabrator Baltimore submit additional information to MDE upon written request. This section should not allow Wheelabrator to engage in further foot-dragging but should require that the additional information must be submitted to MDE within a defined time frame. Commenters recommend that MDE revise the regulation to require that the information must be submitted within 30 days of the date of MDE's written request unless Wheelabrator can show good cause for why it should have 60 days from the date of the written request.

III. MDE Must Revise the Preamble to the Proposed Rule to State that MDE will Commence a Second Rulemaking In 2020 In Order To Adopt Stronger NOx Limits for the Wheelabrator Incinerator.

The preamble to the proposed rule does not include a statement about MDE's future rulemaking process in accordance with statements made by MDE senior staff to AQCAC. During the AQCAC meeting on December 11, 2017, Mr. George (Tad) Aburn, the Director of MDE's Air & Radiation Administration, stated to AQCAC that the preamble to the regulation would state that MDE would move ahead and adopt new NOx limits for the Wheelabrator incinerator after receiving the feasibility analysis.[30] The preamble to the proposed regulation does not include such a statement, and, in fact, makes only one extremely vague reference to a future rulemaking. In the first paragraph, the preamble states that "[t]he purpose of this action is to . . . establish new . . . analysis of possible additional NOx emission control requirements under COMAR."

MDE has represented to its advisory council on air regulations that the preamble to the rule would include a statement about MDE's adoption of additional NOx limits after receiving the feasibility study. This statement was made in the context of a discussion among AQCAC members about whether MDE should have included a presumptive limit in the rule in order to ensure the adoption of stronger limits for the BRESCO plant in the future. AQCAC ultimately concluded that MDE would, in good faith, require stronger limits based on the feasibility study. MDE must revise the preamble so that it is consistent with the representations made to AQCAC.

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[30] Recording of AQCAC December 11, 2017 meeting at 2:54:23, *available at* http://mdewin76.mde.state.md.us/MDEMeetings/ARMA_Audio_Files/AQCAC_12_11_17.MP4; *see also* recording at 2:52:45.

IV. MDE Must Revise the Proposed Rule to Clarify Requirements During Startup and Shutdown Events.

In general, Commenters appreciate MDE's approach of requiring mass-based limits that correspond with the concentration-based 24-hour NOx limits during startup and shutdown events of no more than 3 hours each. However, the proposed regulation is not sufficiently clear about the averaging period for startup and shutdown limits and how startup and shutdown events affect the time period during which the concentration-based 24-hour limits are measured. MDE must revise the proposed regulation to clarify. In addition, the methodology for calculating the mass-based emissions for Wheelabrator during startup and shutdown is based on what appears to be a very shaky assumption about the relationship between measured steam flow and stack flow. MDE should revise the proposed regulation so that Wheelabrator is required to calculate compliance with mass-based limits by using flow data from stack flow monitors in the same way that is required for the Montgomery County Resource Recovery Facility ("MCRRF").

A. <u>MDE Must Clarify the Averaging Period for Mass-Based Startup Shutdown Limits.</u>

MDE has proposed mass-based limits during startup and shutdown events, which events are limited by definition to no more than 3 hours. However, the startup and shutdown limits are measured on a 24-hour average. It appears that MDE is contemplating that the 24-hour periods that include startup and shutdown events will combine up to 3 hours of mass-based limits with no less than 21 hours of concentration-based limits.

As Commenters stated in their October 6, 2017 joint comments, we believe that the startup and shutdown emissions should be averaged over the period of the actual event, i.e. over 3 hours at most. However, if MDE proceeds with an approach that blends startup/shutdown emissions with emissions during normal operations, then the proposed regulation should be revised to clarify this. Specifically, MDE should make add the text shown below in bold to proposed COMAR 26.11.08.10M(1)[31]:

> M. Compliance with the NOx Mass Loading Emission Limitation
> for the Wheelabrator Baltimore Inc.
> (1) Compliance with the NOx mass loading emission limitation
> for periods of startup and shutdown in §D(2) of this regulation shall
> be demonstrated by calculating the 24-hour average of all hourly
> average NOx emission concentrations from continuous emission
> monitoring systems **for the 24-hour period that begins with the first hour of the startup or shutdown event.**

B. <u>MDE Must Clarify How Startup and Shutdown Events Affect the Period Over Which The 24-Hour Limits for Normal Operations Are Measured.</u>

In addition, MDE should clarify how a startup or shutdown event affects the period over which the 24-hour limits applicable during normal operations are calculated. Proposed COMAR

[31] MDE should also make the same change to proposed COMAR 26.11.08.10L(1), which applies to the Montgomery County facility.

26.11.08.10(D)(3)-(4) states the following with respect to the 24-hour limits during normal operations:

> (3) On days when the unit is in startup, the NOx 24-hour block average emission rate under §B of this regulation will apply for the 24-hour period after startup is completed.
>
> (4) On days when the unit is in shutdown, the NOx 24-hour block average emission rate under §B of this regulation will apply for the 24-hour period prior to the commencement of shutdown.

Under these provisions, if a startup event were to occur from midnight until 3 am on a given day, the concentration-based limit would be measured from 3 am until 3 am the following day. However, this is contradicted by the definition of "24-hour block average emissions rate," which term is used to identify the emissions limits in proposed COMAR 26.11.08.10(B) and contemplates a block that is always from midnight to midnight. The proposed definition of "24-hour block average emission rate" is:

> a value of NOx emissions in ppmv, corrected to 7 percent oxygen, calculated by:
> (a) Summing the hourly average ppmv of NOx emitted from the unit during 24 hours between midnight of one day and ending the following midnight, excluding periods of startup and shutdown; and
> (b) Dividing the total sum of hourly NOx ppmv values emitted during 24 hours between midnight of one day and ending the following midnight by 24.[32]

Commenters recommend that MDE stick with an approach that measures the 24-hour limits during normal operations as between midnight and midnight with startup and shutdown periods excluded but with the following changes (strikeout shows removed text and bold shows added text). The changes below also reflect the fact that it is not appropriate to divide emissions during normal operations by 24 if they do not reflect 24 hours of actual data.

> (b) Dividing the total sum of hourly NOx ppmv values emitted during 24 hours between midnight of one day and ending the following midnight by ~~24~~ **the number of hours for which data is available after startup and shutdown periods have been excluded.**

C. MDE Should Require that the Mass-Based Startup and Shutdown Limits for the BRESCO Incinerator Must Be Calculated Based on Stack Flow Rates Derived From Flow Monitors.

Under proposed COMAR 26.11.08.10M(2), Wheelabrator is to calculate its mass-based limits during startup and shutdown by utilizing "the applicable Prevention of Significant

[32] Proposed COMAR 26.11.08.01(B)(62).

Deterioration calculation methodology[,]" which is set forth in its Title V permit.[33] However, this methodology uses a "stack test air flow to steam flow factor" assuming a linear relationship between steam flow and stack flow. As demonstrated in the attached stack test data from the BRESCO incinerator,[34] this relationship does not appear to be an accurate predictor of stack flow rate even during normal operations at high steam loads. Additionally, Commenters have not seen any evidence to suggest this relationship will accurately predict stack air flow during periods of startup and shutdown. During startup, high levels of excess air are introduced into the furnace to establish good combustion, which is likely to have a direct impact on stack air flow.[35] Commenters are very concerned about the proposed use of this methodology for calculating total emissions during startup and shutdown and especially concerned it will make it difficult to assess compliance with mass-based emission limits.

According to statements in Wheelabrator's 2016 Relative Accuracy Test Audit ("RATA") documents,[36] there are stack flow monitors currently installed on the BRESCO incinerator.[37] It would make far more sense and be far more accurate for Wheelabrator to use air flow data from these existing monitors to calculate the mass-based limits as is required at the MCRRF. MDE should revise proposed COMAR 26.11.08.10(M)(2) (applicable to BRESCO) so that it mirrors proposed COMAR 26.11.08.10(L)(2) (applicable to MCRRF). MDE should also revise COMAR 26.11.08.10(M)(2) so that it reflects the fact that not all startup or shutdown events will take the maximum time of 3 hours that is allowed for such an event. Commenters believe that COMAR 25.11.08.10(M)((2) should read as follows:

> (2)The calculations in §M(1) of this regulation shall utilize stack flow rates derived from flow monitors, for all the hours during the startup or shutdown period and the remaining hours of the 24-hour period.

V. MDE Should Require Installation of Ammonia CEMS at BRESCO.

Commenters have ongoing concerns regarding the apparent failure to monitor ammonia slip at the facility. As stated within the June 2017 Fuel Tech Study, "ammonia slip needs to be

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33 Wheelabrator Baltimore, L.P., Title V Permit No. 24-510-01886 (April 1, 2014) p. 39.

34 Table 2-17 (Summary of Run-by-Run Air Flow Results), Emissions Testing Report 16009 Volume I – Text and Appendices A and B Performed by Testar Engineering P.C. for Wheelabrator Technologies, Inc. at the Wheelabrator Baltimore, LP Baltimore Maryland Units 1, 2, and 3 SDA Inlets and ESP Outlets (May 2016) p. 2-19. Excerpts attached hereto as Attachment C.

35 Preamble to the Proposed Rule. 45:17 Md. R. at 810 (Aug. 17, 2018) ("During periods of startup and shutdown, additional ambient air is introduced into the furnace. Applying the correction factor of 7 percent oxygen during these periods grossly misrepresents the actual NOx emissions produced from startup and shutdown operations. Therefore, an equivalent mass-based emission limit is substituted.")

36 2016 is the most recent RATA test that Commenters possess, but we have no reason to believe that the stack flow monitors have been removed from the BRESCO incinerator since then.

37 Annual CEM RATA Testing #16009R Text and Appendices performed by Testar Engineering P.C. for Wheelabrator Technologies, Inc. at the Wheelabrator Baltimore, LP Baltimore Maryland Units 1, 2, and 3 SDA Inlets and ESP Outlets (May 2016) ("2016 RATA)") p. 3-3 ("Each outlet is equipped with a stack flow rate monitoring system consisting of an Optical Scientific Inc (OSI) Model OFS 2000.") *See also* Table 3-1 (Facility CEMS Analyzers), 2016 RATA, p. 3-2 (showing a flow rate monitor at each ESP outlet). Excerpts attached hereto at Attachment D.

determined given its importance in determining the effectiveness of the SNCR process."[38] Ammonia slip is a key parameter to measure as an indicator of whether the urea is being released into the ideal temperature range and is given adequate residence time to react for SNCR systems. Although the facility does not currently have a concentration-based ammonia slip limit within its Title V/Part 70 permit, Wheelabrator has acknowledged that ammonia slip is a key design parameter for the facility to determine its ability to meet NOx emission limits without resulting in visible emissions.[39]

It appears fairly certain that the facility has not been routinely and continuously monitoring ammonia with CEMS or that MDE has received annual ammonia slip CEMS data from the facility. Commenters are also concerned about the absence of a limit for ammonia slip in the proposed rule especially as Connecticut includes such a limit in its incinerator NOx RACT regulations. EIP also provided examples in its May 9, 2017 comments of similar Wheelabrator incinerators in other states that are subject to a NOx limit of 150 ppm on a 24-hour basis and an ammonia slip limit of 20 ppm.

Ammonia slip measurement is critical for ongoing optimization, for the feasibility study of alternatives, and is an essential part of maintaining efficient operations in the future if any combination of SNCR or SCR is chosen as the control technology. Given its importance in monitoring the success of control technology, there appears to be no reason for MDE not to require use of ammonia CEMS at the incinerator and no reason for not requiring an ammonia slip limit. MDE should revise the proposed regulation to include an ammonia slip limit of no higher than 20 ppm and should require that ammonia CEMS be installed to monitor ammonia slip, as also discussed in EIP and CBF's October 6, 2017 comments, EIP's May 9, 2017 comments, and the May 2017 Sahu Report.

Thank you for considering our comments.

Sincerely,

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[38] June 2017 Fuel Tech Study, p. 5.

[39] Wheelabrator Technologies PowerPoint, Wheelabrator Baltimore NOx RACT Review January 17, 2017, pp. 5-7, a
http://mde.maryland.gov/programs/Regulations/air/Documents/SHMeetings/MunicipalWasteCombustors/MWCWheelabratorNOxRACTPresentation.pdf

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ATTACHMENT A

EXPERT REPORT

On

NOx Emissions from the Wheelabrator Baltimore Municipal Waste Incinerator in Baltimore City, owned and operated by Wheelabrator Baltimore, L.P. ("Wheelabrator")

by

Dr. Ranajit (Ron) Sahu, Consultant[1]

May 10, 2018

Introduction

In November of 2017, the Maryland Department of the Environment (MDE) shared with public stakeholders a draft regulation, dated November 17, 2017, that would revise Maryland's standards limiting emissions of nitrogen oxides (NOx) from large municipal waste combustors. The proposed revisions are to Title 26 Department of the Environment, Subtitle 11 Air Quality, Chapter 08 Control of Incinerators of COMAR. There are two large municipal waste combustors in Maryland, the larger being the Wheelabrator facility in Baltimore City.

I was asked to review certain materials relating to the Wheelabrator Baltimore municipal waste combustor and to give my opinion on what is achievable in terms of NOx reduction at this facility. Specifically, I reviewed the following materials in the preparation of this report: (1) the 2017 Fuel Tech Report on optimization of the existing controls at the facility; (2) the 2016 Quinapoxet Report; on optimization of the existing controls at the facility; (3) 1-hour averaged NOx CEMS data collected at the three boilers at the Wheelabrator facility for the calendar year 2017; [2] and (4) the November 2017 draft regulation circulated by MDE. As discussed in more detail below, I have previously commented on an optimization study performed in 2016 (the Quinapoxet Study).

My observations and conclusions based on this review are set forth below.

[1] Resume provided in Attachment A.

[2] In early 2018, MDE began making hourly CEMS data from the Wheelabrator facility available to the public online. The data that I reviewed is available under Special Studies, Wheelabrator Annual CEM Data Reports, Data, at the following link: http://mde.maryland.gov/programs/Air/Pages/ARAResearch.aspx.

NOx Reasonably Achievable Control Technology (RACT) for the Wheelabrator Baltimore Facility

Wheelabrator operates a municipal waste combustion facility in Baltimore. As noted in its application for its Title V permit application, submitted in 2006:

> "The facility is a municipal solid waste resource recovery facility (SIC Code 4953). It consists of three municipal waste combustors that generate steam…."

Each of these three combustors (hereafter "boilers" or "Units") and noted as Boiler 1 (Unit 1), Boiler 2 (Unit 2), and Boiler 3 (Unit 3), respectively – are identical as described by Wheelabrator in its 2006 application:

> "…750 ton per day Wheelabrator-Frye mass burn waterwall municipal waste combustor equipped with SNCR, SDA, ESP and activated carbon injection systems. Combustion gases are exhausted through a stack…that contains three flues (one for each of the three combustors)…."

In its November 2017 proposed regulation for the Wheelabrator facility, MDE effectively proposed a NOx RACT level with specified numerical limits (as noted below) followed by a potential future lower NOx limit– the latter to be developed based on the results of a feasibility study to be submitted by Wheelabrator to MDE in 2020. The November 2017 proposed regulation requires that the analysis will be prepared by an independent third party.

The proposed NOx RACT for Wheelabrator set forth in the November 2017 rule is:

A. a 24-hour block average emission rate[3] of 150 parts per million (ppmv);

and

B. a 145 ppmv rate over a 30-day period – both corrected to 7% oxygen.[4]

Per the proposed RACT, the 150 ppmv level is to be achieved by 2019 and the 145 ppmv level is to be achieved by 2020. The November 17, 2017 draft regulation also includes section E, "Additional NOx Emission Control Requirements," which states that "(1) Not

[3] The use of the term, "emission rate" to describe the proposed RACT level, is, in my opinion, inaccurate. Typically emission rate denotes the mass emissions of a pollutant (i.e., in pounds, grams, tons, etc.) either per unit time (i.e., gram/second, pound/hour, ton/year, etc.) or per unit of process input (i.e., lb/million Btu of heat input, lb/ton of waste burned), or per unit of process output (i.e., lb/pound of steam generated), etc. The proposed NOx RACT levels – i.e., parts per million in the exhast gases, corrected to 7% oxygen, are, more properly, concentrations, not emission rates.

[4] In all instances in this Declarations, it should be assumed that NOx levels discussed are always corrected to the 7% oxygen basis, whether explicitly stated or otherwise.

later than January 1, 2020, the owner or operator of Wheelabrator Baltimore, Inc. shall submit a feasibility analysis for additional control of NOx emissions from the Wheelabrator Baltimore Inc. facility to the Department."

Optimizing SNCR at the Wheelabrator, Baltimore Facility

Briefly, in SNCR, a NOx-reducing reagent, such as ammonia or urea is injected into the exhaust gases from a boiler, within a specified gas temperature range (typically when the gas temperature is between 1800-2100 F). At Wheelabrator, urea is injected as liquid droplets using a number of injectors, all located in a single plane at each boiler. Urea converts to ammonia and some ammonia leaves the system. The ammonia that leaves the system is considered unreacted ammonia and is known as the "ammonia slip." The goal of SNCR is to reduce NOx while keeping ammonia slip to a low level. Details of the existing SNCR system at Wheelabrator are provided in the 2017 Fuel Tech Report which is discussed and quoted from extensively later in this document.

I am aware of at least two attempts at "optimizing" the performance of the existing SNCR systems at Wheelabrator since 2016. From February to March of 2016, Wheelabrator conducted an optimization study[5] ("Quinapoxet Study"). I have previously commented on the significant technical shortcomings of this study.[6] Nonetheless, and in spite of these shortcomings, this study showed that certain, modest NOx reductions were possible with additional urea flow and modification of SNCR configuration. More recently, Fuel Tech completed a 4 -day optimization study in early June 2017,[7] which was followed by additional optimization testing of all 3 boilers from June 12-14, 2017 and June 20-29, 2017.[8] I discuss the findings of this work in the next section.

Findings in the 2017 Fuel Tech Report

I note first that Fuel Tech was charged with optimizing the current SNCR controls at each boiler to achieve NOx levels below 150 ppm

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[5] Final Report NOx Control System Optimization at the Wheelabrator Baltimore WTE Facility, Quinapoxet Solutions, (undated, 2016), Quinapoxet Solutions.

[6] My comments on this optimization study are set forth in the Expert Report on NOx Emissions from the Wheelabrator Baltimore Municipal Waste Incinerator in Baltimore City, owned and operated by Wheelabrator Baltimore, L.P. ("Wheelabrator") by Dr. Ranajit (Ron) Sahu, Consultant, May 5, 2017.

[7] Bisnett, Michael, Fuel Tech, NOx Optimization Project Wheelabrator Baltimore Inc., Baltimore, Maryland Units 1,2 & 3, June 5-9. 2017 ("2017 Fuel Tech Report"). I received an incomplete pdf copy of the report with 24 pdf pages. The last page of the report (before two non-numbered pages containing emails) is noted as "Page 22 of 31."

[8] The data for the June 12-14 and 20-29 days was submitted to MDE separately from the Fuel Tech Report.

> "Fuel Tech Inc. (FTI) was contracted by Wheelabrator to conduct SNCR system optimization testing at their Waste to Energy (WTE) facility located in Baltimore, Maryland. The objective was to obtain provide further optimization of the SNCR system to reduce NOx levels below 150 ppmdc (corrected to 7%02) while minimizing ammonia slip…"[9]

Briefly, Fuel Tech described the optimization details as follows:

> "For this optimization program, additional changes were made to the existing SNCR equipment to allow for more flexibility for enhancing NOx removal. These changes primarily included installation of new NOx injector tips with 30 deg up angle cone spray and use of alternate rear furnace wall injector ports. The use of the additional rear wall injector ports and modified injector tips enhanced the coverage of the injectors allowed for more flexibility to optimize the SNCR system to control NOx below the 150 ppmdc (corrected to 7% 02) target while simultaneously maintaining low ammonia slip levels."[10]

Admittedly, the Fuel Tech optimization work was of short duration, mainly indicating (and proving, as I show later) that lower than 150 ppm NOx levels can be achieved, even on a short-term, i.e., hourly basis at each boiler. Thus, it was a proof-of-concept study.

As far as baseline NOx levels during the 2017 Fuel Tech study, Fuel Tech notes the following:

> "Baseline NOx values on all 3 units were close to previous optimization testing levels of around 200+ ppmdc. Overall the during this testing period the baseline varied in the range of 190 to 220 ppmdc It appeared that earlier in the day the baseline was lower and increased during the day. The plant confirmed that the NOx would increase at times and but the mechanism or its consistency was not understood."[11]

The allusion to "previous optimization testing" is not entirely clear. It could be referencing the 2016 Quinapoxet Study, which did observe baseline levels around 200 ppm. I note that after years of experience with its boilers, it is troubling that Wheelabrator still does not have a reasonable understanding of the NOx levels from its boilers, as evidenced by Fuel Tech's comment in the last sentence above.

Fuel Tech reports the results of its optimization work at Unit 3 (the first unit at which the work was done on June 6, 2017), as follows:

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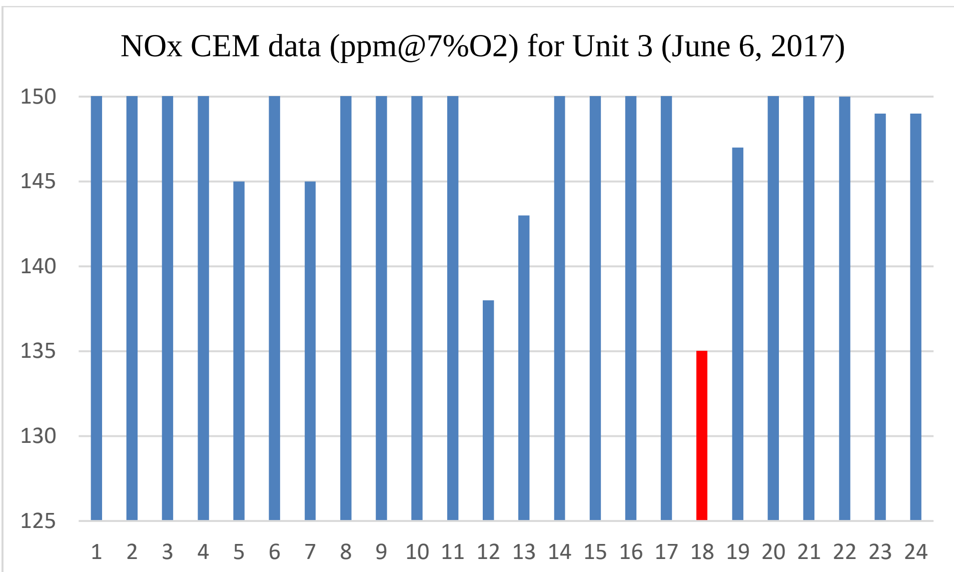
[9] 2017 Fuel Tech Report, p. 3.

[10] 2017 Fuel Tech Report, p. 3.
[11] 2017 Fuel Tech Report, p. 6.

"The results were very good. Using the same urea dosage of 15 gph, with an NSR of 1.14, the NOx reduction increased from 37.5 to 42.7%, utilization increased from 32.9% to 37.4% and the NOx dropped to 130 ppmdc. Individual injector water flow was 1.33 gpm at an air pressure of 40 psig. The measured ammonia slip increased slightly to 3.3 ppm from 1.1 ppm and stack observation indicated there was no visible plume. Making the change to the angled up tips showed that releasing the urea higher in the furnace with the right injector configuration was very beneficial….The initial Unit 3 optimization results were very positive and predictable and, as such, were used as the starting point for further optimization of the other 2 units."[12]

Shown below are the hourly NOx data for Unit 3 from the CEMS for June 6, 2017. It confirms that levels as low as 135 ppm[13] on an hourly basis, were obtained at Unit 3 during the optimization.



At Unit 1, the next Unit subjected to optimization, on June 7, 2017, Fuel Tech describes the results as follows:

"A baseline NOx value was obtained prior to the first test. For the 1st test NOx was kept close to 140 ppmdc with 15 gph of urea and a measured slip of 1.7 ppm (internal citation omitted) and utilization rate of 36.5%. This proved that the final configuration from Unit 3 carried over successfully to Unit 1 as SNCR performance was very good. (internal

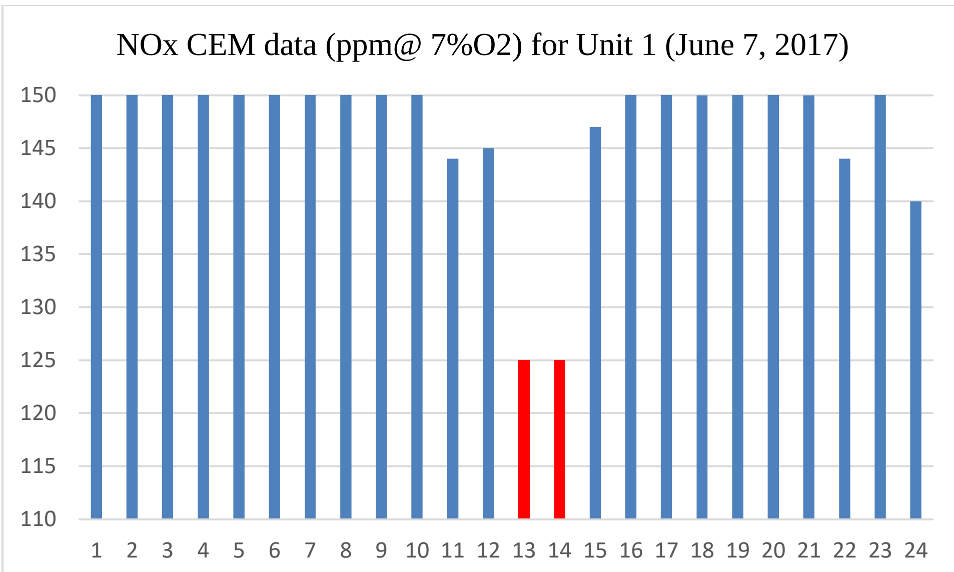
[12] 2017 Fuel Tech Report, p. 11-12.

[13] I do note that, while the Fuel Tech Report shows a NOx level as low as 130 ppm, the CEMS data for that day do not show that level. This discrepancy may simply be due to the different instruments used to measure the NOx levels (i.e., Fuel Tech's instrument and the CEM).

citation omitted). Given the successful duplication of results on Unit 1, further optimization was done to this configuration to evaluate the impact on SNCR performance….

Increasing the urea dosage (internal citation omitted) from 15 to 20 gph was done to determine if there is a point where increasing the urea dosage will not lead to a reasonable increase in the NOx reduction with the 6 injector configuration and essentially determining a point of diminishing returns. Increasing to 20 gph of urea reduced NOx to 130 ppmdc but the utilization dropped from 34.7 to 32.9% while ammonia slip increased slightly from 1.7 to 2.7 ppm evidence that urea rates above 20 gph, ammonia slip would increase very quickly."[14]

Shown below are the hourly NOx levels measured by the CEM on Unit 1. It confirms that levels as low as 125 ppm were obtained during the optimization.[15]



Finally, for Unit 2, the last unit optimized by Fuel Tech on June 8, 2017, Fuel Tech describes the result as follows:

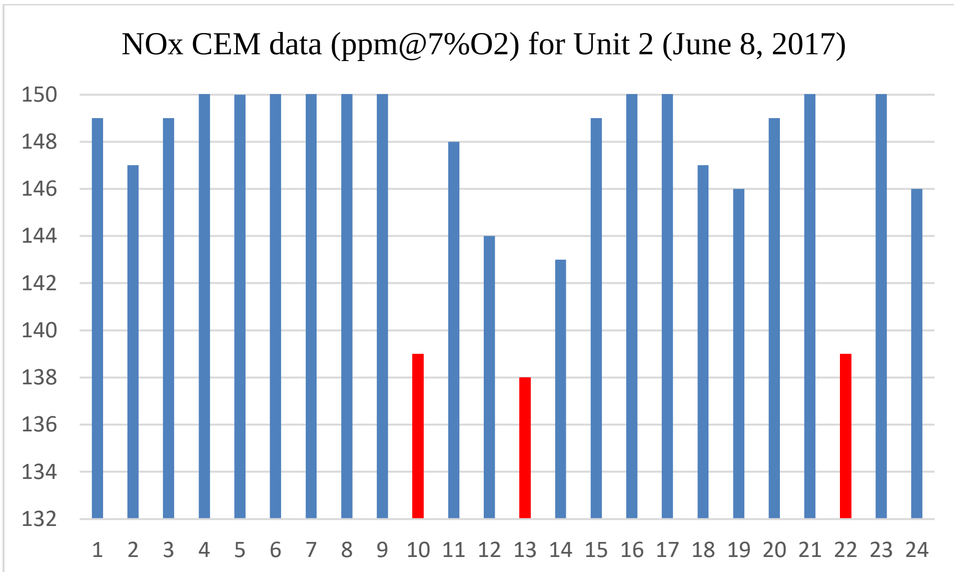
"Starting up the SNCR system for the first set of tests went without incident and the NOx was reduced to 140 ppmdc. (Figure 17) This was achieved with 4 injectors at 1 gpm water flow, 15 gph urea flow, and 40 psig air pressure. NOx levels were about 140 ppmdc and ammonia slip

[14] 2017 Fuel Tech Report, p. 14.

[15] As in the case of Unit 3, there appears to be a slight discrepancy between the NOx levels discussed in the Fuel Tech Report and the NOx CEM. For Unit 2, the CEM showed a value of 125 ppm, while the Fuel Tech Report notes 130 ppm.

was 2.9 ppm….Increasing the urea from 15 to 20 gph reduced NOx to about 135 ppmdc but the slip increases to 3.9 ppm."[16]

Similar to the data presented above for the other two units, I show below the NOx CEM data for Unit 2 for June 8, 2017. This data shows levels lower than 140 ppm with a low of 138 ppm.



Summarizing its results and relating it to the objective of the study, Fuel Tech stated:

> "The results of FTI's short term SNCR optimization testing indicated that use of 30 deg up angled injector tips and injector total liquid flow of 1 gpm provided additional capability for SNCR systems to achieve and maintain NOx emission level of 150 ppmdc with minimal ammonia slip."[17]

Thus, it is clear that, a level of 150 ppm NOx can be achieved today, at each unit at Wheelabrator. In fact, as shown above, hourly levels in the 125-140 range were achievable at each unit during mid-2017.

The proposed RACT limits for Wheelabrator include averaging times longer than hourly – i.e, 150 ppm using a block average of 24 hours and 145 ppm using a 30 day average. The longer the averaging time, the more the ability to smooth out variations. Given these proposed averaging times, and reviewing the results of the 2017 Fuel Tech optimization work, it is my opinion that the proposed RACT levels can be lowered – likely from 150

[16] 2017 Fuel Tech Report, p. 18.

[17] 2017 Fuel Tech Report, p. 21.

down to a level closer to 135 ppm for the 24 hour block average and from 145 down to a level of 130 ppm for the 30-day averaging period.

As the optimization testing discussed in the 2017 Fuel Tech Report was of limited duration, it is my opinion that longer term testing performed using a more methodical approach would likely have shown the Wheelabrator facility's ability to achieve the 130-135 ppm levels discussed above on a more consistent basis is possible right now. These tests would likely have shown the facility's ability to achieve lower NOx levels on a longer term and more consistent basis if Wheelabrator had continued the adjustments made by Fuel Tech in June 2017 at each of its boilers with the express goal of achieving 130/135 ppm levels.

In addition, Wheelabrator should also have monitored and run all necessary feedback loops involving local NOx concentrations near the SNCR injection points, gas temperature in the SNCR injection plane, and ammonia slip. While Fuel Tech tested and showed the ability for automatic SNCR control to meet the 150 ppm setpoint, lower setpoints were not tested to explore the limits of the system. The use of automatic feedback controls at lower NOx setpoints should allow the SNCR system to consistently meet the lower 130/135 ppm levels on a longer term basis.

Wheelabrator should also have continued to optimize injector configurations and parameters as needed to achieve, maintain, and further reduce NOx at each of the boilers along the lines of the adjustments described in the conclusion of the 2017 Fuel Tech Report. Additional SNCR adjustments mentioned include using additional injectors, increasing total liquid flow to injectors, and changing the atomizing air pressure. The Fuel Tech test results indicate that even further NOx reduction may be possible, as the choice to decrease total liquid flow through each injector led to sub-optimal results in terms of NOx concentration, NOx reduction percentage and utilization percentage. Urea flow was also constrained to 20 gph, limiting the amount of information available on additional reduction and corresponding ammonia slip.

Importantly, it is clear to me that a limit of 135 ppm on a 24-hour basis and 130 ppm on a 30-day basis can be achieved <u>now</u> (and that more methodical optimization testing would have shown this to be the case) as opposed to the future dates in MDE's proposed RACT – i.e., 2020 for the 145 ppm 30-day average and 2019 for the 150 ppm 24-hour block average.

<u>Performance Levels After the 2017 Fuel Tech Study</u>

I reviewed the 2017 hourly CEM NOx data for each unit to ascertain if Wheelabrator had attempted to conduct a long-term assessment of the optimization work, as recommended by Fuel Tech.[18] Emails and data submitted to MDE by Wheelabrator show that Wheelabrator conducted longer-term testing from June 12- 14, 2017 and June 20-29, 2017. However, this is still a relatively brief time period for such testing and my review of the hourly data shows that the reductions achieved during the optimization periods were not sustained afterward. Also, the June 12-14, 2017 and June 20-29, 2017 data did not include additional important parameters such as ammonia slip, etc. which were discussed in the Fuel Tech Report covering the June 6-8, 2017 tests.

Shown below are the NOx levels, for each Unit:

- on the days of the optimization tests for that unit, including the initial testing date for each boiler and the subsequent dates (June 12-14 and 20-29, during which all boilers were tested);
- after the optimization tests (i.e., from June 30, 2017, the date on which all of optimization testing ended, until December 31, 2017, after the last day for which CEM data was available); and
- before the optimization testing (i.e., from January 1, 2017, till the day prior to the first optimization day for the respective unit).

Unit 1 Average Hourly NOx (June 7, June 12-14, June 20-29, 2017), ppm	147.1
Unit 1 Average Hourly NOx (June 30 - December 31, 2017), ppm	164.8
Unit 1 Average Hourly NOx (January 1 - June 6, 2017), ppm	158.1

Unit 2 Average Hourly NOx (June 8, June 12-14, June 20-29, 2017), ppm	148.1
Unit 2 Average Hourly NOx (June 30 - December 31, 2017), ppm	165.1
Unit 2 Average Hourly NOx (January 1 - June 7, 2017), ppm	168.6

Unit 3 Average Hourly NOx (June 6, June 12-14, June 20-29, 2017), ppm	144.9
Unit 3 Average Hourly NOx (June 30 - December 31, 2017), ppm	165.1
Unit 3 Average Hourly NOx (January 1 - June 5, 2017), ppm	167.6

It is clear, from Wheelabrator's own CEM data presented above that the lower NOx levels achieved during the optimization were not sustained after the optimization dates at each unit. Arguably, for Unit 1, post-optimization average NOx (164.8 ppm) was worse than the pre-optimization level (158.1 ppm), which was higher than the 147.1 ppm for the optimization dates. For Unit 2, while the post-optimization level (165.1 ppm) was a little lower than the pre-optimization level (168.6 ppm), it was considerably higher than the 148.1 ppm for the optimization periods. Similarly, for Unit 3, the post-optimization level of 165.1 ppm was slightly lower than the pre-optimization level of 167.6, but much higher than the level for the optimization (144.9 ppm) periods.

It is clear that Wheelabrator did not continue to sustain the lower levels achieved during the 2017 Fuel Tech optimization study.

<u>**Conclusions**</u>

Based on my review of prior optimization work on its current SNCR systems including the 2017 Fuel Tech study and my analysis of the 2017 hourly NOx CEMS data for each Unit, I reach the following conclusions:

A. that each of the three units at the Wheelabrator facility can reasonably achieve <u>hourly</u> NOx levels of 150 ppm <u>today</u>, if the existing SNCR systems at each Unit, as modified per the suggestions and descriptions in the 2017 Fuel Tech Report, were properly implemented and operated;

B. that, therefore, 24-hour and 30-day averaged NOx levels of less than 150 ppm should also be achievable <u>today</u>. It is my opinion, based on the data that a 24-hour block level of 135 ppm should be achievable <u>today</u> and that a 30-day average level of 130 ppm should be achievable <u>today</u> at each Unit using optimized, existing SNCR;

C. that, based on the observed NOx levels reported by Wheelabrator post-optimization via the NOx CEM at each Unit, it appears that Wheelabrator did not continue with the optimization of the existing SNCR systems as discussed in the 2017 Fuel Tech Report beyond June 29, 2017. This is consistent with there being no regulatory driver or requirement for Wheelabrator to do so;

D. that Wheelabrator should electronically report not just the hourly NOx (and SO2 and CO) hourly CEMS data are it is currently doing, but also the additional parameters that are listed in the Tables on Page 22 of the 2017 Fuel Tech Report; and, finally

E. notwithstanding all of the above pertaining to the interim NOx levels that can be obtained via the proper and optimized operation of the existing SNCR systems to meet the proposed RACT – it is my opinion, based on my understanding of the boilers at the facility, that I see no technical impediments to the implementation of the even-more NOx reducing technologies, such as SCR (or hybrid SNCR/SCR), in the appropriate locations along the gas paths at each of the boilers. SCR would provide significantly better NOx levels (around 50 ppm, assuming roughly 75% SCR NOx reduction efficiency, a lenient target), than compared to optimized SNCR at 130-135 ppm as noted above.

ATTACHMENT A

RANAJIT (RON) SAHU, Ph.D, QEP, CEM (Nevada)

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

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EXPERIENCE SUMMARY

Dr. Sahu has over twenty eight years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over twenty five years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty five years include various trade associations as well as individual companies such as steel mills, petroleum refineries, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including EPA, the US Dept. of Justice, several states, various agencies such as the California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

In addition to consulting, Dr. Sahu has taught numerous courses in several Southern California universities including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management) for the past seventeen years. In this time period he has also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls) and at California State University, Fullerton (transportation and air quality).

Dr. Sahu has and continues to provide expert witness services in a number of environmental areas discussed above in both state and Federal courts as well as before administrative bodies (please see Annex A).

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.) public sector (such as the US Department of Justice) and public interest group clients with project management, air quality consulting, waste remediation and management consulting, as well as regulatory and engineering support consulting services.

1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.

Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.

1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.

1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.

1989-1990 Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.

1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

1984-1988 Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.

1984 M. S., Mechanical Engineering, Caltech, Pasadena, CA.

1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

"Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.

"Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.

"Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.

"Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.

“Thermodynamics and Heat Transfer,” Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

"Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.

"Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

“Advanced Hazardous Waste Management” University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

“Environmental Risk Assessment,” Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

“Hazardous Waste Remediation” Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

"Air Pollution Controls," University of Southern California, Dept. of Civil Engineering, Fall 1993, Fall 1994.

"Air Pollution Fundamentals," University of Southern California, Dept. of Civil Engineering, Winter 1994.

University of California, Los Angeles

"Air Pollution Fundamentals," University of California, Los Angeles, Dept. of Civil and Environmental Engineering, Spring 1994, Spring 1999, Spring 2000, Spring 2003, Spring 2006, Spring 2007, Spring 2008, Spring 2009.

International Programs

“Environmental Planning and Management,” 5 week program for visiting Chinese delegation, 1994.

“Environmental Planning and Management,” 1 day program for visiting Russian delegation, 1995.

“Air Pollution Planning and Management,” IEP, UCR, Spring 1996.

"Environmental Issues and Air Pollution," IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

President of India Gold Medal, IIT Kharagpur, India, 1983.

Member of the Alternatives Assessment Committee of the Grand Canyon Visibility Transport Commission, established by the Clean Air Act Amendments of 1990, 1992-present.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-present.

Air and Waste Management Association, West Coast Section, 1989-present.

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

Certified Permitting Professional, South Coast AQMD (#C8320), since 1993.

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2017.

PUBLICATIONS (PARTIAL LIST)

"Physical Properties and Oxidation Rates of Chars from Bituminous Coals," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **67**, 275-283 (1988).

"Char Combustion: Measurement and Analysis of Particle Temperature Histories," with R.C. Flagan, G.R. Gavalas and P.S. Northrop, *Comb. Sci. Tech.* **60**, 215-230 (1988).

"On the Combustion of Bituminous Coal Chars," PhD Thesis, California Institute of Technology (1988).

"Optical Pyrometry: A Powerful Tool for Coal Combustion Diagnostics," *J. Coal Quality*, **8**, 17-22 (1989).

"Post-Ignition Transients in the Combustion of Single Char Particles," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **68**, 849-855 (1989).

"A Model for Single Particle Combustion of Bituminous Coal Char." Proc. ASME National Heat Transfer Conference, Philadelphia, **HTD-Vol. 106**, 505-513 (1989).

"Discrete Simulation of Cenospheric Coal-Char Combustion," with R.C. Flagan and G.R. Gavalas, *Combust. Flame*, **77**, 337-346 (1989).

"Particle Measurements in Coal Combustion," with R.C. Flagan, in "**Combustion Measurements**" (ed. N. Chigier), Hemisphere Publishing Corp. (1991).

"Cross Linking in Pore Structures and Its Effect on Reactivity," with G.R. Gavalas in preparation.

"Natural Frequencies and Mode Shapes of Straight Tubes," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Optimal Tube Layouts for Kamui SL-Series Exchangers," with K. Ishihara, Proprietary Report for Kamui Company Limited, Tokyo, Japan (1990).

"HTRI Process Heater Conceptual Design," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).

"Asymptotic Theory of Transonic Wind Tunnel Wall Interference," with N.D. Malmuth and others, Arnold Engineering Development Center, Air Force Systems Command, USAF (1990).

"Gas Radiation in a Fired Heater Convection Section," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1990).

"Heat Transfer and Pressure Drop in NTIW Heat Exchangers," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1991).

"NOx Control and Thermal Design," Thermal Engineering Tech Briefs, (1994).

"From Purchase of Landmark Environmental Insurance to Remediation: Case Study in Henderson, Nevada," with Robin E. Bain and Jill Quillin, presented at the AQMA Annual Meeting, Florida, 2001.

"The Jones Act Contribution to Global Warming, Acid Rain and Toxic Air Contaminants," with Charles W. Botsford, presented at the AQMA Annual Meeting, Florida, 2001.

PRESENTATIONS (PARTIAL LIST)

"Pore Structure and Combustion Kinetics - Interpretation of Single Particle Temperature-Time Histories," with P.S. Northrop, R.C. Flagan and G.R. Gavalas, presented at the AIChE Annual Meeting, New York (1987).

"Measurement of Temperature-Time Histories of Burning Single Coal Char Particles," with R.C. Flagan, presented at the American Flame Research Committee Fall International Symposium, Pittsburgh, (1988).

"Physical Characterization of a Cenospheric Coal Char Burned at High Temperatures," with R.C. Flagan and G.R. Gavalas, presented at the Fall Meeting of the Western States Section of the Combustion Institute, Laguna Beach, California (1988).

"Control of Nitrogen Oxide Emissions in Gas Fired Heaters - The Retrofit Experience," with G. P. Croce and R. Patel, presented at the International Conference on Environmental Control of Combustion Processes (Jointly sponsored by the American Flame Research Committee and the Japan Flame Research Committee), Honolulu, Hawaii (1991).

"Air Toxics - Past, Present and the Future," presented at the Joint AIChE/AAEE Breakfast Meeting at the AIChE 1991 Annual Meeting, Los Angeles, California, November 17-22 (1991).

"Air Toxics Emissions and Risk Impacts from Automobiles Using Reformulated Gasolines," presented at the Third Annual Current Issues in Air Toxics Conference, Sacramento, California, November 9-10 (1992).

"Air Toxics from Mobile Sources," presented at the Environmental Health Sciences (ESE) Seminar Series, UCLA, Los Angeles, California, November 12, (1992).

"Kilns, Ovens, and Dryers - Present and Future," presented at the Gas Company Air Quality Permit Assistance Seminar, Industry Hills Sheraton, California, November 20, (1992).

"The Design and Implementation of Vehicle Scrapping Programs," presented at the 86th Annual Meeting of the Air and Waste Management Association, Denver, Colorado, June 12, 1993.

"Air Quality Planning and Control in Beijing, China," presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

Annex A

Expert Litigation Support

A. Occasions where Dr. Sahu has provided Written or Oral testimony before Congress:

1. In July 2012, provided expert written and oral testimony to the House Subcommittee on Energy and the Environment, Committee on Science, Space, and Technology at a Hearing entitled "Hitting the Ethanol Blend Wall – Examining the Science on E15."

B. Matters for which Dr. Sahu has provided affidavits and expert reports include:

2. Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.

3. Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the United States in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).

4. Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the United States in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

5. Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the United States in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (Middle District of North Carolina).

6. Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the United States in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (Southern District of Ohio).

7. Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.

8. Expert Report and Deposition (10/31/2005 and 11/1/2005) on behalf of the United States in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc.*, 5:04-cv-00034-KSF (Eastern District of Kentucky).

9. Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.

10. Expert Report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.

11. Expert Report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.

12. Expert Report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.

13. Expert Report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo's eight new proposed PRB-fired PC boilers located at seven TX sites.

14. Expert Testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).

15. Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.

16. Expert Report and Deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.,* 2:05cv0885 (Western District of Pennsylvania).

17. Expert Reports and Pre-filed Testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.

18. Expert Report and Deposition (October 2007) on behalf of MTD Products Inc., in connection with *General Power Products, LLC v MTD Products Inc*., 1:06 CVA 0143 (Southern District of Ohio, Western Division) .

19. Expert Report and Deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.

20. Expert Reports, Affidavit, and Deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.

21. Affidavits (May 2010/June 2010 in the Office of Administrative Hearings))/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).

22. Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).

23. Declaration (August 2008) on behalf of the Sierra Club in the matter of Dominion Wise County plant MACT.us

24. Expert Report (June 2008) on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis.

25. Expert Report (February 2009) on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone's proposed Unit 3 in Texas.

26. Expert Report (June 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*

27. Expert Report (August 2009) on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper's proposed Pee Dee plant in South Carolina).

28. Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.

29. Expert Report (August 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

30. Expert Report and Rebuttal Report (September 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

31. Expert Report (December 2009) and Rebuttal reports (May 2010 and June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

32. Pre-filed Testimony (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

33. Pre-filed Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

34. Expert Report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the United States in connection with the Louisiana Generating NSR

Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.

35. Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the United States in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (Eastern District of Michigan).

36. Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.

37. Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (District of Colorado).

38. Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

39. Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

40. Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, November 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. Public Service Company of New Mexico* (PNM), Civil No. 1:02-CV-0552 BB/ATC (ACE) (District of New Mexico).

41. Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

42. Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.

43. Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (Eastern District of Texas, Texarkana Division).

44. Pre-Filed Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

45. Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.

46. Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

47. Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority,* Civil Action No. 4:11-cv-00791 (Southern District of Texas, Houston Division).

48. Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

49. Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

50. Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.*, Civil Action No. A-08-CA-648-LY (Western District of Texas, Austin Division).

51. Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.,* Case No. 3:10-cv-747 (TJM/DEP) (Northern District of New York).

52. Declaration (October 2011) on behalf of the Plaintiffs in the matter of *American Nurses Association et. al. (Plaintiffs), v. US EPA (Defendant),* Case No. 1:08-cv-02198-RMC (US District Court for the District of Columbia).

53. Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association,* Case No. 11-417-MJP (Western District of Washington).

54. Expert Report (March 2012) and Supplemental Expert Report (November 2013) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v.*

ExxonMobil Corporation et al., Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

55. Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency,* Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).

56. Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plant) (Supreme Court of the State of Kansas).

57. Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality,* Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).

58. Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) on behalf of the states of New Jersey and Connecticut in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.,* Civil Action No. 07-CV-5298 (JKG) (Eastern District of Pennsylvania).

59. Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project.

60. Expert Report (August 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC,* 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.

61. Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.

62. Expert Report (October 2012) on behalf of the Appellants (Robert Concilus and Leah Humes) in the matter of Robert Concilus and Leah Humes v. Commonwealth of Pennsylvania Department of Environmental Protection and Crawford Renewable Energy, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2011-167-R.

63. Expert Report (October 2012), Supplemental Expert Report (January 2013), and Affidavit (June 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

64. Pre-filed Testimony (October 2012) on behalf of No-Sag in the matter of the North Springfield Sustainable Energy Project before the State of Vermont, Public Service Board.

65. Pre-filed Testimony (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to

Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

66. Expert Report (February 2013) on behalf of Petitioners in the matter of Credence Crematory, Cause No. 12-A-J-4538 before the Indiana Office of Environmental Adjudication.

67. Expert Report (April 2013), Rebuttal report (July 2013), and Declarations (October 2013, November 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

68. Declaration (April 2013) on behalf of Petitioners in the matter of *Sierra Club, et al., (Petitioners) v Environmental Protection Agency et al. (Resppondents)*, Case No., 13-1112, (Court of Appeals, District of Columbia Circuit).

69. Expert Report (May 2013) and Rebuttal Expert Report (July 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

70. Declaration (August 2013) on behalf of A. J. Acosta Company, Inc., in the matter of *A. J. Acosta Company, Inc., v. County of San Bernardino*, Case No. CIVSS803651.

71. Comments (October 2013) on behalf of the Washington Environmental Council and the Sierra Club in the matter of the Washington State Oil Refinery RACT (for Greenhouse Gases), submitted to the Washington State Department of Ecology, the Northwest Clean Air Agency, and the Puget Sound Clean Air Agency.

72. Statement (November 2013) on behalf of various Environmental Organizations in the matter of the Boswell Energy Center (BEC) Unit 4 Environmental Retrofit Project, to the Minnesota Public Utilities Commission, Docket No. E-015/M-12-920.

73. Expert Report (December 2013) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

74. Expert Testimony (December 2013) on behalf of the Sierra Club in the matter of Public Service Company of New Hampshire Merrimack Station Scrubber Project and Cost Recovery, Docket No. DE 11-250, to the State of New Hampshire Public Utilities Commission.

75. Expert Report (January 2014) on behalf of Baja, Inc., in *Baja, Inc., v. Automotive Testing and Development Services, Inc. et. al*, Civil Action No. 8:13-CV-02057-GRA (District of South Carolina, Anderson/Greenwood Division).

76. Declaration (March 2014) on behalf of the Center for International Environmental Law, Chesapeake Climate Action Network, Friends of the Earth, Pacific

Environment, and the Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. the Export-Import Bank (Ex-Im Bank) of the United States*, Civil Action No. 13-1820 RC (District Court for the District of Columbia).

77. Declaration (April 2014) on behalf of Respondent-Intervenors in the matter of *Mexichem Specialty Resins Inc., et al., (Petitioners) v Environmental Protection Agency et al.,* Case No., 12-1260 (and Consolidated Case Nos. 12-1263, 12-1265, 12-1266, and 12-1267), (Court of Appeals, District of Columbia Circuit).

78. Direct Prefiled Testimony (June 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17319 (Michigan Public Service Commission).

79. Expert Report (June 2014) on behalf of ECM Biofilms in the matter of the US Federal Trade Commission (FTC) v. ECM Biofilms (FTC Docket #9358).

80. Direct Prefiled Testimony (August 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of Consumers Energy Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17317 (Michigan Public Service Commission).

81. Declaration (July 2014) on behalf of Public Health Intervenors in the matter of *EME Homer City Generation v. US EPA* (Case No. 11-1302 and consolidated cases) relating to the lifting of the stay entered by the Court on December 30, 2011 (US Court of Appeals for the District of Columbia).

82. Expert Report (September 2014), Rebuttal Expert Report (December 2014) and Supplemental Expert Report (March 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

83. Expert Report (November 2014) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

84. *Declaration (January 2015) relating to Startup/Shutdown in the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.*

85. Pre-filed Direct Testimony (March 2015), Supplemental Testimony (May 2015), and Surrebuttal Testimony (December 2015) on behalf of Friends of the Columbia Gorge in the matter of the Application for a Site Certificate for the Troutdale Energy Center before the Oregon Energy Facility Siting Council.

86. Brief of Amici Curiae Experts in Air Pollution Control and Air Quality Regulation in Support of the Respondents, On Writs of Certiorari to the US Court of Appeals for the District of Columbia, No. 14-46, 47, 48. *Michigan et. al., (Petitioners) v. EPA et. al., Utility Air Regulatory Group (Petitioners) v. EPA et. al., National Mining Association et. al., (Petitioner) v. EPA et. al.,* (Supreme Court of the United States).

87. Expert Report (March 2015) and Rebuttal Expert Report (January 2016) on behalf of Plaintiffs in the matter of *Conservation Law Foundation v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

88. Declaration (April 2015) relating to various Technical Corrections for the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.

89. Direct Prefiled Testimony (May 2015) on behalf of the Michigan Environmental Council, the Natural Resources Defense Council, and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Increase its Rates, Amend its Rate Schedules and Rules Governing the Distribution and Supply of Electric Energy and for Miscellaneous Accounting Authority, Case No. U-17767 (Michigan Public Service Commission).

90. Expert Report (July 2015) and Rebuttal Expert Report (July 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants),* Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

91. Declaration (August 2015, Docket No. 1570376) in support of "Opposition of Respondent-Intervenors American Lung Association, et. al., to Tri-State Generation's Emergency Motion;" Declaration (September 2015, Docket No. 1574820) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors for Remand Without Vacatur;" Declaration (October 2015) in support of "Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors to State and Certain Industry Petitioners' Motion to Govern, *White Stallion Energy Center, LLC v. US EPA*, Case No. 12-1100 (US Court of Appeals for the District of Columbia).

92. Declaration (September 2015) in support of the Draft Title V Permit for Dickerson Generating Station (Proposed Permit No 24-031-0019) on behalf of the Environmental Integrity Project.

93. Expert Report (Liability Phase) (December 2015) and Rebuttal Expert Report (February 2016) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., Environmental Law and Policy Center, and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants),* Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

94. Declaration (December 2015) in support of the Petition to Object to the Title V Permit for Morgantown Generating Station (Proposed Permit No 24-017-0014) on behalf of the Environmental Integrity Project.

95. Expert Report (November 2015) on behalf of Appellants in the matter of *Sierra Club, et al. v. Craig W. Butler, Director of Ohio Environmental Protection Agency et al.,* ERAC Case No. 14-256814.

96. Affidavit (January 2016) on behalf of Bridgewatch Detroit in the matter of *Bridgewatch Detroit v. Waterfront Petroleum Terminal Co., and Waterfront Terminal Holdings, LLC.*, in the Circuit Court for the County of Wayne, State of Michigan.

97. Expert Report (February 2016) and Rebuttal Expert Report (July 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

98. Direct Testimony (May 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

99. Declaration (June 2016) relating to deficiencies in air quality analysis for the proposed Millenium Bulk Terminal, Port of Longview, Washington.

100. Declaration (December 2016) relating to EPA's refusal to set limits on PM emissions from coal-fired power plants that reflect pollution reductions achievable with fabric filters on behalf of Environmental Integrity Project, Clean Air Council, Chesapeake Climate Action Network, Downwinders at Risk represented by Earthjustice in the matter of *ARIPPA v EPA, Case No. 15-1180.* (D.C. Circuit Court of Appeals).

101. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

102. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Backus Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

103. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Drakulic Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

104. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Deutsch Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

105. Affidavit (February 2017) pertaining to deficiencies water discharge compliance issues at the Wood River Refinery in the matter of *People of the State of Illinois (Plaintiff) v. Phillips 66 Company, ConocoPhillips Company, WRB Refining LP (Defendants)*, Case No. 16-CH-656, (Circuit Court for the Third Judicial Circuit, Madison County, Illinois).

106. Expert Report (March 2017) on behalf of the Plaintiff pertaining to non-degradation analysis for waste water discharges from a power plant in the matter of *Sierra Club (Plaintiff) v. Pennsylvania Department of Environmental Protection (PADEP) and Lackawanna Energy Center*, Docket No. 2016-047-L (consolidated), (Pennsylvania Environmental Hearing Board).

107. Expert Report (March 2017) on behalf of the Plaintiff pertaining to air emissions from the Heritage incinerator in East Liverpool, Ohio in the matter of *Save our County (Plaintiff) v. Heritage Thermal Services, Inc. (Defendant), Case No. 4:16-CV-1544-BYP*, (US District Court for the Northern District of Ohio, Eastern Division).

108. Rebuttal Expert Report (June 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight (Plaintiffs) v Coyote Creek Mining Company LLC (Defendant),* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

109. Expert Affidavit (August 2017) and Penalty/Remedy Expert Affidavit (October 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant,)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

110. Expert Report (August 2017) on behalf of Appellant in the matter of *Patricia Ann Troiano (Appellant) v. Upper Burrell Township Zoning Hearing Board (Appellee)*, Court of Common Pleas of Westmoreland County, Pennsylvania, Civil Division.

111. Expert Report (October 2017), Supplemental Expert Report (October 2017), and and Rebuttal Expert Report (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

112. Declaration (December 2017) on behalf of the Environmental Integrity Project in the matter of permit issuance for ATI Flat Rolled Products Holdings, Breckenridge, PA to the Allegheny County Health Department.

113. Expert Report (Harm Phase) (January 2018) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants),* Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).

C. Occasions where Dr. Sahu has provided oral testimony in depositions, at trial or in similar proceedings include the following:

114. Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill.

115. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

116. Trial Testimony (February 2003) on behalf of the United States in the Ohio Edison NSR Cases, *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).

117. Trial Testimony (June 2003) on behalf of the United States in the Illinois Power NSR Case, *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).

118. Deposition (10/20/2005) on behalf of the United States in connection with the Cinergy NSR Case. *United States, et* al. *v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (Southern District of Indiana).

119. Oral Testimony (August 2006) on behalf of the Appalachian Center for the Economy and the Environment re. the Western Greenbrier plant, WV before the West Virginia DEP.

120. Oral Testimony (May 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) re. the Thompson River Cogeneration plant before the Montana Board of Environmental Review.

121. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.

122. Oral Testimony (August 2008) on behalf of the Sierra Club and Clean Water re. Big Stone Unit II before the South Dakota Board of Minerals and the Environment.

123. Oral Testimony (February 2009) on behalf of the Sierra Club and the Southern Environmental Law Center re. Santee Cooper Pee Dee units before the South Carolina Board of Health and Environmental Control.

124. Oral Testimony (February 2009) on behalf of the Sierra Club and the Environmental Integrity Project re. NRG Limestone Unit 3 before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

125. Deposition (July 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al*.

126. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coleto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

127. Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

128. Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.

129. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).

130. Oral Testimony (November 2009) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

131. Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).

132. Oral Testimony (February 2010) on behalf of the Environmental Defense Fund re. the White Stallion Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

133. Deposition (June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

134. Trial Testimony (September 2010) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (Western District of Pennsylvania).

135. Oral Direct and Rebuttal Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).

136. Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.

137. Oral Testimony (October 2010) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.

138. Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

139. Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

140. Deposition (December 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC,* 09-CV100-RET-CN (Middle District of Louisiana).

141. Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).

142. Oral Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).

143. Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).

144. Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.

145. Oral Testimony at Hearing (March 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).

146. Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).

147. Oral Testimony at Hearing (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.

148. Deposition (March 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.

149. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

150. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).

151. Deposition (February 2014) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

152. Trial Testimony (February 2014) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.,* Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).

153. Trial Testimony (February 2014) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).

154. Deposition (June 2014) and Trial (August 2014) on behalf of ECM Biofilms in the matter of the *US Federal Trade Commission (FTC) v. ECM Biofilms* (FTC Docket #9358).

155. Deposition (February 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and Pacificorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

156. Oral Testimony at Hearing (April 2015) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).

157. Deposition (August 2015) on behalf of Plaintiff in the matter of *Conservation Law Foundation (Plaintiff) v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).

158. Testimony at Hearing (August 2015) on behalf of the Sierra Club in the matter of *Amendments to 35 Illinois Administrative Code Parts 214, 217, and 225* before the Illinois Pollution Control Board, R15-21.

159. Deposition (May 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

160. Trial Testimony (October 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

161. Deposition (April 2016) on behalf of the Plaintiffs in *UNatural Resources Defense Council, Respiratory Health Association, and Sierra Club (Plaintiffs) v. Illinois Power Resources LLC and Illinois Power Resources Generation LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (Central District of Illinois, Peoria Division).

162. Trial Testimony at Hearing (July 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.

163. Trial Testimony (December 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.

164. Trial Testimony (July-August 2016) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).

165. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

166. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Backus Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

167. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Drakulic Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

168. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Deutsch Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.

169. Deposition Testimony (July 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight v Coyote Creek Mining Company LLC (Defendant)* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).

170. Deposition Testimony (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

171. Deposition Testimony (December 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).

172. Deposition Testimony (January 2018) in the matter of National Parks Conservation Association (NPCA) v. State of Washington Department of Ecology and British Petroleum (BP) before the Washington Pollution Control Hearing Board, Case No. 17-055.

173. Trial Testimony (January 2018) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

ATTACHMENT B

City of Baltimore
Council Bill 18-0101R
(Resolution)

Introduced by: Councilmembers Clarke, Henry, Middleton, Scott, Burnett, Cohen, Dorsey, Bullock, Sneed, Reisinger
Introduced and adopted: September 17, 2018

A Council Resolution Concerning

Request for State Action – Require a Rigorous Pollution Control Study and Stronger Nitrogen Oxides Limits for the Wheelabrator Baltimore Incinerator

FOR the purpose of urging that the Maryland Department of the Environment ("MDE") require a rigorous analysis relating to the installation of new pollution control technology for nitrogen oxides ("NOx") at the Wheelabrator Baltimore incinerator; requesting that, following the receipt of this analysis, MDE commence a second rulemaking process and set much stronger NOx pollution limits; and requesting that MDE share the analysis with the Council as soon as possible after receiving it.

Recitals

Emissions of nitrogen oxides ("NOx") contribute to the formation of three pollutants in the ambient (outdoor) air: ground-level ozone, nitrogen dioxide, and fine particulate matter. Each of these pollutants can have adverse effects on human health, including worsening symptoms of asthma in people who already have the condition. Baltimore City has substantially higher rates of asthma hospitalizations and emergency room visits due to asthma than the rest of the State of Maryland.

The Baltimore area, which includes Baltimore City and five additional counties, is designated as a nonattainment area for ground-level ozone by the U.S. EPA, meaning that the area does not meet federal air quality standards for ozone. NOx is the primary pollutant that contributes to the formation of ground-level ozone.

Many factors contribute to Baltimore's ozone problem, including pollution from power plants located in other states. Locally, the municipal solid waste incinerator operated by Wheelebrator Baltimore, L.P. and located in South Baltimore is a major source of NOx emissions.

In 2016, the Baltimore incinerator emitted 1,141 tons of NOx, making it the fifth largest emitter of NOx in the State of Maryland that year. The Baltimore incinerator also emitted more NOx per unit of energy generated in 2016 than any of the seven coal plants in Maryland.

Short-term emission limits for incinerators are expressed in parts per million by volume dry at 7% oxygen (hereinafter "ppm"). On October 16, 2017, the Council passed Resolution 17-0034R, which requested that the Maryland Department of the Environment ("MDE") set a NOx limit no higher than 150 ppm on a 24-hour average for the Wheelabrator Baltimore incinerator. This limit had been previously adopted under the federal Reasonably Available Control Technology ("RACT") standard in Connecticut and New Jersey and proposed in Massachusetts. Resolution 17-0034R also requested, pursuant to an amendment adopted on September 28, 2017,

EXPLANATION: Underlining indicates matter added by amendment.
~~Strike out~~ indicates matter deleted by amendment.

that MDE use its legal authority to go beyond the RACT standard in order to set a NOx limit of 45 ppm on a 24-hour basis, which is the limit that would likely be set for a new incinerator.

On August 17, 2018, MDE issued a notice of proposed action in the Maryland Register for a regulation that sets new NOx emission limits for Maryland's two municipal solid waste incinerators. Under MDE's proposed regulation, the Wheelabrator Baltimore incinerator must meet a NOx limit of 150 ppm on a 24-hour average starting on May 1, 2019 and a NOx limit of 145 ppm on a 30-day average starting on May 1, 2020. MDE projects that these new limits will reduce the incinerator's NOx emissions by 200 tons per year, meaning that, after the limits go into effect, the Wheelabrator Baltimore incinerator will likely continue to emit around 900 tons per year of NOx.

In addition, the proposed regulation requires that, no later than January 1, 2020, Wheelabrator must submit an analysis of the feasibility of additional control of NOx emissions to MDE, including the potential to install state-of-the-art NOx control technology on the Wheelabrator Baltimore incinerator. Wheelabrator Baltimore would also be required to propose new NOx pollution limits to MDE by January 1, 2020 for the Baltimore incinerator based on the results of the feasibility analysis.

MDE has the legal authority to set NOx emission limits that are much stronger and more protective of health than the 150 and 145 ppm limits in the regulation that was proposed on August 17, 2018. However, there is no language in the proposed regulation that compels MDE to commence a second rulemaking and to set stronger NOx emissions limits for the Baltimore incinerator after it receives the feasibility analysis and proposed NOx limits from Wheelabrator.

The Baltimore incinerator receives financial benefits because it is treated as a Tier 1 source of renewable energy under Maryland's Renewable Portfolio Standard. Under this program, Marylanders are supposed to reap benefits from renewable energy resources that include long-term decreased emissions and a healthier environment.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF BALTIMORE, That the Council requests that Maryland Department of the Environment ensure that the analysis submitted by Wheelabrator by January 1, 2020 is a rigorous and serious assessment of the feasibility of installing new NOx pollution control technology on the Wheelabrator Baltimore incinerator. Specifically, MDE should not accept an analysis that fails to evaluate any kind of pollution control technology on the basis that the control technology has not been installed on an existing incinerator as part of a retrofit elsewhere. The Council requests that MDE ensure that Wheelabrator fully evaluate the technical feasibility of installing, at minimum, the following control technology on the Wheelabrator Baltimore facility, regardless of cost or whether the technology has been used in other retrofits: selective catalytic reduction (SCR); hybrid SCR/selective non-catalytic reduction (SNCR); and regenerative selective catalytic reduction (RSCR). In addition, the study should evaluate the options of boiler modification and boiler replacement. If cost is a concern for Wheelabrator, this should be explained separately from the evaluation of technical feasibility.

AND BE IT FURTHER RESOLVED, That the Council also urges the Maryland Department of the Environment to commence a second rulemaking process as soon as possible after receiving the feasibility analysis from Wheelabrator in order to set a second set of NOx emission limits. The Council requests that MDE use this rulemaking process to establish much stronger and more health-protective limits than those set forth in the August 17, 2018 proposed rule.

AND BE IT FURTHER RESOLVED, That the Council requests that MDE transmit the feasibility analysis and proposed emissions limits that it receives from Wheelabrator to the Baltimore City Health Department, the Baltimore City Department of Public Works, and the Office of the President of the Baltimore City Council upon MDE's receipt.

AND BE IT FURTHER RESOLVED, That a copy of this Resolution be sent to the Governor, the Secretary of the Maryland Department of the Environment, the Director of the Air and Radiation Management Administration, the Division Chief of the Air Quality Regulations Division, the Mayor, and the Mayor's Legislative Liaison to the City Council.

ATTACHMENT C

EMISSIONS TESTING REPORT 16009
Volume I - Text and Appendices A and B
COPY 0

REVISION 0

PERFORMED FOR:

WHEELABRATOR TECHNOLOGIES, INC.

Hampton, New Hampshire

at the

Wheelabrator Baltimore, LP

Baltimore, Maryland

Units 1, 2, and 3 SDA Inlets and ESP Outlets

May 2016

by

TESTAR Engineering, P.C.

7424-108 ACC Boulevard

Raleigh, North Carolina 27617

License Number C-3896

Table 2-17
Summary of Run-by-Run Air Flow Results

Run Number	Run Date	Run Time	Steam Flow, Klbs/hour	Flue Gas Temp, Deg F	Air Flow, ACFM	CO2, %	O2, %	Air Flow, DSCFM	Air Flow, DSCFM @ 7%O_2
1-O-M29-1	05/17/16	0828-1103	193	297	191,760	8.4	11.0	111,572	79,465
1-O-M29-2	05/17/16	1129-1403	192	298	189,304	8.5	10.8	108,062	78,520
1-O-M29-3	05/17/16	1434-1702	192	298	200,799	8.3	11.2	116,022	80,965
1-O-M29-4	05/18/16	0813-1035	192	297	178,673	8.2	11.2	102,704	71,671
		Average =>	**192**	**298**	**190,134**	**8.4**	**11.1**	**109,590**	**77,655**
2-O-M29-1	05/18/16	0942-1208	192	305	202,188	8.0	11.4	114,156	78,020
2-O-M29-2	05/18/16	1252-1527	192	305	203,513	8.5	11.0	113,933	81,147
2-O-M29-3	05/18/16	1556-1826	192	306	199,175	8.7	10.8	111,048	80,690
2-O-M29-4	05/19/16	0808-1036	192	304	189,193	8.3	11.2	106,791	74,523
		Average =>	**192**	**305**	**198,517**	**8.4**	**11.1**	**111,482**	**78,595**
3-O-M23-1	05/17/16	0821-1236	191	311	193,942	8.4	11.0	111,547	79,447
3-O-M23-2	05/18/16	0801-1224	192	310	181,921	8.9	10.6	103,996	77,062
3-O-M23-3	05/18/16	1246-1707	192	312	187,611	9.0	10.5	105,590	79,003
3-O-M29-1	05/19/16	0923-1214	192	310	190,809	8.2	11.3	109,577	75,679
3-O-M29-2	05/19/16	1301-1522	192	310	183,769	8.3	11.2	104,775	73,117
3-O-M29-3	05/19/16	1601-1821	192	311	183,783	8.8	10.7	105,577	77,474
3-O-M29-4	05/20/16	0740-0952	192	312	173,432	8.7	10.8	100,467	73,001
		Average =>	**192**	**311**	**185,038**	**8.6**	**10.9**	**105,933**	**76,398**
		Facility Average =>	**192**	**304**	**191,230**	**8.4**	**11.0**	**109,002**	**77,549**

ATTACHMENT D

ANNUAL CEM RATA TESTING #16009R

Text and Appendices

COPY 0
REVISION 0

PERFORMED FOR:

WHEELABRATOR TECHNOLOGIES, INC.

Hampton, New Hampshire

at the

Wheelabrator Baltimore, LP

Baltimore, Maryland

Units 1, 2, and 3 SDA Inlets and ESP Outlets

May 2016

by

TESTAR Engineering, P.C.

7424-108 ACC Boulevard

Raleigh, North Carolina 27617

License Number C-3896

919/957-9500

integrated signal processing and PLC for control all analyzer functions including optical bench operation, detector signal processing, dynamic gas calibrations, sample system operation, and operational status alarms. The dry-based CO_2, SO_2, NO_x, CO, and actual H_2O measurements and operational status outputs are sent to the ESC 8816 data logger.

Table 3-1
Facility CEMS Analyzers

Pollutant Monitor	Unit	Location	Range	Analyzer	Serial Number
O_2	1	Economizer	0 - 25%	Perkin-Elmer MCS 100e	91
SO_2	1	Economizer	0 - 600 ppm	Perkin-Elmer MCS 100e	91
O_2	1	ESP Outlet	0 - 25%	Perkin-Elmer MCS 100e	94
SO_2	1	ESP Outlet	0 - 150 ppm	Perkin-Elmer MCS 100e	94
NO_x	1	ESP Outlet	0 - 300 ppm	Perkin-Elmer MCS 100e	94
CO	1	ESP Outlet	0 - 200 ppm 0 - 2000 ppm	Perkin-Elmer MCS 100e	94
CO_2	1	ESP Outlet	0 - 20%	Perkin-Elmer MCS 100e	94
H_2O	1	ESP Outlet	0 - 25%	Perkin-Elmer MCS 100e	94
Flow Rate	1	ESP Outlet	0 - 7920 fpm	OFS 2000	10100560
O_2	2	Economizer	0 - 25%	Ecochem MC3	583-O2
SO_2	2	Economizer	0 - 600 ppm	Ecochem MC3	583-SO2
O_2	2	ESP Outlet	0 - 25%	Ecochem MC3	618-O2
SO_2	2	ESP Outlet	0 - 150 ppm	Ecochem MC3	618-SO2
NO_x	2	ESP Outlet	0 - 300 ppm	Ecochem MC3	618-NOx
CO	2	ESP Outlet	0 - 200 ppm 0 - 2000 ppm	Ecochem MC3	618-CO
CO_2	2	ESP Outlet	0 - 20%	Ecochem MC3	618-CO2
H_2O	2	ESP Outlet	0 - 25%	Ecochem MC3	618-H2O
Flow Rate	2	ESP Outlet	0 - 7920 fpm	OFS 2000	10100561
O_2	3	Economizer	0 - 25%	Perkin-Elmer MCS 100e	93
SO_2	3	Economizer	0 - 600 ppm	Perkin-Elmer MCS 100e	93
O_2	3	ESP Outlet	0 - 25%	Ecochem MC3	555-O2
SO_2	3	ESP Outlet	0 - 150 ppm	Ecochem MC3	555-SO2
NO_x	3	ESP Outlet	0 - 300 ppm	Ecochem MC3	555-NOx
CO	3	ESP Outlet	0 - 200 ppm 0 - 2000 ppm	Ecochem MC3	555-CO
CO_2	3	ESP Outlet	0 - 20%	Ecochem MC3	555-CO2
H_2O	3	ESP Outlet	0 - 25%	Ecochem MC3	555-H2O
Flow Rate	3	ESP Outlet	0 - 7920 fpm	OFS 2000	10100562 E

3.4 Oxygen Analyzer

The oxygen analyzer in the MCS100e and MC3 uses the zirconium oxide measurement technique and is integrated into the sample flow path inside the MCS 100e/MC3 analyzers.

3.5 OFS 2000 Stack Gas Flow Rate Monitor

Each outlet is equipped with a stack flow rate monitoring system consisting of an Optical Scientific Inc (OSI) Model OFS 2000. The OFS 2000 measures the velocity of scintillation or turbulence patterns in stack gas flow to determine stack gas velocity. Scintillation is the variation of light caused by its passage through pockets of air with different temperature and density. An LED in the transmitter of the motor emits a light beam that illuminates twin photo detectors in the receiver. The time it takes for the same scintillation pattern to pass from one detector to the other is converted to stack gas velocity. The received signal is then amplified and sent to the Digital Signal Processor (DSP) in the Control Unit which in turn is sent to the ESC Model data logger where the velocity signal is converted to wet standard flow (wscfm). The data logger converts dry CO_2 to wet CO_2 and calculates lbs/hr from wet scfm and wet CO_2.

3.6 ESC Data Acquisition System

The ESC data acquisition system (DAS) consists of three Model 8816 data loggers (one for each MWC unit), a UNIX based central polling and reporting computer, and an engineering workstation. The 8816 data loggers receive measurement data and signals from the MCS 100e/MC3 analyzers and transmit the data to the central polling computer. The 8816 loggers also receive the status inputs from the MCS 100e/MC3 CEMs to record analyzer calibrations, provide data status flags, and generate alarms to alert operators of CEM problems or excess emissions events. The data loggers store up to four weeks of hourly CEM analyzer data so data recording is not affected if the central computer goes down. The loggers also receive the steam flow, carbon feed rate, and ESP inlet temperature signals from the plant DCS to calculate averages and for permanent recording. The Central Polling and Reporting computer is located in the CEM shelter and receives all data from the 8816 loggers, calculates the required emission units and averaging times, generates the daily calibration reports, and provides all required data recording and reporting. Data from the Central Computer is used for the relative accuracy testing and calibration drift determinations. The computer also provides the necessary permanent data storage. Computer data is also periodically transmitted to an offsite remote file server for backup. The Engineering workstation provides a remote link to the Central Computer for data review and generation of reports.