

**Comments on the Virginia Department of Environmental Quality (VDEQ) Draft
Stationary Source Permit to Atlantic Coast Pipeline, LLC to Construct and Operate
a Natural Gas Compressor Station (Registration Number: 21599)
located at 5297 S James River Hwy, Wingina, VA 24599**

By Ranajit Sahu¹ on behalf of the Chesapeake Bay Foundation, Inc.

I provide the following comments on the air pollution permit sought for the compressor station to be built in Buckingham County, Virginia, for the Atlantic Coast Pipeline (ACP). While I appreciate the many questions asked by the Virginia Department of Environmental Quality (DEQ) during the review of the application and supporting materials, nonetheless deficiencies in the proposed permit are significant and numerous. As such, I recommend that the Virginia Air Board and the DEQ either deny the permit or reissue a revised permit for additional public comment before taking final action.

The compressor station facility mainly consists of four compressor turbines of various sizes. Their basic purpose is to provide additional pressure to the natural gas being transported in the pipeline so that the gas can travel further down the pipeline to points downstream. Since any fluid, like natural gas, loses pressure due to friction as it is transported in a pipe, the compressor station basically provides a “boost” to the gas in order that it may travel farther. Providing this boost, however, requires running the compressors, which means burning some of the gas being transported. Combustion of this gas will result in the production (and emission) of a range of air pollutants including criteria pollutants such as NO_x, CO, SO₂, PM (various sizes), etc. as well as air toxics (benzene, formaldehyde, hexane, polycyclic aromatic hydrocarbons, etc.) and greenhouse gases (CO₂, unburnt methane, N₂O, etc.). Additional combustion emissions will be emitted from an emergency engine located onsite. In addition, the compressor station will also emit non-combustion pollutants, such as fugitive emissions of the natural gas itself from leaks (from various valves, pumps, flanges, gaskets, etc.) as well as from maintenance activities such as pipeline cleaning (“pigging”) and other, periodic actions such as testing for safety, etc. when

¹ Resume provided in Attachment A.

natural gas will be vented periodically. Still other non-combustion emissions include fugitive hydrocarbons from tanks, etc. All of these emissions will be emitted into the ambient air in the vicinity of the compressor station where they will not only impact the immediate vicinity and residents but also be transported over longer distances, creating additional air pollutants, which will impact even distant locations and globally. Local impacts include incrementally greater health risks due to the emissions of numerous toxic air contaminants, some of which will be present in the gas itself and others generated during combustion of the gas in the turbines. Longer range impacts include the emissions of pollutants such as NO_x and hydrocarbons, which are not only pollutants in their own right but are also precursors of pollutants formed in the atmosphere such as ozone. NO_x and SO₂ are precursors of fine particulate matter (secondary PM_{2.5}). Finally, greenhouse gases which affect the global climate (which, in turn, will affect local conditions in Virginia) such as methane in the natural gas as well as combustion products such as carbon dioxide will also be emitted by the proposed compressor station.

1. The Need for a Station of this Size, or its Particular Location are Not Supported by the Record

Neither the permit application materials nor the draft permit or DEQ's analysis/ rationale for issuing the permit include any discussion of the overall size of the proposed compressor station or the choice of the four different Solar turbines (CT-01 is a Solar Mars turbine; CT-02 is a Solar Taurus turbine; CT-03 is a Solar Titan turbine; and CT-04 is a Solar Centaur turbine)² that will comprise the heart of the station. Collectively, these four compressor turbines will have a rating of approximately 54,000 hp.³

Since environmental impacts, including air emissions, depend directly on the size of the station, the public needs to be provided analysis and support for the need for 54,000 hp of compression capability. For example, it is not clear whether the proposed size of the station is actually needed for the gas flows expected to be transported by the current Atlantic Coast Pipeline, or to support some future expanded version of the pipeline or to support some other altogether different future

² Draft Permit, p. 5.

³ Draft Permit, p. 5.

pipeline. The applicant and DEQ should provide the requisite background information on the size of the station and why this size is appropriate.

Curiously, even basic facts such as the level of compression in the pipeline, which affects the size of the station, are not consistent in the record. For example, in the Final Environmental Impact Statement (FEIS) for the pipeline, the line pressure is noted as 1440 psig⁴ or approximately 1454.7 psia. Yet, as I will note later, the emissions calculations supporting the permit have used, variously 1400 or, finally 1200 psig. Both the FEIS and the permit calculations cannot be correct. If, in fact, the permit calculations, which use the 1200 psig value, are correct, that means that the “Final” EIS is wrong. Since the line pressure dictates the size of the compressor stations, including the Buckingham station as well as the two others supporting the pipeline, perhaps all of them are oversized if they now have to support a line pressure of 1200 and not 1440 psig. I ask the DEQ to clarify.

Additionally, the permit does not discuss why the station has to be situated where it is proposed and not at a different location. As it is proposed, it is right on the Transco line, which suggests that there may be plans by the station owner to facilitate transport of additional gas on that line to undisclosed locations. Given that the proposed station will also create significant noise and lighting impacts, in addition to the air pollutants that it will emit, such impacts could be reduced or minimized (along with avoiding clear-cutting trees) if the station were to be moved to a different location, such as the Midland site, only a few miles away from the current site – i.e., to an already-vacant area away from homes. It is my understanding that the DEQ has statutory authority to go beyond just the air permitting issues to look at and address broader environmental impacts from the proposed station.

2. All of the Application Materials and Clarifications Submitted by the Applicant Should be Part of the Permit and Therefore Enforceable

⁴ “The AP-1 mainline would originate at the terminus of the TL-635 loopline in Harrison County, West Virginia and extend to the southeast through Virginia to its terminus near the border of Virginia and North Carolina in Northampton County, North Carolina and the proposed location of Compressor Station 3. The AP-1 mainline would transport up to 1.5 Bcf/d of natural gas to multiple delivery points along its route. The proposed maximum allowable operating pressure (MAOP)² of the AP-1 mainline is 1,440 pounds per square inch gauge (psig).” FEIS, Volume 1, p. 2-5.

It is evident from a review of: (i) the application materials submitted by the applicant; (ii) additional analyses such as the dispersion modeling conducted by the applicant; and (iii) responses by the applicant to questions raised by DEQ – that these contain numerous assumptions that affect the emissions calculations as well as the results of the dispersion modeling – which have been relied upon to conclude that air pollutant emissions from this proposed facility will not significantly impact anything – locally, regionally, or globally. Yet, unless these numerous assumptions are made enforceable, along with appropriate recordkeeping and reporting requirements, as applicable – none of the conclusions that are asserted relying on these assumptions mean anything.

I will discuss specific assumptions made in support of analyses such as the impacts of toxic air contaminants like formaldehyde and hexane, etc. later in these comments. However, it is clear that ALL such assumptions (and not just those affecting a few pollutants) need to be made enforceable. This is a glaring deficiency in the draft permit and its resolution will likely require that a revised draft permit be made available for public comment before it is ready for review by the Air Board.

3. The Equipment Sizes Stated in the Permit Are Not Enforceable and Should be Enforceable

As but one example of the point made in the prior section, without any technical or legal justification whatsoever, the draft permit simply states that the “[S]pecifications included in the above tables [on page 5 of the Draft permit] are for informational purposes only and do not form enforceable terms or conditions of the permit.”⁵ Such an open-ended description of the compressor station’s specifications is unacceptable. Emissions from compressor turbines are directly a function of the size of the turbines. Thus, the size of the equipment is a very critical aspect of the potential and actual emissions from that equipment. It makes no sense therefore to not require that the size (as well as make and model) of the equipment shown in the table on page 5 of the draft permit as an enforceable term. If the DEQ intends to leave the important characteristics of the

⁵ Draft Permit, p. 6.

various equipment that comprise the proposed compressor station as unenforceable, it should provide a thorough justification as opposed to a single, conclusionary sentence.

4. The Applicant and the DEQ Cannot Rely on Manufacturer's Emissions Data Supporting the Permit

The entire edifice upon which the draft permit rests, is the critical analyses undertaken in the dispersion modeling conducted by the applicant,⁶ which in turn relies, importantly, on emissions calculations and estimates.⁷ In many cases, the applicant points to the turbine manufacturer (Solar) as the source of the emissions data and assumptions. For example, in the Appendix C emissions calculations as part of the updated modeling report submitted on July 10, the applicant refers to manufacturer's data at Note 2 to Table C-2; Note 4 to the first table shown as Table C-4 and as Note 3 to other tables on the same page; Note 1 and Note 3 regarding the emission factor for formaldehyde to Table C-6; various attributions, including Note 4 to Solar on the page marked Table C-11; and several pages of Solar data following Table C-11 at the end of Appendix C. The support for and accuracy of the manufacture's data is unknown.

Confusingly, in addition to the emissions calculations shown in Appendix C, there appear to be identical emissions calculations tables after the last of the contours shown in Appendix H.

The emissions calculations refer to a couple of Solar Product Information Letters (PIL). I first address formaldehyde because of its critical impacts as a toxic air contaminant on the immediate community which I discuss later. PIL-168 dated May 2012 was the source of the formaldehyde emission factor used in the emissions and modeling analysis per Note 1 to Table C-6. PIL-168 was submitted to the DEQ by the applicant as part of the August 7, 2017 revised application. In PIL-168, at Table 1, which is the source of the emission factor for formaldehyde, it is clear that Solar is relying on a 2003 EPA document and that the emission factor is not maximum but a 95th

⁶ Updated Air Quality Modeling Report, submitted July 10, 2018 to the DEQ.

⁷ Appendix C to the July 10, 2018 Updated Air Quality Modeling Report. This version of the emissions calculations appears to be the most recent of all of the emissions calculations in the record. Therefore, my comments on the emissions calculations, unless explicitly noted as referencing any other prior version, all refer to this, July 10, 2018 version of the emissions calculations.

percentile value. Importantly, PIL-168 makes it clear that the formaldehyde emissions from any of the turbines will depend on many variables such as: ambient temperature; humidity; atmospheric pressure; fuel quality; test method measurement variability; and additional unspecified operational factors. Therefore it is not surprising when Solar clearly states in PIL-168 that “Solar does not typically warranty the emission rates for VOC, SO₂ or formaldehyde.” I could not find any express warranties by Solar with regards to these pollutant emission factors in the record.

Next, with regards to emissions of pollutants, during startup, shutdown, and commissioning,⁸ the application relies on Solar PIL-170, an updated February 2018 version of which was submitted to the DEQ as Attachment 4 to the June 29, 2018 comment responses to the DEQ. However, this PIL-170 makes it explicit that Solar simply does not stand behind any of the emission factors provided in the PIL. At the beginning of this PIL, Solar could not be more clear:

“...Emissions estimates related to the start-up, shutdown, and commissioning of combustion turbines will not be warranted. The estimates in this document are based on limited engine testing and analysis. The engine testing was conducted at idle and other *non-SoLoNOx* mode load points. An actual SU/SD event was not measured...The estimates are most commonly used for potential to emit calculations to determine air permitting status. Solar discourages customers from accepting the estimates as start-up and shutdown event permit limits with or without source testing requirements. Accurately measuring emissions during a - non-steady state - start-up or shutdown event with steady state source test methods may prove to be very challenging. In the event customers take permit limits and accept compliance testing permit conditions, Solar recommends adding significant margin to the estimates in this document.”⁹ (emphasis added)

Focusing on the last, no additional “significant margin” appears to have been included, as required by Solar, in any of the emissions calculations and dispersion modeling analyses presented by the applicant.

⁸ I note that I could not find any emissions calculations of modeling associated with commissioning of the turbines at the proposed station.

⁹ Solar PIL-170, February 2018, Attachment 4 to June 29, 2018 submittal to the DEQ by the applicant.

Further, on every single table in PIL-170, Solar explicitly states at the top: “Data will NOT be warranted under any circumstances” (emphasis in original).

Plainly, based on the discussion above, to assume that Solar warranties the emissions data, could not be more wrong. Thus, since the applicant made no adjustments to the Solar data and simply used the unadjusted emissions calculations in its dispersion modeling, the conclusions of the modeling are fatally deficient and will under-predict impacts from the proposed facility. Moreover, permit terms that rely on manufacturer’s data or warranties are legally deficient. The DEQ should rectify these fundamental defects in the permit and reissue a revised draft for public comment.

5. The Permit is Improperly Rife with Unenforceable Language in Numerous Permit Conditions

The proposed permit contains at least four instances of vague, undefined, and unenforceable permit terms that must be amended before the permit should be considered for approval.

First, page 6 of the draft permit, paragraph 1, states: “[W]hen a compressor turbine’s inlet air temperature is less than 0°F, the SoLoNOx technology¹⁰ must be operated to maximum extent possible, following the manufacturer’s written protocol or best engineering practices for minimizing emissions.”¹¹ (emphasis added). Nothing in this statement makes it enforceable. The permit does not define what it means by “maximum extent possible,” or “best practices for minimizing emissions. The “manufacturer’s written protocol” developed for this proposed facility is not provided in the record. Thus, neither DEQ, this Board, nor the public have any information to determine whether compliance with this manufacturer’s recommendation is critical to protecting air quality and human health. To the extent that the manufacturer’s literature is provided with the permit application, it is generic in nature and it disclaims all responsibility for any emissions or performance guarantees, as noted later.

¹⁰ SoLoNOx is proprietary NO_x reduction technology of the turbine manufacturer, Solar Turbines.

¹¹ Draft Permit, p. 6.

Unsupported statements are meaningless. By law, the Board and DEQ must create an enforceable permit so that actual performance of the facility, once constructed and in operation, can be properly evaluated against measurable permit terms. Loose “recommendations” and unenforceable language in the draft permit must be replaced by defined, enforceable, conditions.

Second, paragraph 4 on page 6 of the draft permit states: “[T]he permittee shall operate and maintain each compressor turbine, all air pollution control equipment, and all monitoring equipment in a manner consistent with good air pollution control practices for minimizing emissions at all times, including during start-up, shutdown, and malfunction.” (emphasis added). Again, none of the emphasized text is enforceable. The phrase “good air pollution control practices for minimizing emissions” is undefined. Thus, it is not subject to monitoring or review when the plant is operating and is a meaningless permit term. Each term of the permit must be well defined and subject to reliable monitoring. Accordingly, the permit must clearly define what “good air pollution practices” means and how compliance with that term will be determined.

Third, paragraph 4(e) on page 7 of the draft permit states: “During start-up and shutdown, the compressor turbine SCR system (including ammonia injection) and oxidation catalyst system shall be operated in a manner to minimize emissions following the manufacturer's written protocol or best engineering practices for minimizing emissions. Written documentation shall be maintained explaining the sufficiency of the practices. If such practices are used in lieu of the manufacturer's protocol, the documentation shall justify why the practices are at least equivalent to manufacturer's protocols with respect to minimizing emissions.” (emphasis added). Since there is no size-specific manufacturer's protocol, this entire condition is unenforceable. Moreover, terms such as “operated in a manner to minimize emissions” and “best practices for minimizing emissions” are capable of such broad interpretation they are meaningless as enforceable permit terms subject to monitoring and compliance assurance. Thus, such terms will not result in any actual emissions minimization or assurance to the Board, DEQ or the public that the compressor station will be operated in a manner most protective of air quality and human health.

Finally, paragraph 6(e) on page 8 of the draft permit states: “[T]he permittee shall install a vent gas reduction system (VGRS¹²) to ensure the sufficient differential pressure required in Condition

6.d is maintained. The VGRS shall be provided with adequate access for inspection and shall be in operation as necessary to ensure sufficient differential pressure between the seal gas and compressor turbine case such that the dry seal is maintained for the respective compressor turbine in compliance with Condition 6.g.” (emphasis added). The permit should provide a numerical value for what is “sufficient differential pressure” for each seal/turbine. Without a numerical value, the Board, DEQ, and the public can have no assurance that the station will be operated in a manner most protective of air quality and human health.

6. The Definition of Start-up (and Shutdown) Is too Broad and Should be Narrowed

The permit allows various pollution controls to not run during periods of start-up and shutdown. See, for example, paragraphs 1¹³ and 2¹⁴ on page 6 of the draft permit. Effectively, the operator is excused from using, for each of the four turbines, the NO_x controls (SoLoNO_x or SCR) during start-up and shutdown or the CO/VOC control (oxidation catalyst) during start-up.

It should follow logically, given these broad exemptions from operating the controls during start-up and shutdown, that the definition of what constitutes the start-up and shutdown periods would be carefully constrained and minimized for each turbine. Yet, the permit does no such thing. Rather, it contains the following definitions of start-up and shutdown:

“4(a). For the purpose of this permit, start-up is defined as the period beginning with the first fuel fed to the compressor turbine and ending when the compressor turbine reaches 50% load.

4(b). For the purpose of this permit, shutdown is defined as the period beginning when the compressor turbine drops below 50% load for the purpose of ceasing operation and ends when fuel feeding stops.”¹⁵

¹² The purpose of the VGRS is to minimize emissions of the pipeline gas during venting events associated with maintenance and other activities. Without proper operation of the VGRS, more gas would be vented to the atmosphere, leading to greater likelihood of adverse air quality and health impacts.

¹³ “The SoLoNO_x technology shall be in operation at all times the respective compressor turbine is operating except during start-up and shutdown.” (emphasis added)

“Each SCR shall be in operation at all times the respective compressor turbine is operating, except during start-up and shutdown...” (emphasis added)

¹⁴ “Each oxidation catalyst system...shall be in operation at all times the respective compressor turbine is operating, except during each unit start-up.” (emphasis added)

The VDEQ does not provide any support for the choice of 50% load as being the appropriate upper-bound for the end of start-up or the beginning of shutdown. Thus, for CT-01, per its rated load of 15,900 hp, start-up would be up to 7,950 hp – which is greater than the entire rated load for CT-04. Similarly, for CT-03, per its rated load of 20,500 hp, start-up could be up to 10,250 hp. Again, that is more than the rated load for CT-04 and almost the rated load for CT-02. In other words, as long as CT-01 and CT-03 run between 0 and 7,950 hp and between 0 and 10,250 hp, respectively, they can effectively run uncontrolled without having to engage the NO_x and CO/VOC controls that they are equipped with. Put another way, since the entire station size is around 54,000 hp, these definitions of start-up and shutdown allow uncontrolled operations up to 27,000 hp considering all four turbines. This is half of the compressor station’s maximum power output. Even though the permit caps the total time that a turbine can be in start-up and shutdown modes, nonetheless significant emissions can result during start-up and shutdown, given the large sizes of the turbines.

In light of this potentially large start-up and shutdown loophole, which can simply eviscerate the permit, the VDEQ should be directed to:

- (i) provide justification for the size of the station and each turbine, for the intended gas conveyance duty; and
- (ii) change the definition of the end of start-up or beginning or shutdown to a much smaller load – justified on each turbine’s operating characteristics as well as the characteristics of the respective controls and the earliest point they can be engaged.

7. The Permit Provides No Rationale for the Minimum Operating Temperature of the Oxidation Catalyst

Paragraph 2 on page 6 of the draft permit states: “[A]n oxidation catalyst system shall be considered in operation when the catalyst bed inlet gas temperature is above 490°F.” Since this oxidation catalyst is supposed to reduce CO and VOC emissions, including many toxic air compounds that are VOCs, it is important that it remain operational for the widest possible

¹⁵ Draft Permit, p. 6.

temperature range. Yet, the permit simply includes the 490 F minimum operating temperature for the catalyst without any technical support.

I ask that the record and permit adequately support and identify the lowest possible minimum operating temperature of the oxidation catalyst. The record should include the operating characteristics from various vendors of different oxidation catalysts and the permit should require that the oxidation catalyst with the lowest minimum operating temperature be used.

8. The Control Efficiency of SCR is Unsupported and Too Low

Each of the four turbines uses SCR to control NOx. However, the control efficiency for SCR is stated as 58%. The SCR vendor (Peerless) data uses 58.33% value as best as I could read the vendor tables.¹⁶ However, neither the permit application nor anything from the vendor indicates why this value was chosen. More importantly, it is not clear why a higher value could not be used, resulting in lower NOx limits for the turbines. Thus, this assumption of just 58% NOx removal efficiency by the applicant is unsupported. I ask that the DEQ provide support for this assumption and additional technical justification as to why higher control efficiencies are not possible.

9. The Time Allowed to Repair Leaking Components Should be Reduced

The draft permit, condition 7(b) on page 9, states: “[T]he first attempt to repair any fugitive emissions component found to be leaking during an AVO¹⁷ inspection or a quarterly survey shall be made as soon as practicable but no later than 5 days after discovery. The leaking fugitive emissions component shall be repaired within 15 days of discovery.” (emphasis added). The proposed compressor station is not like a refinery with tens of thousands of fugitive components. Thus, allowing up to 5 days for a first attempt at repairing a component leaking highly flammable natural gas means allowing large quantities of leaking gas, including other VOCs, to escape. There is no justification for why the first attempt at repair cannot be made sooner. I suggest 24 hours. And, similarly, I suggest shortening the maximum time allowed for repair to be no more than 3 days. This will allow the facility to keep adequate spare components onsite and not have an

¹⁶ Attachment 3 to the June 29, 2018 comment responses to DEQ.

¹⁷ AVO stands for audio, visual, and olfactory means of detecting a leak – i.e., relying on the senses of the human observer.

extended period of uncontrolled leaks of fugitive natural gas and VOCs from the facility. Not only is the safety of the operating personnel at risk by this overly lax term but also is the safety of surrounding community members some who live within close proximity of the proposed site.

10. Reporting Provisions in the Draft Permit Are Inadequate

Conditions 8, 9, 10, 11, and 12 in the draft permit contain several monitoring provisions for various turbine as well as air pollution control parameters. Condition 16 requires fuel monitoring for sulfur content. Condition 17 requires tracking the operating hours of the emergency engine. Condition 35 requires that the facility keep onsite records of the various monitoring parameters. However, reporting to the public and the DEQ, discussed in Condition 36, is very limited. Other than certifying compliance and/or reporting exceedances, excursions, etc. – none of which are independently verifiable without a review of the underlying records – the reporting provisions in Condition 36 are very weak. All of the monitoring as well as testing records should be kept not only onsite but also be publicly reported in quarterly reports.

11. The Draft Permit Should t Require Continuous Monitoring of Emissions from the Turbines

A glaring omission in the draft permit is the lack of any Continuous Emissions Monitors (CEMs) for any of the pollutants that will be emitted from, at least, the four turbines.¹⁸ While the permit requires continuous monitoring of various operating parameters, curiously it only relies on stack testing (Conditions 29 and 31) to verify that the emission limits of various pollutants for each of the turbines (Conditions 20, 21, 22, and 23). Stack testing, no matter how frequent, is no substitute for directly monitoring the emissions using CEMS. CEMS for all of the major pollutants expected to be emitted from each of the turbines, including NO_x, CO, SO₂, VOCs, filterable PM, and VOCs are widely available and in use at similar sources. Thus, there is absolutely no justification whatsoever to not specify that CEMS for these pollutants as well as continuous flow monitors (so that, in combination, the mass emissions specified in Conditions 20-23) are required at each of the four turbines.

¹⁸ The proposed permit also allows emissions from other sources associated with the compressor station.

Further, since Conditions 20-23 note that the limits specified in these permits as a “3-hour average,” only the use of CEMS can ensure that the limits at each turbine are being met for all times – and not just for the single 3-hour period of a stack test which is required every two years per Condition 31. Without CEMS, staged stack tests for 3 hours every 2 years at each turbine cannot represent actual operations for all of the other times that the turbines will be operating. Three hours of monitoring every 2 years represents a miniscule 0.017% of the operating time of each turbine. Thus, the proposed permit does little to ensure compliance with the emissions limits specified in Conditions 20-23. The Board and DEQ should amend the permit to require CEMS for NO_x, CO, VOC, SO₂, filterable PM, and flow at each turbine stack. All of the CEMs data collected should be make publicly available both online and in paper format.

12. The Permit Does Not Contain Limits for Many Air Toxic Compounds that will be Emitted and Implicitly Underestimates the Potential Health Risks Posed by the Facility

Combusting natural gas in turbines such as the ones proposed for this compressor station will result in the emissions of many partially combusted, so-called “products of incomplete combustion.” Table 3.1-3 from US EPA’s AP-42 compilation of emission factors,¹⁹ shown below, lists 11 air toxic compounds or families of compounds emitted from the combustion of natural gas, the source of fuel for the turbines being permitted.

¹⁹ Available at <https://www3.epa.gov/ttn/chief/ap42/ch03/index.html>

Table 3.1-3. EMISSION FACTORS FOR HAZARDOUS AIR POLLUTANTS FROM NATURAL GAS-FIRED STATIONARY GAS TURBINES^a

Emission Factors ^b - Uncontrolled		
Pollutant	Emission Factor (lb/MMBtu) ^c	Emission Factor Rating
1,3-Butadiene ^d	< 4.3 E-07	D
Acetaldehyde	4.0 E-05	C
Acrolein	6.4 E-06	C
Benzene ^e	1.2 E-05	A
Ethylbenzene	3.2 E-05	C
Formaldehyde ^f	7.1 E-04	A
Naphthalene	1.3 E-06	C
PAH	2.2 E-06	C
Propylene Oxide ^d	< 2.9 E-05	D
Toluene	1.3 E-04	C
Xylenes	6.4 E-05	C

While the list of potential air toxic compounds listed in Table 3.1-3 is by no means complete, it should be a starting point for estimating the emissions from the four turbines proposed at the facility. Yet, the draft permit discusses only two potential compounds – formaldehyde (Condition 47) and hexane (Condition 48). On its face, the draft permit is simply incorrect, incomplete, and inadequate in not addressing the many other toxic air contaminants that will be emitted from this facility. Since many of these air toxic compounds can pose significant health hazards to exposed individuals, not including a thorough analysis (and appropriate limits) for such compounds is a failure of the regulatory process.²⁰

DEQ should be directed to:

- (i) properly estimate the quantities of all air toxic compounds that will be emitted from the facility including from the four turbines as well as the fugitive non-combustion sources;

²⁰ See the expert testimony of Dr. George Thurston which accompanies the Chesapeake Bay Foundation's comments.

- (ii) require testing and verification of the emissions estimated in (i) above on a periodic basis; and
- (iii) conduct a health risk assessment, using conservative assumptions, to quantify the health impacts of such emissions on the population in the vicinity of the proposed station and confirm that the incremental health risks are not unacceptable.

13. Impacts Due to Hexane and Formaldehyde Emissions Are Likely to be Significant

The revised modeling report summarizes the ambient impacts for hexane and formaldehyde as excerpted below (red boxes are my notations):

Table 4-3 Air Toxics Model Results

Pollutant	Averaging Period	Scenario	Significant Concentration ($\mu\text{g}/\text{m}^3$)	Model Result ($\mu\text{g}/\text{m}^3$)
Formaldehyde	1-hour	50% Load	62.5	38.9
		75% Load		38.9
		100% Load		38.9
		Startup (blended with 50% load)		40.5
		Shutdown (blended with 50% load)		40.2
	Annual	50% Load	2.4	0.081
		75% Load		0.079
		100% Load		0.076
Hexane 1-hour	hour	Pigging (Launching)	8,800	6,277
		Pigging (Receiving)		6,897
		Purging from Startup Events		1,370
		Blowdown from Shutdown Events		4,518
		Normal Operations		20

Setting aside the justification for the two “significant concentration” values shown above for formaldehyde and hexane, it is clear that the model results are not significantly lower than the significant concentrations. Since both of these are toxic air contaminants, it behooves the DEQ to closely examine the many assumptions that underlie these estimated results.

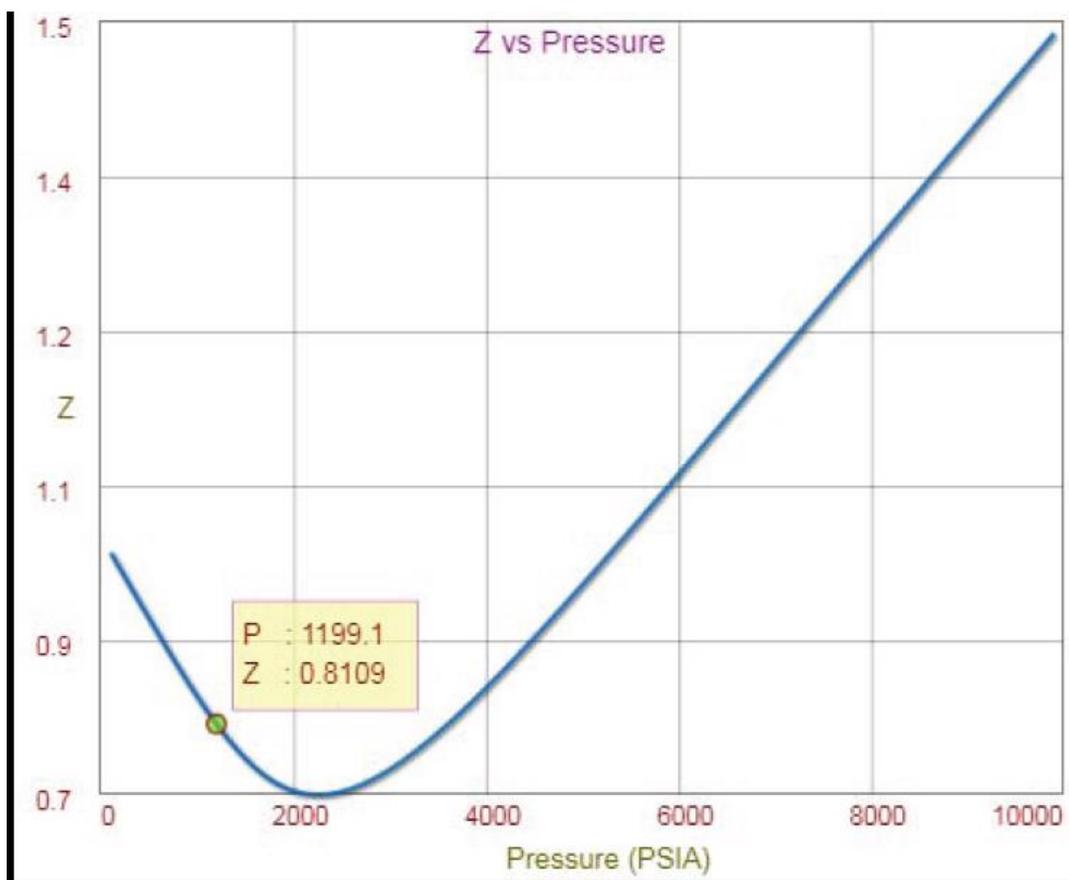
As previously noted, one of the key inputs for the modeling results shown above are the emissions inputs.

For formaldehyde, I have discussed earlier that the applicant cannot rely on the manufacturer's data (which Solar does not warranty, since the data were not generated by Solar to begin with). And, it is clear that instead of using maximum values of formaldehyde that should have been used, at best a 95th percentile value was used. Since, as noted earlier, per Solar itself, many factors can and will affect formaldehyde emissions from each of the turbines, simply plucking the value from Table 1 of Solar PIL-168 is not appropriate. Given the small margin by which the model concentration is lower than the significant concentration (i.e., only around 2/3 of the significant concentration), which can easily be overcome with modest variability in the formaldehyde emissions, it is my opinion that actual formaldehyde impacts have been underpredicted.

For hexane, which the table above shows also has impacts that are not too much lower than its corresponding significant level, the emissions calculations rely on many assumptions, including as a starting point the hexane concentration in the gas itself. This is noted as 0.032% in Table C-3A of the revised emissions calculations. Yet, it is not likely that the level of hexane in the gas will be constant, at just this value. There is no discussion of the variability of hexane in the gas – especially given the long life of this facility. As an example, if this miniscule level of hexane were to be doubled, the predicted model concentrations in the table above would exceed the significant concentration under several scenarios. Yet, nowhere does the record indicate that the 0.032% level of hexane in the gas is the maximum value that can be expected.

Of course, there are also many additional numerous assumptions that underlie the mass estimates of hexane emissions used in the analysis besides the concentration of hexane in the gas, such as those shown that accompany the July 13, 2018 response to DEQ. An important assumption is the line pressure, assumed to be “maximum operating pressure” of 1200 psi. As I have pointed out earlier, the FEIS (and earlier versions of the calculations) have assumed that the line pressure will be 1400 psi or more. Of course, one should expect greater emissions of gas (and hexane) with greater line pressures. The tables accompanying the July 13, 2018 submittal contain numerous pipe geometry assumptions (such as lengths and diameters, etc. which are used to estimate the volume of gas, containing hexane, that will be vented) – and these are not enforceable under the

permit as written. The tables contain yet other assumptions used to estimate the vent gas (and hexane) mass – such as the assumed compressibility factor Z . Z is assumed to be 0.87356 “based on engineering estimate provided by DETI” per Note 5 under the unnumbered table. Yet, there is no support for this. Shown below is a screen-shot of Z for natural gas, from an engineering calculator²¹ using the same composition of the natural gas as represented in the final emissions calculations, at 1200 psi, using the well-known Dranchuk and Abou-Kassem equation of state (DAK - EOS). It is significantly different than 0.87356 assumed in the calculations.



Given all of the above (and additional technical deficiencies that are too numerous to list), it is my opinion that the modeled level of hexane will under-predict actual impacts of this harmful toxic air contaminant. Before the Air Board considers approving a permit for this station, it should

²¹ <https://checalc.com/solved/naturalgasZ.html>

require DEQ to re-model hexane emissions from the proposed station and determine their potential to harm workers or residents and report its findings to the Board.

14. The Draft Permit Does Not Include Estimates of Greenhouse Gases That Will Be Emitted from the Facility

Methane, the largest component of natural gas, as well as N₂O and CO₂ – both combustion products of natural gas, are greenhouse gases. Yet, the permit simply does not mention, much less quantify the emissions of all three of these greenhouse gases. Regardless of whether controls are required for greenhouse gases, it is simply unacceptable for the permit to not acknowledge and quantify the emissions of greenhouse gases from the facility especially in light of the significant risks posed to the Commonwealth of Virginia and its citizens from sea level rise and climate change.²² The DEQ should remedy this omission before issuing the final permit.

15. The Draft Permit Does Not Contain Estimates of Emissions from Accidental Events That May Occur

Natural gas is a flammable substance. Explosions at facilities like the proposed compressor station have occurred several locations such as Artemas, Pennsylvania, Branchford, New Jersey and Watford City, North Dakota.²³ As such, it is not impossible for there to be potential fires and explosions at the compressor station or at the locations of the incoming and outgoing pipelines. While the probability of such accidents is low, the consequences, if any such accident occurs, would be catastrophic. In addition to the harm from the fires or explosions themselves, such events will also create large quantities of harmful air emissions. The permit does not attempt any quantification of such accidental air emissions, thereby underplaying potential adverse air impacts from the proposed facility. The DEQ should address this in a forthright manner prior to issuance of the final permit.

²² See, Nolan, et al., *Past and future global transformation of terrestrial ecosystems under climate change*, Science, Vol. 361, Issue 6405, pp. 920-923, 31 Aug. 2018. <http://science.sciencemag.org/content/361/6405/920> Natural gas leaks could match climate impacts of coal-burning power plants. <http://www.sciencemag.org/news/2018/06/natural-gas-could-warm-planet-much-coal-short-term>

²³ http://www.times-news.com/news/local_news/gas-explosion-fire-forces-evacuations/article_d6d3b5fa-12d7-57d2-aab4-670b8e514444.html ; <http://www.watfordcitynd.com/?id=10&nid=3533>;

16. The Record's Analysis of the Ozone or Secondary PM_{2.5} Impacts Due to Precursor Pollutants from the Facility is Deficient

Both NO_x and VOCs, which will be emitted from the proposed facility, are precursors of ozone. Similarly, NO_x and SO₂ are precursors of PM_{2.5}, a secondary pollutant that will be formed in the atmosphere. The facility will be located in Virginia where the City of Richmond and several counties upwind of the proposed compressor station are in ozone non-attainment. https://www3.epa.gov/airquality/greenbook/anayo_va.html. In addition, northern Virginia is part of the broader Northeast ozone non-attainment area. As such, any incremental ozone formation associated with the compressor station will adversely affect not only Virginia but also all downwind states from achieving attainment of the ozone National Ambient Air Quality Standard (NAAQS).

As to PM_{2.5}, fine PM in this size range is one of the most harmful air pollutants since they have no threshold for harm, which includes not only respiratory but also cardiac impacts.²⁴

The revised Modeling Report discusses how ozone impacts were estimated from the facility at Section 3.5.2. Secondary PM_{2.5} is discussed in Section 3.5.1. Instead of actually modeling the ozone levels that would occur, using well-known photochemical models, the analysis presented relies on the so-called Modeled Emission rates of Precursors (MERP) approach as discussed in Section 3.5 of the revised Modeling Report. First, in relying on the **draft** December 2016 guidance memorandum as referenced in the Modeling Report, the applicant is perhaps unaware of the update to this guidance. In short, while EPA allows the MERP analysis, there are numerous caveats:

First, echoing what I have stated above, EPA explicitly states that,

“The EPA believes photochemical grid models are generally most appropriate for addressing ozone and secondary PM_{2.5}, because they provide a spatially and temporally dynamic realistic chemical and physical environment for plume growth and chemical transformation.”²⁵

²⁴ See the comments of Dr. George Thurston attached to the comments of the Chesapeake Bay Foundation.

²⁵ Fox, Tyler and Baker, Kirk, Update on MERPs Guidance, US EPA/OAQPS/Air Quality Modeling Group, June 5, 2018, p. 3. Available at https://www3.epa.gov/ttn/scram/2018_RSL/Presentations/1-21_2018_RSL-MERPs.pdf

EPA goes on to emphasize that when the MERP approach is used, it should rely on, among other things:

“... air quality modeling of hypothetical industrial sources with similar source characteristics and emission rates of precursors that are located in similar atmospheric environments and for time periods that are conducive to the formation of O₃ or secondary PM_{2.5}.” (emphasis added).²⁶

In this instance, the revised Modeling Report states that: “Atlantic and DETI have considered model results from the EPA hypothetical source that is closest to the project location. Specifically, model results from EPA Source 9 located in Dinwiddie County, VA...” NO_x, SO₂, and VOC emissions from this hypothetical source have been assumed to be 500 tons/year each (as compared to the estimated 34.2 tons/year of NO_x, 8.3 tons/year of SO₂ and 9.77 tons/year of VOC emissions for the compressor station).

Given the disparate sizes of the modeled source, the compressor station, the different release profiles, the dissimilar air sheds into which the precursor emissions are emitted, it is my opinion that the MERP approach used in the record to discount the formation of ozone and secondary PM_{2.5} from the compressor station, are unreliable. DEQ should ask that direct modeling of these impacts be used.

17. A Revised Draft Permit Should be Reissued for Public Comment

I have identified several significant deficiencies in the subject draft permit issued by the DEQ. Addressing these many deficiencies will require additional work by the DEQ and the applicant. Several aspects of the draft permit either contain vague and uncertain terms or lack sufficient and long-term compliance assurance measures. Given these defects, I recommend that the Board reject the proposed permit and require DEQ to revise the draft accordingly. I further recommend that the DEQ reissue the revised permit for public comment to ensure that the comments I have raised, as well as those others may raise, are fully addressed prior to permit issuance.

²⁶ Id. at p. 5.

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-NO_x ceramic radiant burners, fired heater NO_x 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).

"NO_x 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. (Respondents)*, 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 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) and Rebuttal Expert Report (Harm Phase) (May 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).
114. Declaration (February 2018) on behalf of the Chesapeake Bay Foundation, et. al., in the matter of the Section 126 Petition filed by the state of Maryland in *State of Maryland v. Pruitt (Defendant)*, Civil Action No. JKB-17-2939 (Consolidated with No. JKB-17-2873) (US District Court for the District of Maryland).
115. Direct Pre-filed Testimony (March 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of *NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC*, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).
116. Expert Affidavit (April 2018) and Second Expert Affidavit (May 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.

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

117. 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.
118. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.

119. 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).
120. 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).
121. 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).
122. 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.
123. 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.
124. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.
125. 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.
126. 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.
127. 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.
128. 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.*
129. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coletto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
130. 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).
131. 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.
132. 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).
133. 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.
134. 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).
135. 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.
136. 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).
137. 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).
138. 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).
 139. 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.
 140. 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.
 141. 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.
 142. 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.
 143. 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).
 144. 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.).
 145. 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).
 146. 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).
 147. 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.
 148. 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).
 149. 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).
 150. 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.
 151. 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.
 152. 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).
 153. 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).

154. 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).
155. 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).
156. 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).
157. 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).
158. 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).
159. 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).
160. 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).
161. 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.
162. 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).
163. 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).
164. 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).
165. 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.
166. 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.
167. 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).
168. 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.

169. 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.
170. 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.
171. 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.
172. 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).
173. 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).
174. 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).
175. 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.
176. 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).
177. Trial Testimony (April 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).