

Technical Assessment of Feasibility of Timely Compliance with
Bottom Ash Transport Water at the Four Corners Power Plant

Expert Comments by Dr. Ranajit (Ron) Sahu

June 30, 2019

I. INTRODUCTION AND SUMMARY

The Environmental Protection Agency (EPA) has proposed to reissue a National Pollutant Discharge Elimination System (NPDES) permit (No. NN0000019) to the Four Corners Power Plant (FCPP), authorizing the discharge of a wide range of process waste waters to the receiving waters of the United States as discussed in the draft permit and accompanying Fact Sheet.

Federal Effluent Limitations Guidelines (ELG) apply to the bottom ash transport water (BATW) which contains numerous toxic contaminants. The ELG for BATW is zero discharge of such water. The most recent ELGs for power plants such as FCPP were promulgated in late 2015. EPA, at the apparent request of the plant operator, and with no technical basis or analysis,¹ has proposed that FCPP should not have to comply with the new, more stringent ELG limit for BATW until December 31, 2023, the last date for compliance under the rule.² As noted in the footnote, the public record does not contain any documents in which EPA provides any technical justification that the compliance date be December 31, 2023.

In these technical comments, I note simply, based on the support provided, that technical solutions to achieve the BATW are (and have been, for the last 3 years since the ELG Rule went into effect)

¹ It is clear in the record that has been provided to the public so far that EPA did not conduct any independent analysis of how soon the BATW zero discharge provision could be implemented at the FCPP.

² Per the Draft Permit

“5. Internal Outfall No. 01E – Combined Waste Treatment Pond Discharge
Beginning December 31, 2023, there shall be no discharge of bottom ash transport water from this outfall. However, until December 31, 2023, the Permittee is authorized to discharge as follows from Internal Outfall No. 01E (latitude: 36° 41' 30" N and longitude: 108° 28' 12" W).”

EPA’s entire basis for this decision as noted in its Fact Sheet (p. 4-5) accompanying the draft permit is as follows:

The revised proposed permit is updated from the June 2018 withdrawn permit to include the 2015 ELGs for bottom ash transport water. The 2015 ELGs, 40 CFR Section 423.11(t), allow EPA to select a later date within the range, after receiving information from the discharger, based on the following factors 1) time to expeditiously plan, design, procure, and install equipment; 2) changes being made at the plant pursuant to other regulations, including coal combustion residuals (CCR) under the Resource Conservation and Recovery Act of 1976, as amended (RCRA), and 3) other factors as appropriate. The Applicant submitted information to EPA addressing these factors and requested that EPA utilize December 31, 2023, as the applicable date for the bottom ash transport water discharge prohibition. The proposed permit selects December 31, 2023, as the date the Permittee must meet the no discharge prohibition. EPA selected December 31, 2023, based upon the information submitted by the Applicant pursuant to the 2015 ELGs, as modified by the Postponement Rule. Thus the proposed permit provides that beginning December 31, 2023, there shall be no discharge of bottom ash transport water from Internal Outfall O1E (Combined Waste Treatment Pond Discharge). The proposed permit contains discharge limitations for Internal Outfall O1E (Combined Waste Treatment Pond Discharge) that apply until December 31, 2023. (emphasis added)

readily available and can be implemented in 2 years or less. Even assuming that the owners and operators of FCPP have done nothing to plan for implementation of the BATW ELG (a very generous assumption, given the long time it took to finalize the ELGs in 2015 beginning with rule development starting in 2009, and the more than 3 years since), and that such planning, design, procurement, installation, and operations began now, it should take no more than late to mid-2021 for the BATW ELG (i.e., zero discharge) to be achieved at the FCPP. Many of the coal-fired power plants in the US that face the same regulatory uncertainties as FCPP already achieve the BATW ELG – i.e., zero discharge.³ To my knowledge, there is nothing in the record to show that there are any unique technical issues at FCPP that would prevent current technologies which have been implemented elsewhere multiple times, to also be implemented at the FCPP to meet the BATW ELG.

³ This is clear from the rule-making docket itself.

“In the case of bottom ash transport water, EPA observed that “80% of plants built in the last 20 years have adopted dry bottom ash handling systems.” However, it is not only new plants that adopt dry bottom ash handling systems.[9] Between 2000 and 2009, 12-25 plants, with 15-20 electric generating units, converted from wet to dry bottom ash handling.[10] Another 61 units – 27% of the industry – were planning to convert from wet to dry bottom ash handling prior to implementation of the final rule.[11] Overall, EPA determined that “more than half of the entities that would be subject to BAT requirements for bottom ash transport water are already employing zero discharge technologies ... or planning to do so in the near future.”[12] Dry bottom ash handling systems are therefore undeniably available (in use by the industry). They are also economically achievable: Given the large number of new plants with dry bottom ash handling systems, the large number of wet-to-dry conversion that took place before 2009, and the large number of wet-to-dry conversions that were planned for completion prior to implementation of the ELG Rule, it is obvious that the costs can be borne by the industry.”

(internal citations are as follows: [9] U.S. EPA, Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category: EPA’s Response to Public Comments, Response to Comments, Docket ID No. EPA-HQ-OW2009-0819-6469, at 6-419. [10] U.S. EPA, Technical Development Document for the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, EPA-821-R-15-007, page 4-27 (Sept., 2015) (EPA presented ranges for these values to protect confidential business information). [11] Id. at 7-39. [12] U.S. EPA, Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category: EPA’s Response to Public Comments, Response to Comments, Docket ID No. EPA-HQ-OW2009-0819-6469, at 6-419.)

A recent paper by UCC, a vendor providing BATW zero discharge solutions to industry, discussing the implementation of the BATW ELG at a specific plant noted that:

“Since 2015, with the implementation of the Coal Combustion Residual (CCR) rule and the Effluent Limitations Guidelines (ELG), numerous utilities have moved forward with plans and projects to address the new groundwater and surface water regulatory requirements, with particular attention to bottom ash transport water and bottom ash impoundment closure.

In the recent past, UCC has been contracted to provide wet-to-dry ash conversion and wastewater management/treatment technologies on 53 plants covering 114 operating units. As of the date of this publication, approximately half of the U.S. coal fleet has now converted traditional wet bottom ash systems to either dry handling systems or closed-loop recirculation systems.” (emphasis added)

<https://www.waterworld.com/industrial/wastewater/article/16210351/treating-bottom-ash-transport-water-with-enhanced-wastewater-technologies>

In summary, based on the information I have reviewed, it is my opinion that FCPP can meet the ELG requirements for BATW in no more than 2 years or 24 months from permit issuance.

II. FOUR CORNERS POWER PLANT

Per the Fact Sheet, the FCPP is located in San Juan County about 20 miles southwest of Farmington, New Mexico. The Plant is located on the Navajo Nation and is partially owned and operated by Arizona Public Service (APS) on behalf of itself as well as the Salt River Project Agricultural Improvement and Power District, El Paso Electric Company, Public Service Company of New Mexico, and Tucson Electric Power Company. The Plant provides electrical power to utilities in Arizona, Texas, and New Mexico.

Originally, the FCPP had five generating units (units 1-5). The Plant's total generation capacity was originally 2100 megawatts. Following the shutdown of Units 1, 2, and 3 on December 30, 2013, the Plant's capacity is now 1540 megawatts. The Plant burns low-sulfur coal obtained from the adjacent Navajo Mine, owned by the Navajo Transitional Energy Company, LLC and operated by BHP Minerals.

Information provided in the NPDES permit renewal application Form 2C indicates that 8 mgd of bottom ash sluice water is discharged via outfall 01E. As noted in the Fact Sheet, "[A] large component of Internal Outfall No. 01E discharge is bottom ash transport water, with low-volume wastewater constituting a smaller component of the discharge."⁴

⁴ Fact Sheet, p 7.

III. THE EFFLUENT LIMITATIONS GUIDELINES

The ELGs establish technology-based effluent limitations for wastewater discharges from steam electric power plants such as the FCPP. EPA finalized the ELGs in November 2015, following solicitation of input from the public and the regulated community.⁵

The final ELGs set federal limits on the discharge of toxic metals and other harmful pollutants from wastewater at steam electric power plants. The ELGs are based on technology improvements in the steam electric power industry over the last three decades and establish new requirements for wastewater streams from processes and byproducts associated with flue gas desulfurization, bottom ash transport, and fly ash transport waters.

For bottom ash transport waters, the best available technology economically achievable (BAT) standard permits zero discharge.⁶

Importantly, and a point entirely glossed over and unmentioned by the EPA in its Fact Sheet accompanying the proposed issuance of the FCPP NPDES permit, the BAT standard, as issued in 2015, was to be achieved “as soon as possible (emphasis added) beginning November 1, 2018, but no later than December 31, 2023.”⁷ The 2015 regulations provided that “[t]he phrase ‘as soon as possible’ means November 1, 2018, unless the permitting authority establishes a later date” based on a well-documented justification laying out certain enumerated factors demonstrating that the facility cannot comply with the November 1, 2018 default.⁸ EPA subsequently postponed the November 1, 2018 deadline to November 1, 2020.⁹ EPA did not push back the end of the compliance period (i.e., December 31, 2023).

The regulations note that factors which may affect the compliance date are as follows:

- (1) Time to expeditiously plan (including to raise capital), design, procure, and install equipment to comply with the requirements of this part.
- (2) Changes being made or planned at the plant in response to:
 - (i) New source performance standards for greenhouse gases from new fossil fuel fired electric generating units, under sections 111. 30 I, 302, and

⁵ As EPA noted in the preamble to the final ELG Rule, “EPA initiated a steam electric ELG rulemaking following a detailed study in 2009. EPA published the proposed rule on June 7, 2013, and took public comments until September 20, 2013.” 80 FR at 67,844.

⁶ 40 C.F.R. 423.13 (h)(1)(i) and (k)(1)(i).

⁷ 40 C.F.R. 423.13 (g)(1)(i), (h)(1)(i), and (k)(1)(i). While EPA did move the initial deadline for BATW and FGD wastewater from November 2018 to November 2020, the “as soon as possible” aspect of the regulation did not change.

⁸ 40 C.F.R. 423.11(t).

⁹ See <https://www.federalregister.gov/documents/2017/09/18/2017-19821>. See also Fed. Reg. Vol. 82, No. 179, September 18, 2017, 43494.

307(d)(1)(C) of the Clean Air Act, as amended, 42 U.S.C. 7411. 7601, 7602, 7607(d)(1XC);

(ii) Emission guidelines for greenhouse gases from existing fossil fuel-fired electric generating units, under sections 111. 301, 302, and 307(d) of the Clean Air Act, as amended, 42 U.S.C. 7411. 7601. 7602, 7607(d); or

(iii) Regulations that address the disposal of coal combustion residuals as solid waste, under sections 1006(b), 1008(a), 2002(a), 3001, 4004, and 4005(a) of the Solid Waste Disposal Act of 1970, as amended by the Resource Conservation and Recovery Act of 1976, as amended by the Hazardous and Solid Waste Amendments of 1984, 42 U.S.C. 6906(b), 6907(a), 6912(a), 6944, and 6945(a).

(3) For FGD wastewater requirements only, an initial commissioning period for the treatment system to optimize the installed equipment.

(4) Other factors as appropriate.¹⁰

Importantly, the very first factor enumerated in the above list requires consideration of “expeditious” planning in all aspects of compliance with the ELGs, thereby underscoring EPA’s directive to achieve compliance “as soon as possible.” Nevertheless, the proposed NPDES permit, which selects the latest possible compliance deadline, does not reflect this aspect of the regulation at all.

IV. COMMENTS ON MEETING THE BATW ELG AT FCPP

IV.1 General Discussion

First, as background, in order to gather information on handling BATW during the ELG rulemaking, EPA contacted several ash handling and ash storage vendors. The vendors provided the following types of information for EPA’s analyses:

- Type of fly ash and bottom ash handling systems available for reducing or eliminating ash transport water;
- Equipment, modifications, and demolition required to convert wet-sluicing fly ash and bottom ash handling systems to dry ash handling or closed-loop recycle systems;
- Equipment that can be reused as part of the conversion from wet to dry handling or in a closed-loop recycle system;
- Outage time required for the different types of ash handling systems;
- Maintenance required for each type of system;
- Operating data for each type of system;
- Purchased equipment, other direct, and indirect capital costs for fly ash and bottom ash conversions;

¹⁰ *Ibid.*

- Specifications for the types of ash storage available (*e.g.*, steel silos or concrete silos) for the different types of handling systems;
- Equipment and installation capital costs associated with the storage of fly ash and bottom ash; and
- Operation and maintenance costs for fly ash and bottom ash handling systems.¹¹

The vendor community has now been well aware of the rule requirements for almost a decade (since initial efforts at developing the ELG rule date back to 2009) and participated fully in the ELG rulemaking.

There are numerous well-qualified U.S. vendors (and foreign vendors that are active in the U.S. market) that are capable of providing equipment and services for ash handling and conversion of wet bottom ash handling systems to dry systems or closed-loop recycle systems. Major vendors include United Conveyor Corporation (“UCC”),¹² Clyde Bergemann,¹³ and Magaldi¹⁴—each of which has wet to dry conversion technologies. Other vendors such as Suez (previously GE), Veolia, Nalco, Aquatech, Heartland, LB Industrial Systems, and many others also have potential capabilities and solutions for specific aspects of ash handling. Additional technology developments also continue. For example, Babcock and Wilcox has developed the Submerged Grind Conveyor to address situations where a more compact system may be appropriate.¹⁵ The engineering contractor Burns & McDonnell has stated that they are assisting three utility clients to install this system, and that one system is already operational.¹⁶

The ELG rulemaking docket shows that EPA consulted extensively with at least UCC and Clyde Bergemann with respect to BATW handling during rule development.¹⁷ Both of these vendors have wet to dry ash conversion systems, which have been installed at coal plants around the world, including the U.S. As previously noted, UCC states recently that over half of all US operating coal-fired plants already use zero-discharge technologies for BATW.

¹¹ U.S. EPA, Technical Development Document for the Effluent Limitation Guidelines and Standards for the Steam Electric Power Generating Point Source Category, EPA-821-R-15-007 at 3-21 and 3-22 (Sept. 2015).

¹² UCC offers various hydraulic, mechanical, pneumatic, and vibratory systems for dry bottom ash handling. See http://unitedconveyor.com/bottom_ash. This is the same company previously quoted in a prior footnote.

¹³ Clyde Bergemann offers a trademarked “DRYCON” system for dry bottom ash handling. See <http://www.cbpg.com/en/products-solutions-materials-handling-bottom-ash/drycon%E2%84%A2>

¹⁴ Magaldi offers a dry ash handling system called MAC. See http://www.magaldi.com/en/magaldi_solutions_for/Ash-Handling-Mac_9_11.php#tab_fototab

¹⁵ <https://www.babcock.com/products/submerged-grind-conveyor>

¹⁶ <https://blog.burnsmcd.com/new-bottom-ash-conversion-technology-emerges>

¹⁷ See, *e.g.*, ERG/EPA Call Notes re Ash Handling Conversion in the Industry (May 24, 2012), EPA-HQ-OW-2009-0819-0580, available at <https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0819-0580> (pertaining to EPA and its contractor’s discussions with UCC); ERG Memorandum re Ash Handling Documentation from Communications with Clyde Bergemann (Sept. 30, 2015), EPA-HQ-OW-2009-0819-6232, available at <https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0819-6232>.

That the vendor community for dry bottom ash handling is robust is not surprising given that the U.S. coal-fired power plant fleet at the time of the rulemaking was over 800 units strong, with each unit generating copious amounts of bottom ash that must be handled and managed. Further, as the ELG rulemaking record itself shows and as previously noted, a significant portion of the U.S. coal fleet already meets the BAT standard for BATW using dry handling systems. Vendors, including those mentioned above, already have many technology solutions and offerings for achieving a zero discharge for BATW. As EPA states in the preamble to the ELG Rule:

[T]echnologies for control of bottom ash transport water are demonstrably available. Based on survey data, more than 80 percent of coal-fired generating units built in the last 20 years have installed dry bottom ash handling systems. In addition, EPA found that more than half of the entities that would be subject to BAT requirements for bottom ash transport water are already employing zero discharge technologies (dry handling or closed-loop wet ash handling) or planning to do so in the near future.¹⁸ (emphasis added)

Second, as far as schedule and timing for achieving compliance with the BATW ELG, it is instructive to review the comments provided by utilities themselves during the ELG rulemaking. While numerous parties provided comments to the EPA during the ELG rulemaking, it is particularly important to note certain, relevant portions of comments provided by Southern Company (a large utility with several coal-fired power plants in the Southeastern US) and by the Utility Water Act Group (UWAG), an industry consortium, which includes almost all U.S. utilities (including APS) as its members.¹⁹ In its comments pertaining to bottom ash conversions at that time, Southern Company and UWAG both offer case studies in which units converted from wet to dry bottom ash handling in 27-33 months:

[I]n the case study presented in the attachment, it would take 30-36 months to convert from a wet bottom ash hopper to a dry bottom ash hopper for a large unit. Another case study for adding a remote wet ash hopper and submerged flight conveyor would take 27-33 months.²⁰ (emphasis added)

I am aware from conversations with industry sources and review of compliance approaches at other coal-fired plants that even these timelines of 30-36 months or 27-33 are generous. Current

¹⁸ 80 Fed. Reg. at 67,852.

¹⁹ As UWAG's comments note, "UWAG is a voluntary, *ad hoc*, non-profit, unincorporated group of 198 individual energy companies and three national trade associations of energy companies: the Edison Electric Institute, the National Rural Electric Cooperative Association, and the American Public Power Association. The individual energy companies operate power plants and other facilities that generate, transmit, and distribute electricity to residential, commercial, industrial, and institutional customers." Utility Water Act Group Comments on EPA's Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, at 1 n.1.

²⁰ *Id.* at 84; *see also* Southern Company Comments on EPA's Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, Appendix B.

timelines to achieve compliance are well below 24 months. EPA has not identified any reason that FCPP cannot meet the zero-discharge BAT sooner than December 31, 2023.

I am also aware that other NPDES permits, such as those issued by the Maryland Department of the Environment (MDE) for GenOn plants Chalk Point, Dickerson, and Morgantown have ELG compliance deadlines that are far earlier than December 2023. The compliance date for Chalk Point BATW zero-discharge is November 1, 2020.²¹ The compliance date for Dickerson BATW zero-discharge is November 1, 2020.²² The compliance date for Morgantown's FGD wastewater ELG compliance – which is arguably more complex than BATW discharge ELG compliance is November 1, 2020.²³

IV.1 Site-Specific Discussion

I am aware that the power plant owner, APS, submitted in April 2019, apparently at the request of EPA, a document attempting to support the December 2023 compliance deadline for BATW.²⁴ I have carefully reviewed this document and disagree with its many unsupported excuses and statements. Not only does APS fail to provide any reasoned basis why the compliance timeline should be December 2023 for eliminating BATW discharges at the plant, APS openly admits its lack of planning.

First, APS states that the long compliance timeline is required because it “anticipates implementing three separate, yet interrelated projects at the FCPP to address compliance with both the revised ELGs for BATW and requirements under EPA's CCR regulations.” While this may be true, it does not address the many years the company has been aware that this is the case. In other words, the fact that it has chosen to deal with compliance for the CCR rule and the ELG rule by implementing the three interrelated projects is not a sudden and new revelation. Both rules have been in place for years – with the ELG rule in place almost three and a half years now. So, what has the company been doing for these past many years to plan for the implementation of the CCR and ELG rules? It

²¹ Permit Number: 14-DP-0627 (MD0002658). Available at MDE web portal.
<http://mes-mde.mde.state.md.us/WastewaterPermitPortal/>

²² Permit Number: 14-DP-0048 (MD0002640). Available at MDE web portal.
<http://mes-mde.mde.state.md.us/WastewaterPermitPortal/>

²³ Permit Number: 14-DP-0841 (MD0002674). Available at MDE web portal.
<http://mes-mde.mde.state.md.us/WastewaterPermitPortal/>

²⁴ “NPDES Effluent Limitation Guideline Compliance Project Summary, APS, Four Corners Power Plant,” attached to an email dated April 4, 2019 from Jeffrey Allmon, counsel to FCPP addressed to EPA (Gary Sheth and Dustin Minor). The email states, in part, “[A]s I mentioned earlier today, attached you'll find the updated project summary you requested. Please let me know if you have any questions about this or would like additional information.” I am not aware that EPA asked for any follow up information after this submittal by the company.

does not state – other than to confirm its lack of preparation (which I discuss below). APS then uses its lack of planning to request additional time and a longer compliance schedule.

Second, even accepting that its three inter-related projects have to be implemented, the April 4, 2019 document provides no engineering supported for the stated schedule. As an example, it states:

[A]t this time, the Combined Waste Treatment Pond unit must cease receiving CCR and non-CCR wastestreams by October 31, 2020, and thereafter initiate closure procedures within 30 days....Critical project milestones and timing include, without limitation:

- o Final design for pond clean-out (i.e., CCR removal), second quarter 2020
- o CCR closure by removal, approximately 20 months following BATW holding and treatment tank construction completion (work likely to commence in third quarter of 2020) (*see below*) (emphasis added)

There is simply no support for the 20-month schedule noted above for the closure of the combined waste treatment pond.

Third, as the document states, APS is now in the midst of construction of the BATW Holding & Treatment Tank.²⁵ Setting aside why it began this project as late as “October/November 2018,” the document states, without any support, that it should take over 6 additional months (until the second quarter of 2020) for “operations and testing for TSS, oil and grease, and pH NPDES permit requirements.” This makes no sense whatsoever. Since BATW will be held and treated, it is not clear that this long timeline for just filling the tank and taking samples after treatment for these basic parameters will take 6 months.

In addition, the document attempts to create confusion by mentioning uncertainties in expected flow rates, referring to “possible design change with submerged conveyor system, implicates a change for system volume to 1.7 million gallons per day (I.e., instead of 4.4 million gallons per day...Maximum design flow will be reviewed after the conveyor system options are explored, as well as the overall design of system reviews occur, which will take place during 2019.” But if the holding and treatment tank is being constructed, one can safely assume that as long as the company has used competent engineers as designers for this project, the sizing of the system would be based on reasonable worst-case flows – which is customary. Thus, changes in flow, as long as they are all below the design flow, are irrelevant.

Fourth, in attempting to justify a December 2023 compliance date, APS states in the April 4, 2019 document that reuse makeup water from the BATW closed loop system which will be used as make-up water for the plant’s existing FGD system will require “precise chemistry” requirements of “appropriate quality” to be met. But APS does not state what these precise chemistry and appropriate quality requirements actually are. Moreover, APS does not explain why this issue is unique to FCPP, when every other coal-fired power plant that has closed loop BATW and FGD also

²⁵ The April 4, 2019 document states that construction of this holding tank will be during the second and third quarter 2019. The document notes that this BATW holding and treatment tank “is an integral component of the eventual BATW closed loop recycling system...”

has to deal with this same issue. FGD make up water can be of varying quality without upsetting FGD operations. In this case, this makeup water will be treated water after the aforementioned holding tank and treatment system. There is no legitimate reason to question the ability of the treatment system to meet whatever specifications are necessary for the use of the treated water as FGD makeup water. This is yet another example of APS raising spurious issues.

Fifth, the April 4, 2019 document attempts to justify a December 31, 2023 compliance date by stating the following:

[D]esigning, engineering, constructing, and operating the BATW closed-loop recycling system will require precise data on the total volume of water being managed in this system. At this time, the volume needs for this system are based entirely on water balance *calculations* for the entire power plant. (italics in original) Given the lack of water flow meters throughout the system of water use at the FCPP, among other factors, these water balance calculations are not precise; as such, the BATW holding and treatment tank system is being designed to handle a range of flow volumes. Once the BATW closed-loop recycling system is put into operation, however, there will be very little allowance for variations in flow volumes within this system. Again, real-world, operational data on the water flow volumes being managed in the BATW holding and treatment tank system will be needed to properly design and engineer the pumping and pipe systems for the BATW closed-loop recycling system (e.g., as to capacity sizing). In addition, at this time, the FCPP is starting to implement a number of water conservation strategies and it is not yet clear what impact those strategies will have on the water flow volumes that will be managed in the BATW closed-loop recycling system. Once again, real world, operational data associated with the BATW holding and treatment tank system will be needed to account for the impacts of the plant's water conservation strategies on the design and engineering of pumps and piping used in the BATW closed-loop recycling system. (emphasis added)

This whole paragraph above is riddled with unsupported and embarrassing admissions. One, it is not clear how the plant has managed to operate for the last four decades given the "...lack of water flow meters..." Even assuming the plant lacks water flow meters, APS could have installed water flow meters in the last 10 years since the ELG rulemaking was underway, or at least in the three-and-a-half years since the ELG Rule was finalized. Two, the document seems to assume that it is sufficient to repeatedly mention words like "precise" and phrases like "real world" to provide a rationale for the requested compliance date. In reality, these words, in context, mean nothing. All engineering systems, no matter what the matter at hand, have to be precise and deal with variability by making conservative assumptions in design. Compliance with the BATW standards is no different.

Sixth, continuing the theme of unsupported timelines, the April 4, 2019 document mentions additional project timelines as follows: "Additional tank design and engineering, 18 months; Pumps design and purchase, four to eight months; Construction of pump pit tank and piping system, 12 months; and Commissioning and pump tie-in, three months." APS does not justify any of these timelines. In fact, the reference to the "additional tank design and engineering" timeline is not only

unsupported, it is unclear why *any* tank design and engineering should take 18 months... Any tank design and engineering should not take more than 3 months at the latest, and in even lesser time if done expeditiously. The other timelines quoted above are similarly unsupported.

In closing, the April 4, 2019 document states that:

based upon these factors, APS believes that the “as soon as possible” compliance date for implementing the 2015 ELG Rule's zero-discharge standard for BATW at FCPP is December 31, 2023. This is the soonest date by which APS can achieve compliance through integrated planning for the facility while at the same time avoiding major expenditures to comply with the final effluent limits for BATW until EPA completes its pending rulemaking.

I disagree. APS has simply not supported its “belief.” And APS makes no mention of the regulatory requirement for “expeditious” compliance. Indeed, APS’ entire justification is the very opposite of attempting to achieve “expeditious” compliance. The company’s arguments regarding coordination with the CCR rule are not unique to this plant, as most other coal plants are subject to both the CCR and ELG rules and have managed to address (or are addressing) both rules. Based on the discussion above, it is my opinion that the power plant has had ample time to do engineering work to address the ELG rule. But APS has dragged its feet by choice. As I have noted, over half the current coal-fired fleet already meets the zero-discharge requirements for BATW. Even if APS were to begin work now to comply with the ELG Rule (i.e., pretending that APS has done zero planning till today), APS should be able to meet the BATW ELG in 24 months at most.

V. COMPARISON OF THE PROPOSED COMPLIANCE SCHEDULE WITH THE SCHEDULE FOR LARGE PROJECTS

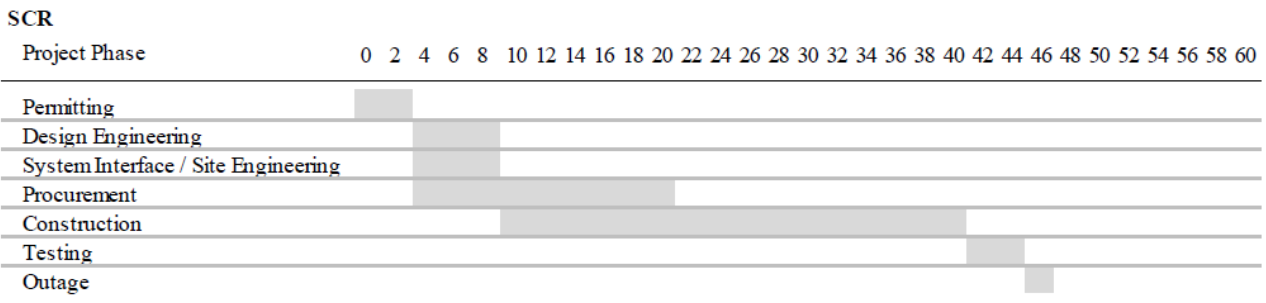
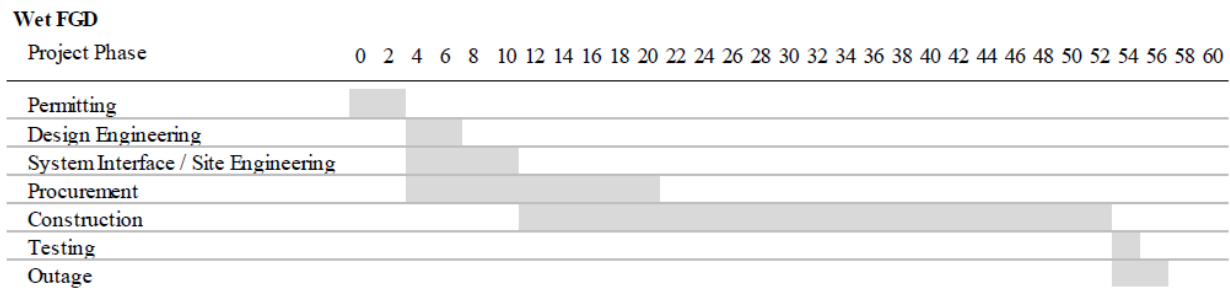
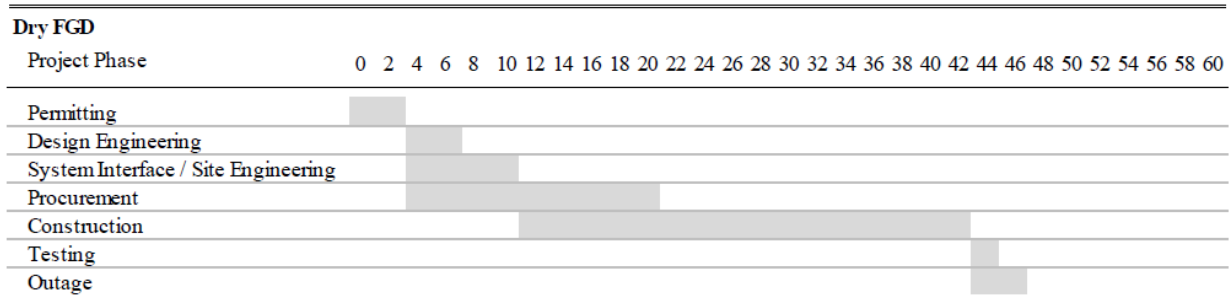
As a point of comparison, the utility industry is familiar with implementing large capital projects in short timeframes – including many projects that are much bigger in scope and complexity than meeting the BATW requirements at FCPP. Consider, for example, air pollution control projects such as the installation of dry and wet FGD systems for SO₂ control and the installation of Selective Catalytic Reduction (“SCR”) controls for NO_x control. These projects often cost hundreds of million dollars, as opposed to the much smaller capital requirements mentioned in APS’ April 4, 2019 document discussed in the previous section.²⁶ Yet, while often complex and challenging to implement, timelines to install new FGD and SCR controls typically are in the range of 3 to 5 years—starting from conceptual engineering through completion during scheduled outages.

Three example timelines are shown below—for dry FGD, wet FGD, and SCR projects, respectively—as developed by a contractor for MISO, the independent system operator for the

²⁶ I do not want to leave the impression that I agree with the capital costs mentioned in the FCPP April 4, 2019 submittal to the EPA – only that, even taking those costs at face value, the BATW zero-discharge project is far smaller than the costs for installing a new FGD or new SCR at a typical existing coal-fired power plant.

U.S.²⁷ These timelines are generally conservative—i.e., the timelines shown are generally high, reflecting the most complex installations, with typical projects capable of implementation in less time. Nonetheless, as the charts below illustrate, the expected durations for implementing dry FGD or SCR are around 46 months and around 56 months for wet FGD.

Typical Timelines for Dry FGD, Wet FGD, DSI and ACI Retrofit Projects



Given the far greater complexity of these projects, FCPP’s assertions that the relatively much simpler installation of a zero discharge BATW treatment system at the plant will take an additional 56 months (excluding the more than 3.5 years since the rule went into effect and the almost 10 years that have elapsed since the company has had notice that EPA was likely to address BATW in this manner) —is simply untenable.

²⁷ The Brattle Group, *Supply Chain and Outage Analysis of MISO Coal Retrofits for MATS*, Appendix A (May 2012), available at http://www.brattle.com/news-and-knowledge/news/brattle-economists-identify-challenges-for-miso-s-coal-fleet-to-comply-with-epa-s-mats-rule_2

VI. CONCLUSIONS

Given the discussion above, it is my opinion that APS can meet the zero discharge BAT standard for BATW within 24 months after starting compliance efforts.

VII. AUTHOR'S EXPERTISE AND QUALIFICATIONS

Dr. Ranajit Sahu has over twenty-five 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; 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.

A significant portion of Dr. Sahu's educational background and consulting experience deals with addressing environmental impacts due to coal-fired power plants including all aspects of air emissions from such plants as well as environmental impacts from water/wastewater, cooling water, and solid/hazardous wastes at such plants and impacts due to coal mining, transportation, and stockpiling.

Dr. Sahu holds a B.S., M.S., and Ph.D., in Mechanical Engineering, the first from the Indian Institute of Technology (Kharagpur, India) and the latter two from the California Institute of Technology (Caltech) in Pasadena, California. His research specialization was in the combustion of coal and, among other things, understanding air pollution aspects of coal combustion in power plants as well as the formation of ash during combustion.

An abbreviated resume for Dr. Sahu is provided in Attachment A.

The opinions expressed in the report are Dr. Sahu's and are based on the data and facts available at the time of writing. Should additional relevant or pertinent information become available, Dr. Sahu reserves the right to supplement the discussion and findings.

ATTACHMENT A – RESUME

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

CONSULTANT, ENVIRONMENTAL AND ENERGY ISSUES

311 North Story Place

Alhambra, CA 91801

Phone: 702.683.5466

e-mail (preferred): sahuron@earthlink.net

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).