Controlling toxic air pollution from coal-fired power stations in New South Wales

Preliminary submission
on the Environmental Protection Licences for:

Vales Point Power Station (EPL761)
Mt Piper Power Station (EPL13007)
Eraring Power Station (EPL1429)
Bayswater Power Station (EPL779)
Liddell Power Station (EPL2122)

November 2018

About Environmental Justice Australia

Environmental Justice Australia is a not-for-profit public interest legal practice. We are independent of government and corporate funding. Our legal team combines technical expertise and a practical understanding of the legal system to protect our environment.

We act as advisers and legal representatives to community-based environment groups, regional and state environmental organisations, and larger environmental NGOs, representing them in court when needed. We also provide strategic and legal support to campaigns to address climate change, protect nature and defend the rights of communities to a healthy environment.

We also pursue new and innovative solutions to fill the gaps and fix the failures in our legal system to clear a path for a more just and sustainable world.

For further information on this submission, please contact:

Dr James Whelan, Researcher and Community Organiser
M: 0431 150 928
E: James.Whelan@envirojustice.org.au

Submissions to be sent to:

Head, Regulatory and Compliance Support Unit
NSW Environment Protection Authority
PO Box A290, Sydney South NSW 1232
poeo.licensing@epa.nsw.gov.au

About this review

The Environment Protection Licences (EPLs) for the Eraring, Mount Piper and Vales Point power stations are due for review by early January 2019. This process occurs every five years.

The reviews are due to conclude on 24 December (Vales Point), 1 January (Mt Piper) and 6 January (Eraring). EPLs for Bayswater and Liddell power stations are not due until January 2020 and May 2022, but public comment can be made at any time. As such, EJA request that this be accepted as a submission on the licences of all five licences.

We note with concern that the EPA has not initiated any structured community engagement such as calling for submissions, convening public meetings or advertising in local newspapers. The power stations are the source of much of the toxic air pollution in New South Wales, and controlling this pollution is a subject of significant public interest. Environmental Justice Australia requested an extension to avoid the summer break and allow for community involvement, but this request was declined. In response, EJA established a web-based submission platform. Since 1 November, that site has registered 140 submissions.

We intend to make a subsequent and final submission before the 30 November and request that this submission be considered as a preliminary submission. Attachment A should be considered as part of this submission, providing expert opinion from regulatory expert Dr Ron Sahu. Our final submission will include advice from Dr Sahu on the Vales Point and Mt Piper power stations.

1. Power stations are a major source of air pollution, harming community health.

The five coal-fired power stations in NSW are the state's main source of several toxic air pollutants including sulfur dioxide (SO_2) and oxides of nitrogen (NOx).

Nationally, power stations are responsible for an annual health bill of $2.6 billion.[1] Toxic emissions from power stations cause adverse health impacts in communities at least 200 kilometres away. In NSW, particle characterisation studies have shown that air pollution from the Hunter and Central Coast power stations travels as much as 200 kilometres to Sydney contributing to poorer air quality and exposing millions of people to toxic emissions. Power stations account for 54% of the city's oxides of nitrogen and 87% of sulfur dioxide.[2]

People who live within 50 kilometres of coal-fired power stations face a risk of premature death as much as three to four times that of people living further away.[3]

There is no threshold below which particle pollution is not harmful to human health. Measures to reduce fine particle ($PM_{2.5}$) concentrations can result in an immediate health benefit. Broome et al (2015) concluded that 5,500 years of life are lost to air pollution each year in Sydney and that, "reducing air pollution by even a small amount will yield a range of health benefits."[4]

2. Licences for these power stations have extraordinarily high pollution limits.

In most countries, environmental regulators have progressively lowered pollution limits, as more has been learned about health impacts and as emission control technology has advanced. These lower limits motivate generators to control air pollution. Not so in Australia, where pollution stations operate with licence conditions comparable to those that were set when the power stations were first commissioned. The following table compares the licence limits set for Vales Point, Eraring and Mt Piper with power stations in the United States, Europe and China.

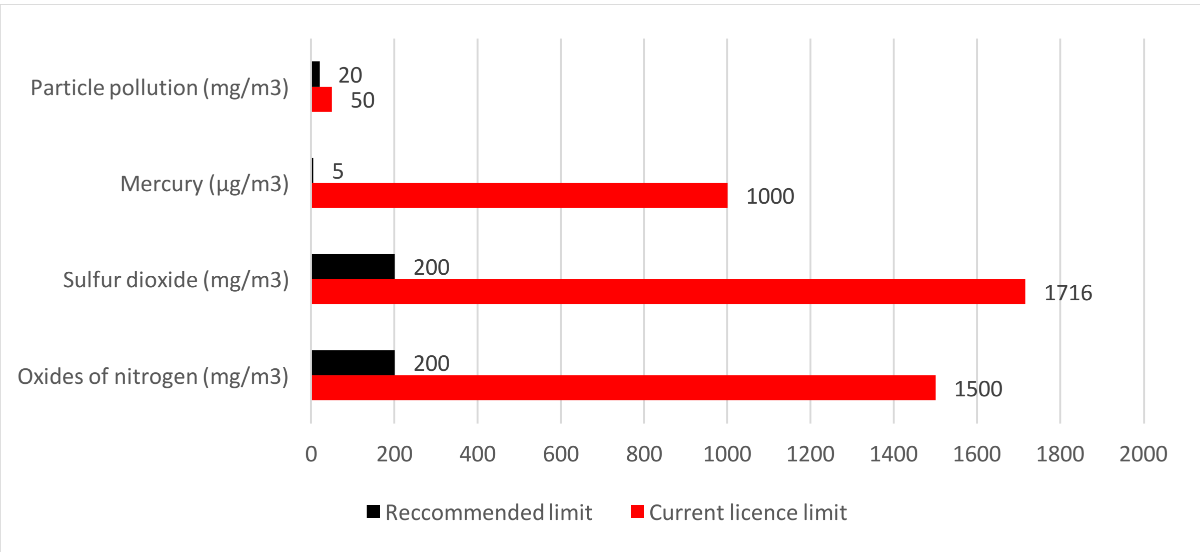
Table 1: Comparison of stack emission limits in various countries for key pollutants

	Particle pollution	Sulfur dioxide	Oxides of nitrogen	Mercury
United States	125mg/m^3	1517mg/m^3	875mg/m^3	1.5µg/m^3 (black coal) 14µg/m^3 (brown coal)
European Union	50mg/m^3 (black coal) 100mg/m^3 (brown coal)	400mg/m^3	200mg/m^3	30µg/m^3 (Germany only, no EU standard)
China	30mg/m^3	200mg/m^3 (400mg/m^3 for provinces with high sulfur coal)	200mg/m^3	30µg/m^3
Vales Point	100mg/m^3	1716mg/m^3	1500mg/m^3	1000ug/m^3
Eraring	50mg/m^3	1716mg/m^3	1100mg/ m^3	200ug/m^3
Mt Piper	50mg/m^3	1716mg/m^3	1500mg/m^3	200ug/m^3

Pollution licences in NSW are decades behind best practice. The EPLs for both Vales Point and Liddell power station describe the operators' obligation to prepare Pollution Reduction Studies to "undertake a review of international best practice measures available to minimise the generation and emission of NOx", referring to 500 milligrams per cubic metre (mg/m^3) as 'international best practice'. This is a clear indication of how out of touch the NSW EPA is: 500mg/m^3 is *not* best practice, and has not been for decades.

EJA commissioned Dr Ron Sahu for advice on the licence limits that should be set for NSW power stations. Dr Sahu is an air pollution expert, with more than 30 years' experience in regulation and compliance. Dr Sahu's expert opinion on the Eraring power station and his CV are attached as Attachment A. On the basis of Dr Sahu's advice, EJA recommend that the NSW pollution licences be amended, consistent with international best practice, as summarised in Figure 1.

Figure 1: Current and recommended stack emission licence limits



Recommendation 1: That the EPLs for all five power stations be amended to reflect international best practice (noting that this entails amendment of the Clean Air regulations contained within the *Protection of the Environment Operations Act 1997*).

3. Readily available equipment would reduce toxic pollution by 85% or more.

None of these three power stations are required under their EPLs to install or operate best practice emission controls that are readily available and mandatory in many other countries for power stations of a comparable age. The justification offered by the NSW EPA is that the licences reflect 'readily available technology' when the power stations were commissioned. [1] Until and unless localised air pollution problems are demonstrated, EPLs remain unchanged.

In the United States, Europe and Japan, older power stations have been required to retrofit best practice emission control technologies (ECTs) including Flue Gas Desulfurisation (FGD), Selective Catalytic Reduction (SCR) and Activated Carbon Injection (ACI), reducing emissions of SO_2, NOx and mercury respectively by 85% or more.

The NSW EPA recently required the Vales Point power station to prepare a Pollution Reduction Report (PRR) to identify and assess pollution reduction technologies for NOx emission reductions. This report identified Selective Catalytic Reduction (SCR) as the most effective control to reduce NOx. This emission control technology is standard practice internationally. As early as 2012, more than 90% of the power stations in Asia had fitted SCR and all new power plants need to be fitted with both FGD and SCR. [2]

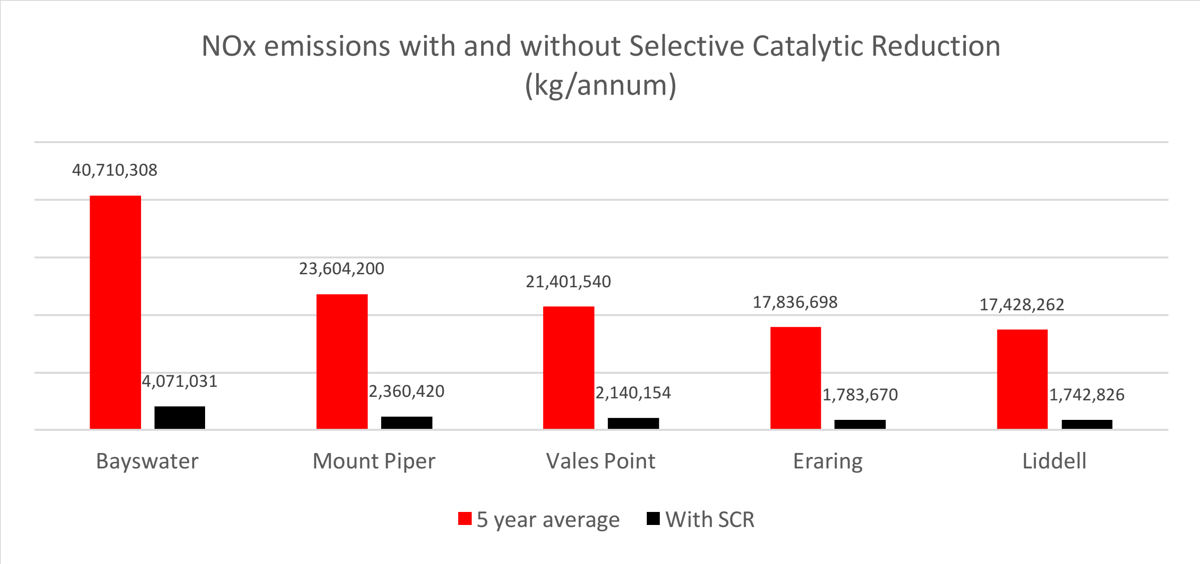
The best available pollution control for SO_2 emissions reductions from coal-fired power stations is flue gas desulfurisation (FGD). FDG can remove up to 99% of SO_2 emissions, substantially reducing community and environmental exposure to this pollutant and reducing the creation of toxic secondary sulfates.

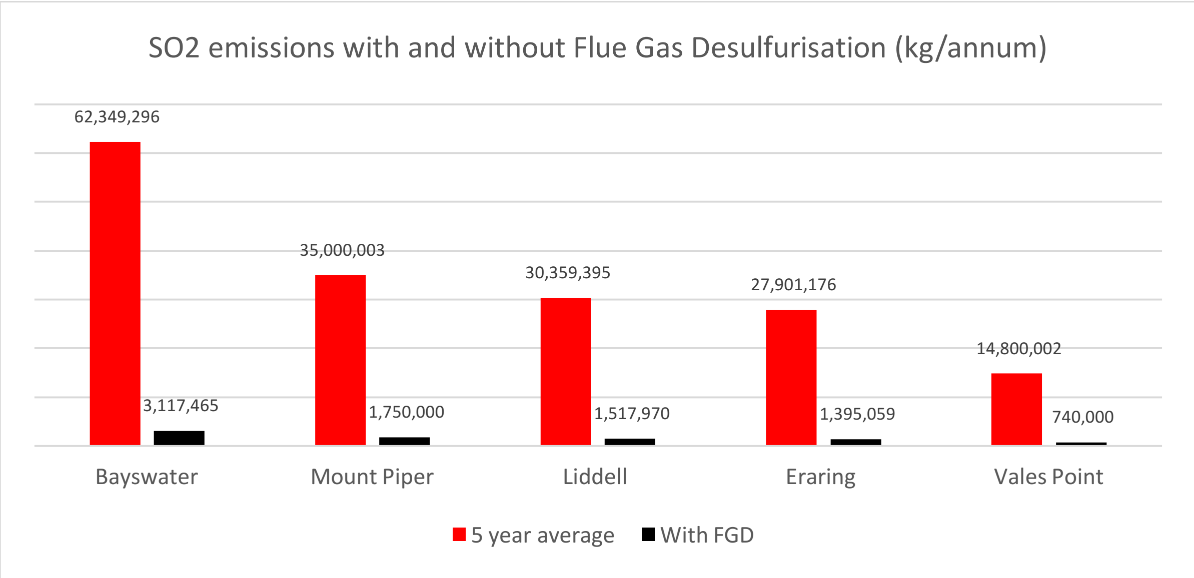
The following three figures demonstrate the reduction in toxic emissions that can be achieved by installing these three emission controls. Each figure illustrates the annual emissions of these five power stations, based on an average of the last five National Pollutant Inventory reports. A conservative estimate of the potential emission reduction is used in each instance: 90% for FGD to capture NOx and ACI to control mercury emissions, and 95% for FGD to reduce emissions of SO_2. In fact, reductions greater than this are feasible.

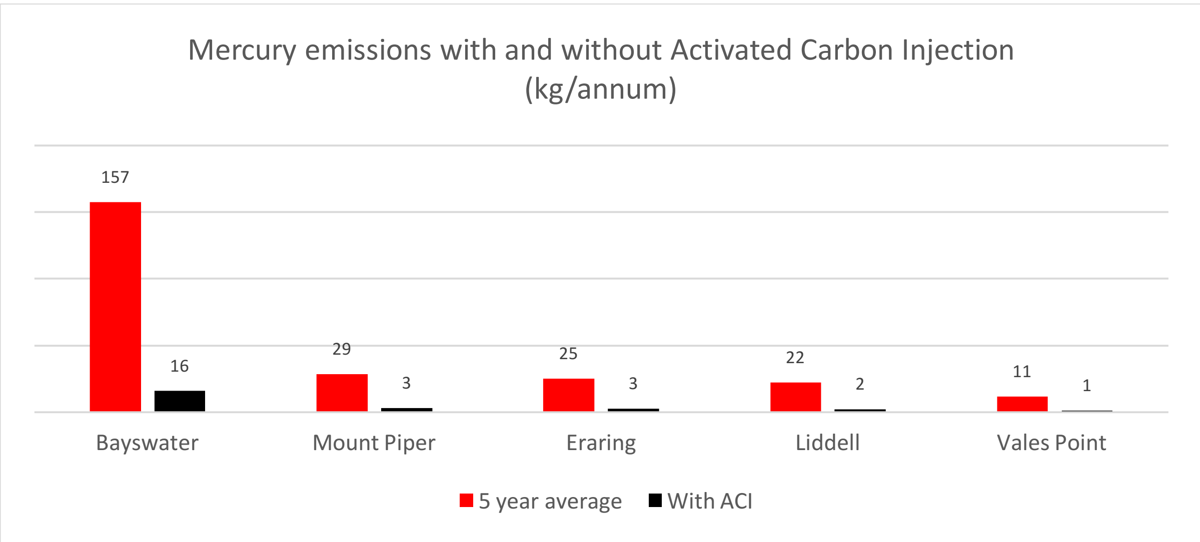
---

[1] Regional EPA director Adam Gilligan, in response to a question asked at public meeting in Wyee, 19/4/18. This explanation is also provided in the March 2018 NSW EPA Review of Coal Fired Power Stations Emissions and Monitoring, p.10.

[2] Jacobs, 2017, Vales Point Power Station NOx Pollution Reduction Study, p.42.


NOx emissions with and without Selective Catalytic Reduction (kg/annum)
40,710,308
4,071,031
23,604,200
2,360,420
21,401,540
2,140,154
17,836,698
1,783,670
17,428,262
1,742,826
Bayswater
Mount Piper
Vales Point
Eraring
Liddell
5 year average
With SCR


SO2 emissions with and without Flue Gas Desulfurisation (kg/annum)
62,349,296
3,117,465
35,000,003
1,750,000
30,359,395
1,517,970
27,901,176
1,395,059
14,800,002
740,000
Bayswater
Mount Piper
Liddell
Eraring
Vales Point
5 year average
With FGD


Mercury emissions with and without Activated Carbon Injection (kg/annum)
157
16
29
3
25
3
22
2
11
1
Bayswater
Mount Piper
Eraring
Liddell
Vales Point
5 year average
With ACI

Retrofitting emission control technologies (ECTs) has the added benefit of generating significant employment, as does pollution control in general.

Recommendation 2: That the five NSW coal-fired power stations be required to install best practice emission control technologies including Flue Gas Desulfurisation, Selective Catalytic Reduction and Activated Carbon Injection.

4. Generators' estimates of their toxic pollution are not reliable or accurate.

Community members have the right to know what they're breathing, and the right to trust that pollution monitoring and reporting is accurate and reliable. But pollution monitoring and reporting arrangements in NSW fall well short of this ideal.

There are two mechanisms for community members to access information about air pollution from power stations: (1) annual estimates of toxic emissions as reported to the National Pollutant Inventory and (2) data from the self-reporting that is required as a condition of the power stations' Environment Protection Licences. At present, neither of these arrangements meet community expectations, nor do they provide an accurate or useful picture of actual emissions.

The discrepancies in the NPI emission reports from the Mt Piper power station serve as a powerful illustration of how inaccurate polluters' reports can be. Fine particle pollution is the air pollutant of greatest concern to Australian governments, and power stations are the nation's single greatest source of $PM_{2.5}$. In their last five annual reports for the National Pollutant Inventory (NPI), EnergyAustralia reported that their Mt Piper power station emitted 160,000kg, 210,000kg, 130,000kg, 10,000kg then 59,400kg of fine particle pollution. If this was accurate, it would suggest Mt Piper had successfully reduced toxic fine particle pollution by 95% in just three years, only to see emissions increase again by a factor of six. In reality, EnergyAustralia had installed no new $PM_{2.5}$ controls during this period. The variation did not reflect huge changes in energy output from the power station.

Problems with the accuracy of NPI reporting were highlighted in the NSW EPA's March 2018 Review of Coal Fired Power Stations Air Emissions and Monitoring. The review made four recommendations that aim to investigate and develop improved and more consistent emission estimation techniques.

EPA officials have suggested to EJA and other community groups that we can rely on the pollution reports that are published on generators' websites. This suggests that the EPA have not attempted to access and analyse this data. In our experience, there are four compelling reasons not to rely on this arrangement and – instead – to require real-time monitoring data to be collected by OEH monitoring stations and reported through the OEH website.

(1) The companies that own and operate the five NSW power stations publish their monitoring data on websites that are difficult to locate and navigate.
(2) Data is published in PDF format, month by month, so it is not in a format that can be collated to provide a longer term data set, such as being imported into Excel. To construct a simple dataset with monitoring by all power stations for all pollutants for the last five years would take days. By contrast, the OEH website allows ready access data for any period of time up to the present, for any number of monitoring sites and for all pollutants that are monitored.

(3) It can take several weeks before monitoring data is available on a company's website. This is of limited use to a community member who is experiencing respiratory problems or observing a pollution event. By contrast, the OEH website allows data access almost immediately.
(4) Self-reported pollution data is not generally considered trustworthy by community members. Self-reporting is without doubt an inferior arrangement to monitoring and reporting that is undertaken by a government agency.

Recommendation 3: That the NSW EPA adopt a much stronger role in ensuring the accuracy of toxic air pollution reporting by coal-fired power stations, including penalising generators that provide false and misleading reports.

Recommendation 4: That the OEH take responsibility for continuous emission monitoring and reporting pollution adjacent to power stations, integrating this data into the public-accessible NSW OEH portal to enable real-time data access.

5. The licences for NSW power stations are inconsistent and need to be standardised.

During 2017, the NSW EPA audited the licences of all five NSW power stations and their compliance with these licences. The audit report[5], published in March 2018, confirmed a range of significant discrepancies and inconsistencies between the five licences, and recommended that the licences be standardised.

Environment Protection Licences specify the stack emission limits for key pollutants and operators' obligations regarding monitoring. These licence conditions specify the number of locations for 'point source' pollution monitoring, which is conducted in the power station stacks, and for ambient air pollution concentrations which is conducted at ground level, generally near the boundary and adjacent residential areas. Table 2 demonstrates the significant differences between these obligations.

Table 2. Monitoring requirements and stack emission limits set under EPLs

	Date of commissioning and grouping under the Clean Air schedules.	**Number and type of required air pollution monitoring locations**	**NOx limit**	**Mercury limit**	**Particle pollution limit**
Eraring	1982-84 Group 3	5 point source (stack emissions); 6 ambient air	1100mg/m^3	200µg/m^3	50mg/m^3 (expressed as solid particles)
Vales Point	1978 Group 5*	2 point source (stack emissions); 5 ambient air	1500mg/m^3	100µg/m3	100mg/m3
Mt Piper	1992-93 Group 4	2 point source (stack emissions); 1 weather	1500mg/m^3	200µg/m^3	50mg/m^3
Liddell	1971-73 Group 5*	9 point source (stack emissions); 1 weather	1500mg/m^3	100µg/m^3	100mg/m^3
Bayswater	1985-86 Group 3	4 point source (stack emissions); 3 ambient air; 1 weather	1500mg/m^3	100µg/m^3	100mg/m^3

The differences between pollution monitoring arrangements for these five power stations also relate to the frequency of reporting and to which pollutants are monitored. Table 3 highlights some of these differences. Note especially that there is no requirement for mercury monitoring at Liddell. Continuous stack monitoring is considered international best practice, but Mt Piper is only expected to monitor pollution concentrations either quarterly or yearly.

Table 3: Monitoring requirements defined in EPLs for each power station

	SO_2	**NOx**	**Mercury**	**Solid particles**	**Undifferentiated particles (opacity)**
Eraring	Continuous	Continuous	Yearly	Yearly	Continuous
Vales Point	Continuous	Continuous	Yearly	Continuous	Continuous
Mt Piper*	Quarterly	Quarterly	Yearly	Yearly	None
Bayswater	Continuous	Continuous	Yearly	Yearly	Continuous
Liddell	Continuous	Continuous	None	None	Continuous

** Note: Mount Piper must install continuous monitoring system by 28 February 2019*

EPLs for these five power stations do not contain emission limits for concentrations of sulfur dioxide. Instead, they include emissions limits for SO_3 and all except Mount Piper have reportable limits which appear to be used by the power stations as a de facto SO_2 limit. All five licences direct the licensees to report to the EPA if sulfur dioxide exceeds 600ppm at any time, despite there being no direct limit in the EPLs for those emissions and therefore no penalty if that level is exceeded.

Three of the five EPLs specify a limit for the permissible concentration of sulfur in coal, as illustrated in Table 4.

Table 4: EPL conditions relating to sulfur content in coal fuel for each power station

Power station	**Sulfur content in coal**
Eraring	Sulfur content in coal or any fuel in any boiler cannot exceed 0.5% by weight on monthly average
Vales Point	Sulfur content in coal or any fuel in any boiler cannot exceed 0.5% by weight on monthly average
Mount Piper	No sulfur content limit in coal
Bayswater	No sulfur content limit in coal
Liddell	Sulfur content of coal as fired in boilers cannot exceed 1.0%

The power stations have various obligations to report exceedances of their pollution licences. The operators of Eraring, Bayswater, Liddell and Vales Point power stations must report produce an 'air exceedance report' for the NSW EPA if SO_2 stack emissions exceed 600 parts per million, but the Mt Piper licence does not include this requirement. Eraring and Vales Point must report an exceedance of limits set by their licences to the EPA within 7 days. Liddell must report an exceedance within 30 days, and Mt Piper and Bayswater are only required to report exceedances in their annual report to the EPA.

Recommendation 5: That the EPLs for NSW power stations be standardised, as recommended in the NSW EPA's 2018 Review of Coal Fired Power Stations.

7. There is no air pollution control strategy in NSW.

The NSW EPA released the 'Air Options Paper' in late 2018, as a first step toward a state-wide air pollution control strategy. This initial 'Options Paper' spoke in general terms about controlling air pollution from power stations and noting that neither FGD nor SCR are fitted to the state's five power stations, but making no specific commitments. It generated several hundred submissions, many advocating specific controls for coal-fired power stations. An Air Pollution Summit was then held in July 2017, still with no specific proposals for pollution control. No apparent progress has been made since then.

The NSW Load-Based Licencing scheme is the only program that provides any incentive for polluters to reduce air pollution, though critics agree that the fees are set much too low. This problem is acknowledged by generators. The NOx Pollution Reduction Study prepared for Vales Point concludes that the total estimated costs of NOx control far outweigh in the saving in LBL fees (p.57). The LBL scheme has been under review since late 2016, without apparent progress. In the absence of any effective air pollution control strategy and arrangements to monitor and adjust it, these power station licences are one of very few mechanisms for pollution control.

Recommendation 6: That the NSW Air Pollution Control Strategy be finalised and implemented as a matter of urgency.

Recommendation 7: That the NSW Load-Based Licencing scheme be revised, with much higher emission fees to provide an incentive for pollution control.

8. Air particle pollution is not monitored near Eraring or Vales Point power stations.

The NSW Office of Environment and Heritage operate 50 air pollution stations throughout the state, including 18 in Sydney, 6 in Newcastle and 14 in the Hunter Valley. But there is just one air pollution monitoring station between Sydney and Newcastle at the Wyong racetrack. This is 30km from Eraring and Vales Point power stations. People living closer to the power stations and their coal mines and ash dumps have no access to data about local levels of air pollution.

EPA officials claim that air pollution concentrations in the Central Coast and Lake Macquarie are 'generally good', citing reviews of monitoring data prepared by consultants Todoroski Air Sciences in 2014 and 2015. It should be noted that this assessment was undertaken without the benefit of an air pollution monitoring network and before Australian governments adopted (in December 2015) a standard for annual average $PM_{2.5}$ concentrations and committed to a stricter long-term (2025) standard for 24-hour average $PM_{2.5}$ concentrations. The 2015 Todoroski report acknowledged that the Wyong monitoring site sometimes recorded particle pollution concentrations below zero (which is not possible). In short, the Todoroski reports are an inadequate basis to conclude that there is no need for pollution controls and OEH monitoring near these power stations.

Recommendation 8: That the NSW Office of Environment and Heritage air pollution monitoring and data access system be expanded to include at least three air pollution monitors on the Central Coast, in locations selected to provide a measurement of air pollution upwind and downwind of the Eraring and Vales Point power stations.

9. Air particle pollution is not monitored near Mt Piper.

There is no OEH monitoring site between Sydney and Bathurst to the West. The EPA and OEH recently commenced a 12-month project to monitor particle pollution (PM_{10} and $PM_{2.5}$) in Katoomba and Lithgow, but the trial will not include monitoring SO_2, NOx or other toxic gases.

Recommendation 9: That the NSW Office of Environment and Heritage air pollution monitoring and data access system be expanded to include at least two air pollution monitors in Lithgow, in locations selected to provide a measurement of air pollution upwind and downwind of the Mt Piper power station.

Recommendations

Recommendation 1: That the EPLs for all five power stations be amended to reflect international best practice (noting that this entails amendment of the Clean Air regulations contained within the *Protection of the Environment Operations Act 1997*).

Recommendation 2: That the five NSW coal-fired power stations be required to install best practice emission control technologies including Flue Gas Desulfurisation, Selective Catalytic Reduction and Activated Carbon Injection.

Recommendation 3: That the NSW EPA adopt a much stronger role in ensuring the accuracy of toxic air pollution reporting by coal-fired power stations, including penalising generators that provide false and misleading reports.

Recommendation 4: That the OEH take responsibility for continuous emission monitoring and reporting pollution adjacent to power stations, integrating this data into the public-accessible NSW OEH portal to enable real-time data access.

Recommendation 5: That the EPLs for NSW power stations be standardised, as recommended in the NSW EPA's 2018 Review of Coal Fired Power Stations.

Recommendation 6: That the NSW Air Pollution Control Strategy be finalised and implemented as a matter of urgency.

Recommendation 7: That the NSW Load-Based Licencing scheme be revised, with much higher emission fees to provide an incentive for pollution control.

Recommendation 8: That the NSW Office of Environment and Heritage air pollution monitoring and data access system be expanded to include at least three air pollution monitors on the Central Coast, in locations selected to provide a measurement of air pollution upwind and downwind of the Eraring and Vales Point power stations.

Recommendation 9: That the NSW Office of Environment and Heritage air pollution monitoring and data access system be expanded to include at least two air pollution monitors in Lithgow, in locations selected to provide a measurement of air pollution upwind and downwind of the Mt Piper power station.

References

[1] Biegler, T. 2009, 'The Hidden Costs of Electricity: Externalities of Power Generation in Australia' (Report, Australian Academy of Technological Sciences and Engineering, <http://www.atse.org.au/Documents/Publications/Reports/Energy/ATSE%20Hidden%20Costs%20Electricity%202009.pdf>

[2] EPA (2012), 2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW, Technical Report No.1 (pp.171; 156)

[3] Paul R Epstein, Testimony for the Kentucky General Assembly, House of Representatives Committee on Health and Welfare (25 February 2010) Kentuckians for the Commonwealth http://www.kftc.org/sites/default/files/docs/resources/dr._epstein_testimony.pdf.

[4] Broome, R.A., Fann, N., Navin Cristina, T.J., Fulcher, C., Duc, H. & Morgan, G.G., 2015, 'The health benefits of reducing air pollution in Sydney, Australia', *Environmental Research* No.143, pp.19-25.

[5] NSW EPA, 2018, Review of Coal Fired Power Stations Air Emissions and Monitoring, https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/18p0700-review-of-coal-fired-power-stations.pdf

Comments on the Licence Review for Eraring Power Station

Dr. Ranajit (Ron) Sahu, Ph.D., QEP, CEM
Engineer & Air Quality Consultant
Alhambra, CA
sahuron@earthlink.net
(+1) 702 683 5466

1 November 2018

These comments are provided in response to the NSW EPA's review of Licence 1429 to the operator of the Eraring Power Station (hereafter Eraring). Eraring, with its 4 units with a combined capacity of 2880 MW is Australia's largest power station. It is around 35 years old.

I have over 30 years of experience in environmental, mechanical, and chemical engineering, including extensive experience with design and specification of pollution control equipment at thermal coal plants. An abbreviated CV is provided in the Appendix. A complete version is available upon request.

My comments are organized as several major issues, followed at the end by some requested clarifications.

Major Issue – Lack of Proper Suite of Pollution Controls

Other than a fabric filter for control of coal fly ash particulate matter from the boilers, none of the units at Eraring are equipped with any other air pollution control equipment.

Modern (and even many older) power plants of this size, not only in the developed countries in the US, Canada, and many European countries, but also in developing countries such as India and China, etc. use significant additional air pollution controls to reduce emissions of a range of pollutants from their coal-fired boilers.

These pollution controls include:

1. Wet or dry flue gas desulfurization (FGD or scrubbers) to control and reduce emissions of sulfur dioxide (SO_2) by as much as 98-99% of what comes out of the boilers – even for units that purport to burn coal with relatively low sulfur such as Eraring;[1]
2. Selective catalytic reduction (SCR) to control and reduce emissions of nitrogen oxides (NO_x, consisting of NO and NO_2) by as much as 90-95% of what comes out of the boilers;
3. Additives such as activated carbon to reduce emissions of harmful toxic compounds such as mercury and dioxins; and
4. Additional additives to reduce emissions of acid gases such as hydrochloric acid, hydrofluoric acid, and the like.

As the World Bank draft guidelines of 2017 reinforce:

> More minor changes to improve environmental performance [of existing thermal power plants] would include fitting of low-NO_x burners; and injection of urea or ammonia (for either SNCR [Selective Non-Catalytic Reduction] or SCR) for NO_x control; addition of post-combustion alkaline reagent injection (dry; semi-dry; or wet FGD) for SO_2 and HCl control; injection of activated carbon to capture heavy metals and dioxins/furans; and improvement of particulate control measures by adding cyclones and fabric filters….[2]

Thus, from an air emissions control standpoint, each of the units at Eraring, equipped with just a fabric filter for control of particulate emissions,[3] is woefully lacking when compared to its peer group of coal-fired units around the world.

[1] I note that while the sulfur content of coal burned at Eraring is limited to 0.5% by weight, (see O6.1) this is on a monthly basis. Of course, that means that on any given day or hour, the actual sulfur content (and resulting SO_2 emissions) could be much higher.

[2] World Bank/IFC, Environmental, Health, and Safety Guidelines for Thermal Power Plants, Table 6 (May 31, 2017), (hereafter WB/IFC Guidelines), available at https://www.ifc.org/wps/wcm/connect/9a362534-bd1b-4f3a-9b42-a870e9b208a8/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES, p. 61.

[3] I note that the concentration limit for particulate matter, even with the fabric filter present, is not particularly stringent – meaning that the effectiveness of the fabric filters at the units could be better.

That this would be the case in Australia, a developed country, is, frankly, shocking.

Major Issue – Outdated or Irrelevant Concentration Limits for Air Pollutants

Not only are the four units at Eraring not subject to proper mass-based emission limits (which would require than to install, run, and maintain a proper suite of air pollution controls like the ones listed above – for the entire range of unit operations), typically expressed as gram/MJ of heat input or similar; the concentration-based limits that are present in section L3 of the licence are, in general, too high as to be irrelevant. I note that this has been recognized by the EPA itself in its recent analysis of the licences of coal-fired power plants in NSW.[4]

As an example, there are simply no concentration-based limits for SO_2 in the licence, a major pollutant – although the licence does require continuous monitoring of this pollutant and a reporting of excess emissions greater than 600 ppm (or roughly 1,716 mg/ cubic meter[5]) see section R1.12). While it appears that the lack of SO_2 concentration limit might be because of the condition requiring coal sulfur content to be less than 0.5%, that prohibition is on a monthly basis and is no substitute for an absolute concentration limit applicable at all times.

The licence review should require maximum reduction of SO_2 with the addition of wet Flue Gas Desulfurization (FGD) using limestone ($CaCO_3$) or similar reagents for 99% removal efficiency,[6] and the wet FGD system should be operated for maximum efficiency and required to be in use whenever coal is burned.

---

[4] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. Item 6 in Section 4.1 under Recommendations notes that the EPA should "…investigate the potential for reducing EPL emission limits where there is a demonstrated history of compliance by an appreciable margin."

[5] I uses a conversion factor of 2.86 mg/cubic meter per ppm for SO_2 consistent with the EPA's assumption in this regard. See Ibid., Table 4. However, I note that the limit value in Table 4 (1,760 mg/cubic meter) appears to be slightly in error.

[6] A. L. Morrison *et al.*, Analysis of Pollution Control Costs in Coal Based Electricity Generation – Technology Assessment Report, Cooperative Research Centre for Coal in Sustainable Development (January 2008) (hereinafter "Morrison 2008"), at 25-26, https://www.researchgate.net/publication/237460048_ANALYSIS_OF_POLLUTION_CONTROL_COSTS_IN_COAL_BASED_ELECTRICITY_GENERATION_TECHNOLOGY_ASSESSMENT_REPORT_68 (noting that a high velocity limestone with forced oxidation wet FGD system is capable of removing 99.6% of SO_2 under test conditions).

While wet FGD systems are relatively expensive, Eraring is expected to run for many years into the future, so I would expect that capital investments will be recoverable.

Lower levels of SO_2 reduction are possible, with corresponding lower capital costs, using dry scrubbers with efficiencies up to 94%[7] – available in a variety of configurations. At a minimum, SO_2 reduction approaches such as coal cleaning (typically at the mine, where sulfur containing impurities are removed from the coal before it is processed for combustion) as well as Dry Sorbent Injection (DSI),[8] could provide SO_2 reduction of up to 90% (but often much lower)[9] at lower capital costs.

As another example of the very loose concentration limits, consider NO_x, whose current licence limit is 1100 mg/cubic meter, corrected to 7% oxygen at each of the boiler stacks. This is far greater than any developed country standard. In fact, the WHO guideline is 500 mg/cubic meters (albeit at a 6% oxygen basis) for non-degraded air-sheds and 200 mg/cubic meters for a degraded air-shed.[10] Limits in the EU are 200 – 450 mg/cubic meters.[11] Actual emissions of NO_x as reported by the EPA itself in its recent review of coal plants in NSW show that the average and maximum NO_x concentrations at Eraring are, respectively, 415 and 593 mg/cubic meters – significantly below the 1100 mg/cubic meter limit.[12] I recommend that, in the short-term, EPA reduce the current NO_x limit to around 600 mg/cubic meters, which will provide an incentive for the operators at Eraring to maintain their NO_x emissions from the boilers at the levels that they are already

---

[7] WB/IFC Guidelines, at p. 7.

[8] *See*, *e.g.*, Dr. R. Sahu, Technical Report on Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF) (April 2013), at 2-5, http://www.cleanenergy.org/wp-content/uploads/Final_Sahu_DSI_Report.pdf.

[9] *Id., at 5.*

[10] WB/IFC Guidelines, Table 6.

[11] Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED. European Commission, https://ec.europa.eu/energy/en/topics/oil-gas-and-coal/coal-and-other-solid-fuels.

[12] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

capable of achieving.[13] And, in the longer-term (i.e., within 5 years or so), that the Eraring units achieve NO_x levels of 200 mg/cubic meters, which they should be able to do with a suite of NO_x controls including low NO_x burners/over-fire air and post-combustion controls of either Selective Non-Catalytic Reduction (SNCR) or, ideally, SCR.

Next, consider the concentration limit for solid particles, presumably of any size, at 50 mg/cubic meter. I note that the WHO guideline ranges from 20-40 mg/cubic meters,[14] indicating that the current limit is not stringent enough, even with the fabric filter present. And, actual data shows that the units achieve significantly lower levels – average of 9 mg/cubic meters and maximum of 19 mg/cubic meters.[15] Like in the discussion of NO_x above, maintaining the limit at 50 mg/cubic meters is not consistent with licence terms O1 and O2. It should be lowered to 20 mg/cubic meters.

Finally, consider the concentration limit for mercury, which is 0.2 mg/cubic meters or 200 ug/cubic meters. Using typical mercury levels in Australian black coals (average of 0.045 ppm)[16] and typical heating values of black coals of around 25 MJ/kg, one would expect mercury concentrations of less than 10 µg/cubic meter in the stack. So, having a limit of 200 µg/m3 makes no sense. This is reinforced by the actual data reported to the EPA. For Eraring the average mercury concentration was 0.001 mg/cubic meters (or 1 µg/cubic meter) and the maximum was 0.0022 (or 2.2 µg/cubic meter).[17] This limit, for it to have any meaning at all, should be lowered to 5 µg/cubic meter.

Thus, as part of its stated goal of revisiting the current limits in the various NSW coal plants, I urge the EPA to revisit and lower the concentration limits I have discussed above (and others) currently in the licence in L3 for the Eraring boiler stacks. Where the EPA decides to leave the

[13] In fact, this is not only entirely consistent but imperative with the requirement in the licence condition O1 that licenced activities must be carried out in a "competent" manner and also with the requirements in the licence condition O2 that all plant and equipment "must be maintained in a proper and efficient condition" and "must be operated in a proper and efficient manner."

[14] *Id.*

[15] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

[16] https://hub.globalccsinstitute.com/publications/impact-flue-gas-impurities-amine-based-pcc-plants/21-trace-element-contents-australian-thermal-coals

[17] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

current, high limits in place, it has the obligation to provide a technical basis supporting each of the limits in L3.

Major Issue – Lack of Proper Monitoring at Boiler Stacks

Compounding the leniency of the concentration limits discussed above is the fact that the licence conditions are weak with regards to monitoring emissions from the boiler stacks to demonstrate compliance with even the weak limits in L3. EPA itself explicitly recognizes this as a problem in its recent review of coal plants in NSW.[18]

M2 contains the list of monitoring requirements for the main boiler stacks (Points 11,12,13, and 14). As the table shows, other than the requirement for continuous monitoring for the concentrations of NO_x, SO_2, and undifferentiated particulates,[19] all of the other monitoring is only required "yearly" or once per year. That includes parameters of process importance such as gas density, stack gas moisture, stack temperature, and even stack gas flow.

Most modern power plants, especially with a focus on greenhouse gas reductions and efficiency, monitor parameters such as stack gas flow and temperature (which, collectively provide an indication of the heat losses through the stack) continuously. In addition, continuous monitors for filterable PM (of any size fraction), acid gases such as hydrochloric acid, and toxics such as mercury, are widely available and in use in power plants worldwide. For example, over 250 coal-fired units in the US use mercury continuous emissions monitors and dozens use continuous PM monitors as well.

I recommend that the EPA seriously expand the monitoring requirements during the licence review.

[18] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. See section 3.1 where EPA recognizes that "…there are opportunities for improvement in the application of periodic and continuous emission measurement at all power stations."

[19] I note that "undifferentiated particulates" is not defined in the glossary. I assume it means total suspended particulates, undifferentiated as to size. I do see that the same table in M2 also contains a requirement for yearly monitoring for "solid particles" which is also not defined in the glossary. The EPA should make sure that terms such as these are properly defined in the glossary.

Of course, just having the continuous data available to the plant or operator is not sufficient. All of the continuous monitoring data, including from the existing NO_x, SO_2, and undifferentiated particulates should be made available electronically and publicly such as via the public NSW Office of Environment and Heritage website.

Of course, having continuous monitoring at each of the boiler stacks is important not just for transparency, but gives the public and the regulator confidence that there is not any cheating or gaming the system as it stands currently.[20]

Major Issue – Locations of Ambient Air Monitors

Setting aside the dust gauges (Monitoring locations 18, 25, 26, and 27), there are just two ambient air monitoring locations (15 and 16). However, the only pollutants required to be monitored at these two locations are NO_x and SO_2. While that is a start, it is not clear why these ambient locations are not also required to monitor, at a minimum, for fine particulate matter $PM_{2.5}$, the pollutant most widely-recognized as extremely harmful to human health. I recommend that the monitoring be expanded to include continuous $PM_{2.5}$ monitoring, with public reporting of all monitored data.

Importantly, the licence document (or the record) does not provide clarity on why Locations 15 and 16 are even appropriate as the (only) two monitoring locations. While they may have been established in years past based on some rationale, that is not obvious now. In fact, there are indications that these monitoring locations may not be appropriate to capture dust impacts from the plant, including from its ash ponds.[21] I recommend that the EPA evaluate and justify the appropriateness of the ambient monitoring program as a whole – i.e., based on meteorological considerations, establish at least one upwind or background ambient monitor and dust fall monitor; and then establish as many necessary ambient and dust fall monitors that are needed based on fully covering the potential impact area of the Eraring power station. It is likely that a dispersion model,

[20] See, for example, https://www.theherald.com.au/story/4660250/power-stations-under-reporting-toxic-pollution/

[21] For example, during the September 2016 dust storm that blew coal ash from Eraring's ash dumps, current monitors well not well placed to provide any useful information about the event. See https://www.theherald.com.au/story/4452383/dust-fine-for-eraring-criticised/

such as AERMOD, would be necessary to be run to define the areas of maximum impact, which could be the possible locations of the ambient monitors.

As it stands, ambient air monitoring aspects in the licence are, at a minimum, arbitrary (as to rationale for number and location) and incomplete (as to pollutants monitored).

<u>Major Issue – Monitoring for Plant Wastewater Constituents, Ambient Water Quality, and Groundwater</u>

Points 1, 2, 3, 10, 17, and 20 as discussed in P1.3 are the various process discharge monitoring points for waste waters from the plant operations. The constituents to be monitored at these locations is shown in L3.6, which only discusses Points 1 (Copper, Iron, Selenium, and Temperature) and 2 (just pH and TSS[22]). Per section P1.3, points 4, 5, 6, 7, and 8 are the ambient water quality monitoring locations. Also, per P1.3, points 21, 22, 23, and 24 are groundwater monitoring locations.

First, notwithstanding all of the locations shown in section P1.3, section M2.4 only shows monitoring requirements for locations 1, 2, 8, 10, 17, and 21-24. What about monitoring requirements for the rest of the locations identified in P1.3 – namely, 3, 4, 5, 6, 7, and 20? The EPA should clarify.

Second, how were the 100 percentile concentration limits for the constituents listed in L3.6 determined for points 1 and 2?

Third, given the large number of wastes that can be disposed of in the ash repositories (see L5.2), how can the relatively few constituents listed in L3.6 or even in M2.4 be justified?

Fourth, for the groundwater monitoring locations, how were the constituents listed in M2.4 derived? And, why are there no limits for any of these constituents in L3.6.

In summary, there are many disconnects in the licence dealing with wastewater and groundwater monitoring aspects. I recommend that the EPA undertake a logical and systematic approach to

[22] I note, however, the M2.4 contains a requirement to monitor selenium at Point 2 as well.

wastewater discharges to both surface waters and groundwater, whether from legacy activities (i.e., disposal of ash for the last 35+ years) or ongoing or future activities. The licence should be amended to contain the following:

1. A water balance diagram for the plant showing all of the water inflows, uses, and wastewaters that are created;
2. A process flow diagram for wastewaters showing the average and maximum flow rates of each wastewater stream, its source activity, whether that activity is intermittent or continuous, and the disposition of each wastewater stream;
3. The composition of each wastewater stream, based on actual sampling;
4. The disposition of each wastewater stream (whether continuous or emergency and intermittent), including, importantly the locations of final discharge to receiving waters (presumed to be points 1 and 2 but not entirely clear);
5. Locations of groundwater and groundwater flow directions in the area as well as plume maps for all impacted groundwater constituents, presumably based on groundwater sampling data;
6. Locations of any drinking water wells in the area;
7. Background ambient water location, unlikely to have been impacted by Eraring's current and prior locations (including from any sediment deposition/surface water interactions);
8. Any and all applicable water quality protection standards in the receiving waters such as for human contact, fishing, etc.

Only after the above have been established, can a proper assessment of the plant discharge locations, ambient monitoring locations, and groundwater sampling locations be made from a technical standpoint. Of course, only then can the proper universe of constituents that need to be sampled at leach location as well as the frequency of sampling be established.

As it stands, the requirements for wastewater discharge monitoring, groundwater monitoring, and ambient water quality monitoring appear to be ad-hoc and incomplete. I recommend that the EPA provide a complete picture along the lines suggested above.

<u>Additional Clarifications Requested</u>

1. In M6.1, all meteorological monitoring is shown as hourly average. However, there is no justification for not collecting more frequent data for wind speed and direction. The EPA should clarify why the shown hourly frequency is appropriate.
2. As noted above, terms such as solid particles, undifferentiated particulates, etc. are not defined. The glossary should be expanded to include all such terms.
3. M9.2 clarifies that "Special Method 1 means "In Line Instrumentation"". Why then are these noted separately in the tables just above for Points 17 and 20?
4. E4.1(3) has a specific date of 26 October 2018. What is the significance of that date? Has the discharge in question continued after that date?

APPENDIX: CURRICULUM VITAE

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 30 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 25 years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

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

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

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

EXPERIENCE RECORD

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

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

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

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

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

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

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

EDUCATION

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

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

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

TEACHING EXPERIENCE

Caltech

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

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

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

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

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

U.C. Riverside, Extension

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

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

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

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

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

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

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

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

Loyola Marymount University

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

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

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

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

University of Southern California

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

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

University of California, Los Angeles

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

International Programs

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

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

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

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

PROFESSIONAL AFFILIATIONS AND HONORS

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

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

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

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

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

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

QEP, Institute of Professional Environmental Practice, since 2000.

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

Comments on the Licence Review for Mount Piper Power Station

Dr. Ranajit (Ron) Sahu, Ph.D., QEP, CEM
Engineer & Air Quality Consultant
Alhambra, CA
sahuron@earthlink.net
(+1) 702 683 5466

5 November 2018

These comments are provided in response to the NSW EPA's review of Licence 13007 to the operator of the Mount Piper Power Station (hereafter Mt. Piper). Mt. Piper, consisting of 2 coal-fired units with a combined capacity of 1320 MW is a large power station. It is around 25 years old.

I have over 30 years of experience in environmental, mechanical, and chemical engineering, including extensive experience with design and specification of pollution control equipment at thermal coal plants. An abbreviated CV is provided in the Appendix. A complete version is available upon request.

My comments are organized as several major issues, followed at the end by some requested clarifications. I should add that I have reviewed the licence renewals for two other NSW power stations – namely Eraring and Vales Point – and I am also providing comments on those two reviews. However, while there are many and significant shortcomings in the licences for those two power stations, the licence for Mt. Piper is, without question, the worst of the lot.

In fact, it hardly contains any prohibitions at all. A licence like that for Mt. Piper would not pass muster in any regulatory jurisdiction, including most non-developed world countries. I say that having directly worked in countries like India, Bangladesh, South Africa, and Kenya and having familiarity with permits and licences in China, most western European countries, several southeast Asian countries and a few of the old eastern European countries.

That the Mt. Piper licence has been allowed to persist for 25 years does no credit to the NSW EPA.

I am encouraged that the EPA is undertaking a review of the licences for 3 of the coal-fired power stations in NSW and that it intends to remedy some of the more glaring errors. Appropriate actions per the review cannot come soon enough for Mt. Piper.

<u>Major Issue – Lack of Proper Suite of Pollution Controls</u>

Other than a fabric filter for control of coal fly ash particulate matter from the boilers, neither of the units at Mt. Piper are equipped with any other air pollution control equipment. Given its relatively recent vintage, with operations beginning in 1993, when most coal-fired power plants in developed countries at least had advanced pollution controls for SO_2, and many for NO_x as well, this lack of proper air pollution controls beyond fabric filters is both inexplicable and unfortunate.

Modern (and even many older) power plants of this size, not only in the developed countries in the US, Canada, and many European countries, but also in developing countries such as India and China, etc. use significant additional air pollution controls to reduce emissions of a range of pollutants from their coal-fired boilers.

These pollution controls include:

1. Wet or dry flue gas desulfurization (FGD or scrubbers) to control and reduce emissions of sulfur dioxide (SO_2) by as much as 98-99% of what comes out of the boilers;
2. Selective catalytic reduction (SCR) to control and reduce emissions of nitrogen oxides (NO_x, consisting of NO and NO_2) by as much as 90-95% of what comes out of the boilers;
3. Additives such as activated carbon to reduce emissions of harmful toxic compounds such as mercury and dioxins; and
4. Additional additives to reduce emissions of acid gases such as hydrochloric acid, hydrofluoric acid, and the like.

As the World Bank draft guidelines of 2017 reinforce:

> More minor changes to improve environmental performance [of existing thermal power plants] would include fitting of low-NO_x burners; and injection of urea or ammonia (for either SNCR [Selective Non-Catalytic Reduction] or SCR) for NO_x

control; addition of post-combustion alkaline reagent injection (dry; semi-dry; or wet FGD) for SO_2 and HCl control; injection of activated carbon to capture heavy metals and dioxins/furans; and improvement of particulate control measures by adding cyclones and fabric filters….[1]

Thus, as noted above, from an air emissions control standpoint, each of the two units at Mt. Piper, equipped with just a fabric filter for control of particulate emissions,[2] is woefully lacking when compared to its peer group of coal-fired units around the world.

Again, that this would be the case in Australia, a developed country, is, frankly, shocking.

Major Issue – Outdated or Irrelevant Concentration Limits for Air Pollutants

Not only are the two units at Mt. Piper not subject to proper mass-based emission limits (which would require than to install, run, and maintain a proper suite of air pollution controls like the ones listed above – for the entire range of unit operations), typically expressed as gram/MJ of heat input or similar; the concentration-based limits that are present in section L3.2 of the licence are, in general, so high as to be irrelevant. I note that this has been recognized by the EPA itself in its recent analysis of the licences of coal-fired power plants in NSW.[3]

As an example, there are simply no concentration-based limits for SO_2 in the licence from the boilers, a major pollutant – and, unlike even other power stations such as Vales Point (a same sized and somewhat older station) and Eraring – there are no requirements in the licence to: (i) limit the sulfur content of the coal; or (ii) to report as "excess emissions" when a certain SO_2 threshold

[1] World Bank/IFC, Environmental, Health, and Safety Guidelines for Thermal Power Plants, Table 6 (May 31, 2017), (hereafter WB/IFC Guidelines), available at https://www.ifc.org/wps/wcm/connect/9a362534-bd1b-4f3a-9b42-a870e9b208a8/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES, p. 61.

[2] I note that the concentration limit for particulate matter, even with the fabric filter present, is not particularly stringent – meaning that the effectiveness of the fabric filters at the units could be better.

[3] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. Item 6 in Section 4.1 under Recommendations notes that the EPA should "…investigate the potential for reducing EPL emission limits where there is a demonstrated history of compliance by an appreciable margin."

concentration is exceeded. The last is likely because there is currently[4] no requirement to continuously monitor SO_2 concentrations at the boiler stacks. It is imperative that a SO_2 limit be established for the boiler emission points (Points 2 and 3) right away, reflecting current operations; followed by a longer-term, lower limit reflecting the application of control technology such as scrubbers as discussed below.

The licence review should require maximum reduction of SO_2 with the addition of wet Flue Gas Desulfurization (FGD) using limestone ($CaCO_3$) or similar reagents for 99% removal efficiency,[5] and the wet FGD system should be operated for maximum efficiency and required to be in use whenever coal is burned.

While wet FGD systems are relatively expensive, Mt. Piper is expected to run for many years into the future, so I would expect that capital investments will be recoverable.

Lower levels of SO_2 reduction are possible, with corresponding lower capital costs, using dry scrubbers with efficiencies up to 94%[6] – available in a variety of configurations. At a minimum, SO_2 reduction approaches such as coal cleaning (typically at the mine, where sulfur containing impurities are removed from the coal before it is processed for combustion) as well as Dry Sorbent Injection (DSI),[7] could provide SO_2 reduction of up to 90% (but often much lower)[8] at lower capital costs.

[4] I am aware that condition E2.1 in the licence requires that continuous monitoring system must be operational at the power station by end of February 2019 – but this condition does not specify what pollutants this continuous monitoring system will actually monitor – or if SO2 will be a pollutant that it will monitor.

[5] A. L. Morrison *et al.*, Analysis of Pollution Control Costs in Coal Based Electricity Generation – Technology Assessment Report, Cooperative Research Centre for Coal in Sustainable Development (January 2008) (hereinafter "Morrison 2008"), at 25-26, https://www.researchgate.net/publication/237460048_ANALYSIS_OF_POLLUTION_CONTROL_COSTS_IN_COAL_BASED_ELECTRICITY_GENERATION_TECHNOLOGY_ASSESSMENT_REPORT_68 (noting that a high velocity limestone with forced oxidation wet FGD system is capable of removing 99.6% of SO_2 under test conditions).

[6] WB/IFC Guidelines, at p. 7.

[7] *See*, *e.g.*, Dr. R. Sahu, Technical Report on Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF) (April 2013), at 2-5, http://www.cleanenergy.org/wp-content/uploads/Final_Sahu_DSI_Report.pdf.

As another example of the very loose concentration limits, consider NO_x, whose current licence limit is 1.5 grams/cubic meter or 1500 mg/cubic meter, corrected to 7% oxygen at each of the boiler stacks. This is far greater than any developed country standard. In fact, the WHO guideline is 500 mg/cubic meters (albeit at a 6% oxygen basis) for non-degraded air-sheds and 200 mg/cubic meters for a degraded air-shed.[9] Limits in the EU are 200 – 450 mg/cubic meters.[10]

Actual emissions of NO_x as reported by the EPA itself in its recent review of coal plants in NSW show that the average and maximum NO_x concentrations at Mt. Piper are, respectively, 767 and 1200 mg/cubic meters – significantly below the 1500 mg/cubic meter limit,[11] Although the high 1200 mg/cubic meter raises significant concerns as to how the boilers are being operated. I note that these actual data are from quarterly stack tests since there is no requirement currently to continuously monitor NO_x emissions at this power plant. While, condition E2.1 requires that a continuous monitoring system be in place by end of February, 2019, it is not clear if this system will measure NO_x. I recommend that, in the short-term, EPA reduce the current NO_x limit to around 800 mg/cubic meters, which will provide an incentive for the operators at Mt. Piper to maintain their NO_x emissions from the boilers at the levels that they are already capable of achieving.[12] And, in the longer-term (i.e., within 5 years or so), that the Mt. Piper units achieve NO_x levels of 200 mg/cubic meters, which they should be able to do with a suite of NO_x controls including low NO_x burners/over-fire air and post-combustion controls of either Selective Non-Catalytic Reduction (SNCR) or, ideally, SCR.

[8] *Id., at 5.*

[9] WB/IFC Guidelines, Table 6.

[10] Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED. European Commission, https://ec.europa.eu/energy/en/topics/oil-gas-and-coal/coal-and-other-solid-fuels.

[11] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

[12] In fact, this is not only entirely consistent but imperative with the requirement in the licence condition O1 that licenced activities must be carried out in a "competent" manner and also with the requirements in the licence condition O2 that all plant and equipment "must be maintained in a proper and efficient condition" and "must be operated in a proper and efficient manner."

Next, consider the concentration limit for solid particles, presumably of any size, at 50 mg/cubic meter. I note that the WHO guideline ranges from 20-40 mg/cubic meters,[13] indicating that the current limit is not stringent enough, even with the fabric filter present.

However, actual data shows that the units do not achieve significantly lower levels – average of 11 mg/cubic meters and maximum of 39 mg/cubic meters.[14] This means that even the one pollution control at this relatively young power station, i.e., the fabric filter system, is not as well run as it should be. Compare these levels against the 2 mg/cubic meter average value obtained at Vales Point. It is clear that the operators of Mt. Piper do not operate the station consistent with licence terms O1 and O2. The limit for solid particles should be lowered to 20 mg/cubic meters.

Finally, consider the concentration limit for mercury, which is 0.2 mg/cubic meters or 200 ug/cubic meters. Using typical mercury levels in Australian black coals (average of 0.045 ppm)[15] and typical heating values of black coals of around 25 MJ/kg, one would expect mercury concentrations of less than 10 ug/cubic meter in the stack. So, having a limit of 200 ug/m3 makes no sense. This is reinforced by the actual data reported to the EPA. For Mt. Piper the average mercury concentration was 0.001 mg/cubic meters (or 1 ug/cubic meter) and the maximum was 0.0019 (or 1.9 ug/cubic meter).[16] This limit, for it to have any meaning at all, should be lowered to 5 ug/cubic meter.

Thus, as part of its stated goal of revisiting the current limits in the various NSW coal plants, I urge the EPA to revisit and lower the concentration limits I have discussed above (and others) currently in the licence in L3.1 for the Mt. Piper boiler stacks. Where the EPA decides to leave the current, high limits in place, it has the obligation to provide a technical basis supporting each of the limits in L3.1.

---

[13] *Id.*

[14] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

[15] https://hub.globalccsinstitute.com/publications/impact-flue-gas-impurities-amine-based-pcc-plants/21-trace-element-contents-australian-thermal-coals

[16] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

Major Issue – Lack of Proper Monitoring at Boiler Stacks

Compounding the leniency of the concentration limits discussed above is the fact, as I have noted above, that the licence conditions are extremely weak with regards to monitoring emissions from the boiler stacks to demonstrate compliance with even the weak limits in L3.1 EPA itself explicitly recognizes this as a problem in its recent review of coal plants in NSW.[17]

M2.2 contains the list of monitoring requirements for the main boiler stacks (Points 2 and 3). As the table shows, there is no current requirement for continuous monitoring for any pollutant. Quarterly monitoring is required for the concentrations of NO_x, and SO_2. and "yearly" or once per year monitoring for all other parameters such as gas density, stack gas moisture, stack temperature, and even stack gas flow as well as undifferentiated particulates.[18]. I have noted earlier that condition E2.1 requires the installation and operation of a continuous monitoring system by end of February, 2019. I hope that this system includes not just continuous monitoring of NO_x and SO_2, but also that for particulates and additional contaminants as noted below.

Most modern power plants, especially with a focus on greenhouse gas reductions and efficiency, monitor parameters such as stack gas flow and temperature (which, collectively provide an indication of the heat losses through the stack) continuously. In addition, continuous monitors for filterable PM (of any size fraction), acid gases such as hydrochloric acid, and toxics such as mercury, are widely available and in use in power plants worldwide. For example, over 250 coal-fired units in the US use mercury continuous emissions monitors and dozens use continuous PM monitors as well.

[17] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. See section 3.1 where EPA recognizes that "…there are opportunities for improvement in the application of periodic and continuous emission measurement at all power stations."

[18] I note that "undifferentiated particulates" is not defined in the glossary. I assume it means total suspended particulates, undifferentiated as to size. I do see that the same table in M2 also contains a requirement for yearly monitoring for "solid particles" which is also not defined in the glossary. The EPA should make sure that terms such as these are properly defined in the glossary.

I recommend that the EPA significantly expand the monitoring requirements during the licence review and require more comprehensive continuous monitoring by the end of February 2019 per condition E2.1.

Of course, just having the continuous data available to the plant or operator is not sufficient. All of the continuous monitoring data, including from the existing NO_x, SO_2, and undifferentiated particulates should be made available electronically and publicly such as via the public NSW Office of Environment and Heritage website.

Having continuous monitoring at each of the boiler stacks is important not just for transparency, but gives the public and the regulator confidence that there is not any cheating or gaming the system as it stands currently.[19]

Major Issue – Locations of Ambient Air Monitors

There are no ambient air monitors or even dust fall monitors in the licence. This is an area of significant omission. Not only should there be multiple ambient monitors, they should be monitoring NOx, SO2, various sizes of PM including in particular PM2.5, the pollutant most widely-recognized as extremely harmful to human health.

Given this glaring omission in the licence, I recommend that the EPA establish a proper ambient monitoring program for the power station – i.e., based on meteorological considerations, with at least one upwind or background ambient monitor and dust fall monitor; and as many necessary ambient and dust fall monitors that are needed based on fully covering the potential impact area of the Mt. Piper power station. It is likely that a dispersion model, such as AERMOD, would be necessary to be run to define the areas of maximum impact, which could be the possible locations of the ambient monitors.

[19] See, for example, https://www.theherald.com.au/story/4660250/power-stations-under-reporting-toxic-pollution/

As it stands, ambient air monitoring aspects in the licence are, at a minimum, arbitrary (as to rationale for number and location) and incomplete (as to pollutants monitored).

Major Issue – Monitoring for Plant Wastewater Constituents, Ambient Water Quality, and Groundwater

Just as in the case of air monitoring, the monitoring of the water discharges from the power station to receiving waters as well as potential for impacts to groundwater are so lacking as to be embarrassing. In fact, the licence requires just one wastewater discharge location (Point 1) to be monitored, and that too for just conductivity, pH and TSS, per condition M2.4. That's it. There are simply no requirements for any ambient water monitoring or groundwater monitoring. And, given the wide range of wastes that can be managed onsite (see condition L4.3) which can affect the discharge quality of wastewater at Point 1, it makes no sense that that location should only monitor just the three parameters. Even discharge temperature to the receiving waters is not required to be monitored.

Simply put, monitoring of the wastewater impacts from the station to receiving surface waters and groundwater is missing from the licence.

I recommend that the EPA undertake a logical and systematic approach to wastewater discharges to both surface waters and groundwater, whether from legacy activities (i.e., disposal of ash for the last 25 years) or ongoing or future activities. The licence should be amended to include the following:

(i) a water balance diagram for the plant showing all of the water inflows, uses, and wastewaters that are created;

(ii) a process flow diagram for wastewaters showing the average and maximum flow rates of each wastewater stream, its source activity, whether that activity is intermittent or continuous, and the disposition of each wastewater stream;

(iii) the composition of each wastewater stream, based on actual sampling;

(iv) the disposition of each wastewater stream (whether continuous or emergency and intermittent), including, importantly the locations of final discharge to receiving;

(v) locations of groundwater and groundwater flow directions in the area as well as plume maps for all impacted groundwater constituents, presumably based on groundwater sampling data;

(vi) locations of any drinking water wells in the area;

(vii) background ambient water location, unlikely to have been impacted by Mt. Piper's current and prior locations (including from any sediment deposition/surface water interactions);

(viii) any and all applicable water quality protection standards in the receiving waters such as for human contact, fishing, etc.

Only after the above have been established, can a proper assessment of the plant discharge locations, ambient monitoring locations, and groundwater sampling locations be made from a technical standpoint. Of course, only then can the proper universe of constituents that need to be sampled at leach location as well as the frequency of sampling be established.

As it stands, the requirements for wastewater discharge monitoring, groundwater monitoring, and ambient water quality monitoring appear to have been inadvertently missed for the last 25 years. I recommend that the EPA rectify its lack of oversight in this regard.

Additional Clarifications Requested

1. In M5.1, most meteorological monitoring is shown as 15-minute average. However, there is no justification for not collecting more frequent data for wind speed and direction, such as on a 1-minute average. The EPA should clarify why the shown 15-minute frequency is appropriate.

2. As noted earlier, terms such as solid particles, undifferentiated particulates, etc. are not defined. The glossary should be expanded to include all such terms.

APPENDIX: CURRICULUM VITAE

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 30 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 25 years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

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

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

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

EXPERIENCE RECORD

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

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

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

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

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

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

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

EDUCATION

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

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

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

TEACHING EXPERIENCE

Caltech

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

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

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

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

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

U.C. Riverside, Extension

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

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

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

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

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

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

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

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

Loyola Marymount University

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

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

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

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

University of Southern California

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

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

University of California, Los Angeles

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

International Programs

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

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

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

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

PROFESSIONAL AFFILIATIONS AND HONORS

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

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

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

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

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

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

QEP, Institute of Professional Environmental Practice, since 2000.

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

Comments on the Licence Review for Vales Point Power Station

Dr. Ranajit (Ron) Sahu, Ph.D., QEP, CEM
Engineer & Air Quality Consultant
Alhambra, CA
sahuron@earthlink.net
(+1) 702 683 5466

5 November 2018

These comments are provided in response to the NSW EPA's review of Licence 761 to the operator of the Vales Point Power Station (hereafter Vales Point). Vales Point, with its 2 units with a combined capacity of 1320 MW is a large power station. It is around 40 years old.

I have over 30 years of experience in environmental, mechanical, and chemical engineering, including extensive experience with design and specification of pollution control equipment at thermal coal plants. An abbreviated CV is provided in the Appendix. A complete version is available upon request.

My comments are organized as several major issues, followed at the end by some requested clarifications.

Major Issue – Lack of Proper Suite of Pollution Controls

Other than a fabric filter for control of coal fly ash particulate matter from the two boilers, neither of the units at Vales Point are equipped with any other air pollution control equipment.

Modern (and even many older) power plants of this size, not only in the developed countries in the US, Canada, and many European countries, but also in developing countries such as India and China, etc. use significant additional air pollution controls to reduce emissions of a range of pollutants from their coal-fired boilers.

These pollution controls include:

1. Wet or dry flue gas desulfurization (FGD or scrubbers) to control and reduce emissions of sulfur dioxide (SO_2) by as much as 98-99% of what comes out of the boilers – even for units that purport to burn coal with relatively low sulfur such as Vales Point;[1]
2. Selective catalytic reduction (SCR) to control and reduce emissions of nitrogen oxides (NO_x, consisting of NO and NO_2) by as much as 90-95% of what comes out of the boilers;
3. Additives such as activated carbon to reduce emissions of harmful toxic compounds such as mercury and dioxins; and
4. Additional additives to reduce emissions of acid gases such as hydrochloric acid, hydrofluoric acid, and the like.

As the World Bank draft guidelines of 2017 reinforce:

> More minor changes to improve environmental performance [of existing thermal power plants] would include fitting of low-NOx burners; and injection of urea or ammonia (for either SNCR [Selective Non-Catalytic Reduction] or SCR) for NO_x control; addition of post-combustion alkaline reagent injection (dry; semi-dry; or wet FGD) for SO_2 and HCl control; injection of activated carbon to capture heavy metals and dioxins/furans; and improvement of particulate control measures by adding cyclones and fabric filters….[2]

Thus, from an air emissions control standpoint, each of the units at Vales Point, equipped with just a fabric filter for control of particulate emissions,[3] is woefully lacking when compared to its peer group of coal-fired units around the world.

[1] I note that while the sulfur content of coal burned at the Vales Point units is limited to 0.5% by weight, (see O8.1) this is on a monthly basis. Of course, that means that on any given day or hour, the actual sulfur content (and resulting SO_2 emissions) could be much higher.

[2] World Bank/IFC, Environmental, Health, and Safety Guidelines for Thermal Power Plants, Table 6 (May 31, 2017), (hereafter WB/IFC Guidelines), available at https://www.ifc.org/wps/wcm/connect/9a362534-bd1b-4f3a-9b42-a870e9b208a8/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES, p. 61.

[3] I note that the concentration limit for particulate matter, even with the fabric filter present, is not particularly stringent – meaning that the effectiveness of the fabric filters at the units could be better.

That this would be the case in Australia, a developed country, is, frankly, shocking.

Major Issue – Outdated or Irrelevant Concentration Limits for Air Pollutants

Not only are the two units at Vales Point not subject to proper mass-based emission limits (which would require than to install, run, and maintain a proper suite of air pollution controls like the ones listed above – for the entire range of unit operations), typically expressed as gram/MJ of heat input or similar; the concentration-based limits that are present in section L3 of the licence are, in general, too high as to be irrelevant. I note that this has been recognized by the EPA itself in its recent analysis of the licences of coal-fired power plants in NSW.[4]

As an example, there are simply no concentration-based limits for SO_2 in the licence, a major pollutant – although the licence does require continuous monitoring of this pollutant and a reporting of excess emissions greater than 600 ppm (or roughly 1,716 mg/ cubic meter[5]) see section R5.1). While it appears that the lack of SO_2 concentration limit might be because of the condition requiring coal sulfur content to be less than 0.5%, that prohibition is on a monthly basis and is no substitute for an absolute concentration limit applicable at all times.

The licence review should require maximum reduction of SO_2 with the addition of wet Flue Gas Desulfurization (FGD) using limestone ($CaCO_3$) or similar reagents for 99% removal efficiency,[6] and the wet FGD system should be operated for maximum efficiency and required to be in use whenever coal is burned.

---

[4] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. Item 6 in Section 4.1 under Recommendations notes that the EPA should "…investigate the potential for reducing EPL emission limits where there is a demonstrated history of compliance by an appreciable margin."

[5] I use a conversion factor of 2.86 mg/cubic meter per ppm for SO_2 consistent with the EPA's assumption in this regard. See Ibid., Table 4. However, I note that the limit value in Table 4 (1,760 mg/cubic meter) appears to be slightly in error.

[6] A. L. Morrison *et al.*, Analysis of Pollution Control Costs in Coal Based Electricity Generation – Technology Assessment Report, Cooperative Research Centre for Coal in Sustainable Development (January 2008) (hereinafter "Morrison 2008"), at 25-26, https://www.researchgate.net/publication/237460048_ANALYSIS_OF_POLLUTION_CONTROL_COSTS_IN_COAL_BASED_ELECTRICITY_GENERATION_TECHNOLOGY_ASSESSMENT_REPORT_68 (noting that a high velocity limestone with forced oxidation wet FGD system is capable of removing 99.6% of SO_2 under test conditions).

While wet FGD systems are relatively expensive, Vales Point is expected to run for many years into the future, so I would expect that capital investments will be recoverable.

Lower levels of SO_2 reduction are possible, with corresponding lower capital costs, using dry scrubbers with efficiencies up to 94%[7] – available in a variety of configurations. At a minimum, SO_2 reduction approaches such as coal cleaning (typically at the mine, where sulfur containing impurities are removed from the coal before it is processed for combustion) as well as Dry Sorbent Injection (DSI),[8] could provide SO_2 reduction of up to 90% (but often much lower)[9] at lower capital costs.

As another example of the very loose concentration limits, consider NO_x, whose current licence limit is 1500 mg/cubic meter, corrected to 7% oxygen at each of the boiler stacks. This is far greater than any developed country standard. In fact, the WHO guideline is 500 mg/cubic meters (albeit at a 6% oxygen basis) for non-degraded air-sheds and 200 mg/cubic meters for a degraded air-shed.[10] Limits in the EU are 200 – 450 mg/cubic meters[11] And limits in the UK are in the range of 90-200 mg/cubic meters.[12]

Actual emissions of NO_x as reported by the EPA itself in its recent review of coal plants in NSW show that the average and maximum NO_x concentrations at Vales Point are, respectively, 881 and 1099 mg/cubic meters – significantly below the 1500 mg/cubic meter limit.[13]

---

[7] WB/IFC Guidelines, at p. 7.

[8] *See, e.g.,* Dr. R. Sahu, Technical Report on Dry Sorbent Injection (DSI) and Its Applicability to TVA's Shawnee Fossil Plant (SHF) (April 2013), at 2-5, http://www.cleanenergy.org/wp-content/uploads/Final_Sahu_DSI_Report.pdf.

[9] *Id., at 5.*

[10] WB/IFC Guidelines, Table 6.

[11] Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (the Industrial Emissions Directive or IED. European Commission, https://ec.europa.eu/energy/en/topics/oil-gas-and-coal/coal-and-other-solid-fuels.

[12] See Jacobs Report (discussed later), Table 6-3.

[13] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

I recommend that, in the short-term, EPA reduce the current NO_x limit to around 1150 mg/cubic meters, which will provide an incentive for the operators at Vales Point to maintain their NO_x emissions from the boilers at the levels that they are already capable of achieving.[14] And, in the longer-term (i.e., within 5 years or so), that the Vales Point units achieve NO_x levels of less than 200 mg/cubic meters, which they should be able to do with a suite of NO_x controls including low NO_x burners/over-fire air and post-combustion controls of either Selective Non-Catalytic Reduction (SNCR) or, ideally, SCR.

I am aware that the operators of Vales Point power station commissioned, pursuant to condition U1 in the current licence, a Pollution Reduction Study (PRS) and that the consultant who completed the work (Jacobs) has submitted a report[15] to the EPA in mid-2017, or more than a year ago. While EPA's response to the report is as-yet unknown, this review of the licence for Vales Point is an appropriate occasion to review the results of the PRS.

Simply put, the Jacobs PRS report for Vales Point is disappointing. Not surprisingly, the Jacobs report did not identify any technical feasibility issues with the installation of in-boiler combustion controls such as combustion optimization (anticipated 10% reduction in NOx), low NOx burners and over-fire air[16] (50% reduction in NOx) and post-combustion controls such as SCR (85% - 90% reduction in NOx). While I disagree that SCR would only reduce NOx by less than 90%, there is no question that, collectively, just the inclusion of low-NOx burners and over-fire air, coupled with SCR, would reduce NOx emissions from Units 5 and 6 by well over 90% from current levels. Per the Jacobs report, Unit 5 NOx averaged 613 mg/cubic meters and Unit 6 NOx averaged 889 mg/cubic meters,[17] the latter substantially higher than Unit 5 due to the addition of bluff-body

[14] In fact, this is not only entirely consistent but imperative with the requirement in the licence condition O1 that licenced activities must be carried out in a "competent" manner and also with the requirements in the licence condition O2 that all plant and equipment "must be maintained in a proper and efficient condition" and "must be operated in a proper and efficient manner."

[15] Jacobs Group Australia, Vales Point Power Station NOx Pollution Reduction Study (PRS), 29 June 2017.

[16] Confusingly, the Jacobs Report at Table 8.1 separately discusses low NOx burners and OFA, concluding that the latter, by itself, cannot meet the 800 mg/cubic meters limits set forth in the licence. Since Unit 5 had a baseline of 613 mg/cubic meters, that is a moot point for Unit 5. For Unit 6, with a baseline of 889 mg/cubic meters, it is entirely possible that OFA could, in fact, meet the 800 mg/cubic meters limit. Regardless, low-NOx burners and OFA, implemented together, can easily meet the 800 mg/cubic meter limit, although that should not be the final NOx goal for these units.

[17] Jacobs Report, Section 5.1.

burners in an attempt to reduce carbon in the fly ash. Even so, 90% reduction in NOx levels from these baseline levels would mean well below 100 mg/cubic meters NOx concentrations at either unit.

While pointedly not discussing the many significant health and environmental benefits that would accrue from such tremendous NOx reductions at Vales Point, the Jacobs report rejects these NOx control measures (i.e., low-NOx burners/OFA and SCR) via a strange argument that compares costs for these controls with the payments via the load-based licencing (LBL) fees being paid by Vales Point.

Of course, NOx reductions result in real health and environmental benefits – which is why controls such as SCR are installed in coal-units worldwide. Instead of quantifying such benefits (the costs for which routinely exceed costs for controls) and comparing them to the costs of controls, the Jacobs report compares them to the LBL fees – ultimately a self-serving but otherwise pointless and invalid comparison.

I reiterate that the 1500 mg/cubic meters NOx limit for the Point Vales units should be lowered from their current 1500 mg/cubic meters level. More importantly, these units should be equipped with modern NOx controls including SCR for meaningful NOx reductions. The only meaningful conclusion of the Jacobs report is that there is no technical bar to the installation of NOx controls at the Vales Point units.

Next, consider the concentration limit for solid particles, presumably of any size, at 50 mg/cubic meter. I note that the WHO guideline ranges from 20-40 mg/cubic meters,[18] indicating that the current limit is not stringent enough, even with the fabric filter present. And, actual data shows that the Vales Points units achieve significantly lower levels – average of 2 mg/cubic meters and maximum of 7 mg/cubic meters.[19] Like in the discussion of NOx above, maintaining the limit at

---

[18] *Id.*

[19] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

50 mg/cubic meters is not consistent with licence terms O1 and O2. It should be lowered to 10 mg/cubic meters given the performance of these units.

Finally, consider the concentration limit for mercury, which is 1 mg/cubic meters or 1000 μg/cubic meters. Using typical mercury levels in Australian black coals (average of 0.045 ppm)[20] and typical heating values of black coals of around 25 MJ/kg, one would expect mercury concentrations of less than 10 μg/cubic meter in the stack – or 1/100th of the limit. So, having a limit of 1000 ug/m3 makes no sense. This is reinforced by the actual data reported to the EPA. For Vales Point the average mercury concentration was 0.0012 mg/cubic meters (or 1.2 μg/cubic meter) and the maximum was 0.0078 (or 7.8 μg/cubic meter).[21] Thus, the mercury limit, for it to have any meaning at all, should be lowered to no more than 10 μg/cubic meter under current conditions. Over time the limit should be lowered to 1.5 μg/cubic meter, requiring the operator to actually control mercury emissions to some degree.

Thus, as part of its stated goal of revisiting the current limits in the various NSW coal plants, I urge the EPA to revisit and lower the concentration limits I have discussed above (and others) currently in the licence in L3 for the Vales Point boiler stacks. Where the EPA decides to leave the current, high limits in place, it has the obligation to provide a technical basis supporting each of the limits in L3.

Major Issue – Lack of Proper Monitoring at Boiler Stacks

Compounding the leniency of the concentration limits discussed above is the fact that the licence conditions are weak with regards to monitoring emissions from the boiler stacks to demonstrate compliance with even the weak limits in L3. EPA itself explicitly recognizes this as a problem in its recent review of coal plants in NSW.[22]

[20] https://hub.globalccsinstitute.com/publications/impact-flue-gas-impurities-amine-based-pcc-plants/21-trace-element-contents-australian-thermal-coals

[21] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018, Table 7.

[22] NSW EPA, Review of Coal-Fired Power Stations Air Emissions and Monitoring, 2018. See section 3.1 where EPA recognizes that "…there are opportunities for improvement in the application of periodic and continuous emission measurement at all power stations."

M2 contains the list of monitoring requirements for the main boiler stacks (Points 11 and 12). As the table shows, other than the requirement for continuous monitoring for the concentrations of NO_x, SO_2, and undifferentiated particulates,[23] all of the other monitoring is only required "yearly" or once per year. That includes parameters of process importance such as stack gas moisture, stack temperature, and even stack gas flow.

Most modern power plants, especially with a focus on greenhouse gas reductions and efficiency, monitor parameters such as stack gas flow and temperature (which, collectively provide an indication of the heat losses through the stack) continuously. In addition, continuous monitors for filterable PM (of any size fraction), acid gases such as hydrochloric acid, and toxics such as mercury, are widely available and in use in power plants worldwide. For example, over 250 coal-fired units in the US use mercury continuous emissions monitors and dozens use continuous PM monitors as well.

I recommend that the EPA significantly expand the monitoring requirements during the licence review, consistent with its own recommendation in its recent review of the NSW coal plants.

Of course, just having the continuous data available to the plant or operator is not sufficient. All of the continuous monitoring data, including from the existing NO_x, SO_2, and undifferentiated particulates should be made available electronically and publicly such as via the public NSW Office of Environment and Heritage website.

Of course, having continuous monitoring at each of the boiler stacks is important not just for transparency, but gives the public and the regulator confidence that there is not any cheating or gaming the system as it stands currently.[24]

---

[23] I note that "undifferentiated particulates" is not defined in the glossary. I assume it means total suspended particulates, undifferentiated as to size. I do see that the same table in M2 also contains a requirement for yearly monitoring for "solid particles" which is also not defined in the glossary. The EPA should make sure that terms such as these are properly defined in the glossary.

[24] See, for example, https://www.theherald.com.au/story/4660250/power-stations-under-reporting-toxic-pollution/

Major Issue – Locations of Ambient Air Monitors

Setting aside the dust gauges (Monitoring locations 13-17), there is just one ambient air monitoring location (10).

Importantly, the licence document (or the record) does not provide clarity on why Location 10 is even appropriate as the only ambient monitoring location. While it may have been established in years past based on some rationale, that is not obvious now. I recommend that the EPA evaluate and justify the appropriateness of the ambient monitoring program as a whole – i.e., based on meteorological considerations, establish at least one upwind or background ambient monitor and dust fall monitor; and then establish as many necessary ambient and dust fall monitors that are needed based on fully covering the potential impact area of the Vales Point power station. It is likely that a dispersion model, such as AERMOD, would be necessary to be run to define the areas of maximum impact, which could be the possible locations of the ambient monitors.

As it stands, ambient air monitoring aspects in the licence are, at a minimum, arbitrary (as to rationale for the only monitor and its location).

Major Issue – Monitoring for Plant Wastewater Constituents, Ambient Water Quality, and Groundwater

Points 1, 2, 3, 4, and 18 as discussed in P1.4 are the various process discharge monitoring points for waste waters from the plant operations. The constituents to be monitored at these locations is shown in L3.7, which only discusses Points 1, 2, 4, and 18. There appear to be no requirements for Point 3. Per section P1.4, points 6, 7, and 8 are the ambient water quality monitoring locations. Also, per P1.4, points 19-23 are groundwater monitoring locations.

First, how were the 100 percentile concentration limits for the constituents listed in L3.7 determined for points 1, 2, 4, and 18? Similarly, how were the 97^{th} ad 100 percentile limits for temperature at Point 1 determined for temperature?

Second, given the large number of wastes that can be disposed of in the ash pond (see L5.2), how can the relatively few constituents listed in L3.7 or even in M2.2 be justified?

Third, for the same reason as above (i.e., large number of potential discharges to receiving waters from the coal plant via Points 1, 2, 4, and 18, how can the parameters for ambient water monitoring listed in M2.6 (i.e., dissolved oxygen, temperature, salinity, clarity, and zooplankton) be justified. What about all of the actual contaminants discharged by the plant including, in particular, heavy metals?

Fourth, why is Point 18, the over-boarding of the ash dam even allowed?

Fifth, for the groundwater monitoring locations 19-23, how were the constituents listed in M2.2 derived? And, why are there no limits for any of these constituents in L3.7. How exactly does just monitoring groundwater ensure protection of groundwater?

In summary, there are many disconnects in the licence dealing with wastewater and groundwater monitoring aspects. I recommend that the EPA undertake a logical and systematic approach to wastewater discharges to both surface waters and groundwater, whether from legacy activities (i.e., disposal of ash for the last 40+ years) or ongoing or future activities. The licence should be amended to contain the following:

1. A water balance diagram for the plant showing all of the water inflows, uses, and wastewaters that are created;
2. A process flow diagram for wastewaters showing the average and maximum flow rates of each wastewater stream, its source activity, whether that activity is intermittent or continuous, and the disposition of each wastewater stream;
3. The composition of each wastewater stream, based on actual sampling;
4. The disposition of each wastewater stream (whether continuous or emergency and intermittent), including, importantly the locations of final discharge to receiving waters (which should be, at most, Points 1, 2, 4 but not 18);
5. Locations of groundwater and groundwater flow directions in the area as well as plume maps for all impacted groundwater constituents, presumably based on groundwater sampling data;

6. Locations of any drinking water wells in the area;
7. Background ambient water location(s), unlikely to have been impacted by Vales Point's current and prior discharge locations (including from any sediment deposition/surface water interactions);
8. Any and all applicable water quality protection standards in the receiving waters such as for human contact, fishing, etc.

Only after the above have been established, can a proper assessment of the plant discharge locations, ambient monitoring locations, and groundwater sampling locations be made from a technical standpoint. Of course, only then can the proper universe of constituents that need to be sampled at leach location as well as the frequency of sampling be established.

As it stands, the requirements for wastewater discharge monitoring, groundwater monitoring, and ambient water quality monitoring appear to be ad-hoc and incomplete. I recommend that the EPA provide a complete picture along the lines suggested above.

Additional Clarifications Requested

1. In M5.1, many of the meteorological parameters being monitored are on a 15-minute average. However, there is no justification for not collecting more frequent data for at least wind speed and direction. The EPA should clarify why the shown 15-minute frequency is appropriate.
2. As noted above, terms such as solid particles, undifferentiated particulates, etc. are not defined. The glossary should be expanded to include all such terms.
3. E3.1(6) requires the completion of the cooling water discharge impact study by 30 November 2017. Has this been completed? What actions have been taken by the EPA as a result of this study?

APPENDIX: CURRICULUM VITAE

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 30 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 25 years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

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

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

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

EXPERIENCE RECORD

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

1995-2000	Parsons ES, **Associate, Senior Project Manager and Department Manager for** Air Quality/Geosciences/Hazardous Waste Groups, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.
	Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.
1992-1995	Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.
1990-1992	Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.
1989-1990	Kinetics Technology International, Corp. **Development Engineer.** Involved in thermal engineering R&D and project work related to low-NOx ceramic radiant burners, fired heater NOx reduction, SCR design, and fired heater retrofitting.
1988-1989	Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

1984-1988	Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.
1984	M. S., Mechanical Engineering, Caltech, Pasadena, CA.
1978-1983	B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

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

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

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

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

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

U.C. Riverside, Extension

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

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

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

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

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

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

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

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

Loyola Marymount University

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

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

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

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

University of Southern California

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

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

University of California, Los Angeles

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

International Programs

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

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

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

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

PROFESSIONAL AFFILIATIONS AND HONORS

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

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

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

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

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

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

QEP, Institute of Professional Environmental Practice, since 2000.

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