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PROPOSED DUAL GAS DEMONSTRATION PROJECT, MORWELL

AIR QUALITY ASSESSMENT

Prepared for Dual Gas Pty Ltd

22 September 2011

Environmental Science Associates
117 Station Street Carlton 3053

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The management of air quality requires a multi-dimensional approach to take account of the very wide range of contributory factors. Quite understandably, some commentators may find it difficult to understand the intricacies of Victoria's air quality management policies, which can result in misinterpretation of particular provisions of these policies.

Therefore, I have prefaced my assessment of the air quality implications of the proposed Dual Gas Demonstration Project (set out in Part II) by a concise commentary on air quality management in Victoria (in Part I). My comments on EPA's assessment of the works approval application are also provided in Part II, while my responses to the submissions and further particulars lodged by Doctors for the Environment Australia (DEA) are set out in Part III.

PART I. AIR QUALITY MANAGEMENT IN VICTORIA

In 1981, Victoria became the first State in Australia to develop a comprehensive air quality management policy[1] to replace the essentially "ad hoc" approach which had previously applied. The original State Environment Protection Policy (The Air Environment), referred to hereafter as SEPP (TAE) provided a unique "blueprint" for air quality management tailored to the Victorian situation. While SEPP (TAE) has subsequently been amended, and split into two separate policies (dealing with air quality management and ambient air quality, respectively), its underlying scientific and philosophical approach and most of its key elements have been retained.

Part I outlines the range of factors which influence air quality and sets out, in a logical sequence, the factors which EPA is required to consider when assessing a Works Approval Application (WAA) for a major new emission source in the Latrobe Valley (LV), such as the Dual Gas Demonstration Project (referred to hereafter as "the demonstration project").

1. FACTORS WHICH INFLUENCE AIR QUALITY

A wide range of factors combine to determine air quality at a particular time at any specific "receptor" location. These include the following:

- emissions from stationary sources, which typically vary widely with time (in terms of both characteristics and emission rates), depending on the nature and scale of operations and the performance of any emission control equipment;
- physical discharge conditions (eg discharge height, temperature, velocity and nearby structures for stacks) and the geometry of volume and area sources;
- "background" emissions derived from sources such as vehicles, residential, commercial and institutional buildings, waste treatment and disposal facilities, rural activities, wildfires and fuel reduction burns, and "natural" processes (including hydrocarbon emissions from vegetation, and elevated ozone concentrations associated with thunder storms);
- meteorological factors, including wind speed and direction, mixing height, temperature and atmospheric stability, all of which vary widely with time and affect the rate of atmospheric dispersion and transport of contaminants;
- a range of other atmospheric factors which affect air quality, including chemical and photochemical reactions and "washout" of contaminants by rain;
- local and regional topography, which can have a strong influence on meteorology and consequentially the dispersion and transport of contaminants, particularly in relation to katabatic winds, sea breezes, "trapping" of contaminants by inversions, and the potential for plumes from tall stacks to directly impact on elevated terrain.

In light of the above factors, it is understandable that policies designed to manage air quality will be, of necessity, multi-dimensional and relatively complex.

[1] Victorian Government Gazette (13 July 1981). "State Environment Protection Policy (the Air Environment)".

2. OPERATION OF VICTORIAN AIR QUALITY POLICIES

This section outlines how EPA's two current "air policies" are designed to operate when a WAA for a major proposal, such as the demonstration project, is being assessed by EPA. The two policies, which are designed to be read together, are as follows: (direct quotations from the policies are italicised)

The State Environment Protection Policy (Air Quality Management)[2], referred to hereafter as "SEPP (AQM)" was declared in December 2001. The aims of the Policy are to:

> *"(a) ensure that the environmental quality objectives of the State environment protection policy (Ambient Air Quality) are met;*
> *(b) drive continuous improvement in air quality and achieve the cleanest air possible having regard to the social and economic development of Victoria; and*
> *(c) support Victorian and national measures to address the enhanced greenhouse effect and depletion of the ozone layer."*

The State Environment Protection Policy (Ambient Air Quality)[3], referred to as "SEPP (AAQ)" was declared in February 1999. *"The purposes of the Policy are to adopt the requirements of the National Environment Protection Measure for Ambient Air Quality*[4] [the "NEPM"] *and to incorporate relevant components from the State environment protection policy (The Air Environment) (renamed as 'Air Quality Management')."*

2.1. Emission Limits

A proposed new emission source in the Latrobe Valley, which is designated by Schedule F of SEPP (AQM) as an Air Quality Control Region, is required to comply with the emission limits set out in Schedule E of SEPP (AQM). These requirements represent a basic level of emission control for new industrial facilities in air quality control regions, and are more stringent than the (Schedule E) emission controls which apply outside air quality control regions.

Relevant Schedule F requirements are set out in the following table.

[2] Victorian Government Gazette (21 December 2001). "State Environment Protection Policy (Air Quality Management)".
[3] Victorian Government Gazette (9 February 1999). "State Environment Protection Policy (Ambient Air Quality)".
[4] National Environment Protection Council (June 2003). "National Environment Protection (Ambient Air Quality Measure Variation 2003.

Wastes	Sources to which emission limit is applicable	Emission limit
Sulphuric acid mist and sulphur trioxide	All stationary sources	0.2 g/m^3 expressed as SO_3
Oxides of nitrogen	"Fuel burning units - - having a maximum heat input greater than 150 000 MJ/h gross - -"	0.5 g/m^3 for liquid or solid fuels

Nitrogen oxides (NOx) are generated by two processes when fuels are combusted:

- oxidation of atmospheric nitrogen by high temperatures in the combustion zone (thermal NO_x); and
- oxidation of nitrogenous compounds present in liquid or solid fuels (fuel NO_x), however, this is not an issue with natural gas, which contains essentially no nitrogenous matter.

Schedule E lists a NO_x emission limit of up to 0.78 g/m^3 for large solid fuel-fired power station boilers. Substantially lower NO_x limits are listed for gaseous fuels used in fuel burning units (0.35 g/m^3), and 0.07 g/m^3 for large gas turbines operating on gaseous fuels (assumed to be natural gas). The operation of gas turbines on syngas (generated from coal by gasification, and containing nitrogen in the form of ammonia) was not envisaged when Schedule E was developed in the late 1970s.

Schedule E does not list an emission limit for sulphur dioxide (SO_2). This is consistent with the listing in the equivalent schedule (Schedule H) in the original SEPP (TAE), which was based on the fact that both ambient SO_2 monitoring data and the sulphur content of fuels used in Victoria (notably brown coal) were relatively low. The emission limit for sulphuric acid and sulphur trioxide (both typically reported as SO_3) is 0.2 g/m^3.

2.2. Best Practice

Clause 19(1) of SEPP (AQM) requires that *"a generator of a new or substantially modified source of emissions must apply best practice to the management of those emissions."* The following definitions and provisions of SEPP (AQM) assist in interpretation of Clause 19(1):

Best practice is defined in Part IV of the Policy as:

> "- - *the best <u>combination</u> of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity"* [my emphasis].

"Eco-efficient" is defined in Part IV of the Policy as:

> *"producing more goods with less energy and fewer natural resources, resulting in less waste and pollution."*

Clause 18(1) of SEPP (AQM) provides that *"in this policy the management of emission means:*

> *(a) avoiding and minimising emissions in accordance with the preference established in the principle of the waste hierarchy* [avoidance > re-use > re-cycling > recovery of energy > treatment > containment > disposal]; *and*
> *(b) the assessment, monitoring, control, reduction or prohibition of emissions for air quality management purposes".*

2.3. Management of Local Air Quality

Clause 27 of SEPP (AQM) requires *inter alia* that:

> *"(1) In assessing an application for a new development that may have impacts on local air quality, the Authority - - will have regard to protocols for environmental management developed in accordance with this policy, including those for:*
> *- - (c) the use of design criteria* [Schedule A] *and dispersion modelling* [Schedule C] *for assessing emissions."*

Clause 22 of SEPP (AQM) provides that:

> *"(1) The Authority may, in considering licences and works approvals, exempt a scheduled premises from compliance with any requirement of Schedules D and E - - - where the proponent of the works or licensee can demonstrate to the satisfaction of the Authority that:*
>
> > *(a) the discharge or emission does not cause design criteria prescribed in Schedule A to be exceeded and does not adversely affect any beneficial use of the environment;*
> > *(b) compliance with the requirement would increase or create waste disposal problems in either the land, air or water environments;*
> > *(c) compliance with the requirement would preclude the development of innovative control or energy saving technologies; or*
> > *(d) compliance with a requirement contained in Schedules D and E cannot be achieved by the application of best practice for emissions of Class 1 and 2 indicators - - ."*

The modelling procedures to be used to determine whether the discharge or emission will result in exceedence of the design criteria listed in Schedule A is set out in Schedule C of the Policy (modelling emissions to air). The relevant Schedule A design criteria, as 99.9 percentile predicted ground level concentrations (GLCs), are listed in the following table.

Substance	Averaging time	Design criteria, mg/m^3	Design criteria, ppm (volume/volume)
Sulphur dioxide	1-hour	0.45	0.17
Nitrogen dioxide	1-hour	0.19	0.1
Sulphuric acid	3-minute	0.033	-

2.4 Management of Regional Air Quality

Management of regional air quality is addressed by both SEPP (AQM) and SEPP (AAQ), as outlined below.

SEPP (AQM) Provisions

Clause 30 of SEPP (AQM) addresses air quality management in Air Quality Control Regions. Relevant provisions are as follows:

> *"(1) For the purpose of improving or maintaining regional air quality within an Air Quality Control Region, the Authority may:*
>
> > *(a) require emission generators to reduce their emissions to a greater extent than required by clauses 18* [general requirements] *and 19* ["best practice"]; *and*
> >
> > *(b) refuse to issue a works approval for a large new source of emissions unless emission reductions for other sources are able to offset the impacts of the proposed emissions*.
>
> *(2) The Authority may identify priorities and strategies for reducing emissions from particular sources for the purpose of air quality management in a region through the development of an Air Quality Improvement Plan or a protocol for environmental management developed in accordance with this policy".*

Clause 31 of SEPP (AQM) provides *inter alia* that:

> *"(1) The Authority may develop Air Quality Improvement Plans for Air Quality Control Regions, sub-regions or regions of special significance.*
> *(2) The purposes of an Air Quality Improvement Plan are to:*
>
> > *(a) protect the beneficial uses and identify actions that will enable the environmental quality objectives to be met;*
> >
> > *(b) guide, support and promote continuous improvement in air quality to minimise the exposure of the community to air pollution; and*
> >
> > *(c) reduce the impacts of air pollutants on other segments of the environment."*

Schedule B of SEPP (AQM) specifies Intervention Levels for 11 air quality indicators, and notes that:

> *"These criteria are to be used in the assessment of local or neighbourhood <u>air monitoring data</u> as described in Clause 27 of the policy - - <u>Intervention levels are not used in the assessment of the design of individual sources</u>"* [my emphasis].

In this context, Clause 27 of SEPP (AQM) provides *inter alia* that:

> "(*5) The Authority will encourage protection agencies to develop voluntary neighbourhood environment improvement plans to protect the beneficial uses of the neighbourhood air environment.*
> *(6) The Authority may direct a protection agency to develop a neighbourhood environment improvement plan to protect the beneficial uses of the neighbourhood air environment."*

If air quality monitoring data indicate that the intervention levels in a particular neighbourhood are exceeded, this may "trigger" the development of a specific neighbourhood environment improvement plan or protocol for environmental management.

Relevant Schedule B intervention levels are listed in the following table.

Substance	Averaging time	Intervention level, ppm (mg/m^3)
Sulphur dioxide	1 hour	0.21 (0.56)
Nitrogen dioxide	1 hour	0.14 (0.27)

EPA has not developed an air quality improvement plan, a neighbourhood environment protection plan nor a specific protocol for environmental management for the Latrobe Valley.

SEPP (AAQ) Provisions

SEPP (AAQ) has adopted the environmental quality objectives, goals and protocols specified in the NEPM (Ambient Air Quality). An "Environmental Quality Objective" is defined in the Policy to mean *"a level of an indicator prescribed for the protection of a beneficial use as described in Clause 9 - - "*. The beneficial uses are set out in Clause 8, and include: human health and well-being; life, health and well-being of other forms of life including animals and vegetation; visibility; useful life and aesthetic appearance of buildings, structures, property and materials; and aesthetic enjoyment and local amenity.

Relevant SEPP (AAQ) objectives and goals are listed in the following table, while protocols for locating SEPP (AAQ) performance monitoring stations and assessing the data are discussed below (the objectives are specified in the Policy as parts per million by volume – for convenience, I have included the equivalent concentrations as mg/m^3 (in parentheses).

Environmental indicator (pollutant)	Averaging period	Environmental quality objective, ppm (mg/m^3)	Goal (maximum allowable exceedences)
Sulphur dioxide (maximum concentration)	1 hour 1 day 1 year	0.20 (0.53) 0.08 (0.21) 0.08 (0.05)	1 day a year 1 day a year none
Nitrogen dioxide	1 hour 1 year	0.12 (0.23) 0.03 (0.06)	1 day a year none

Clause 14(2) of SEPP (AAQ) requires that the performance monitoring stations used to assess compliance with the above objectives and goals *"must be located in a manner such that they contribute to obtaining a representative measure of the air quality likely to be experienced by the general population in the region of sub-region"*.

This means that these performance monitoring stations are to be located within urban areas, but not in close proximity to major emission sources (such as power stations, major industrial sites or freeways). It follows that the SEPP (AAQ) objectives and goals are not to be used to assess emissions from individual sources.

2.5 Management of Global Air Quality Issues

Clause 33 of SEPP (AQM) specifies the following requirements for the management of greenhouse gases:

> *"(1) Generators of emissions of greenhouse gases must manage their emissions in accordance with the provisions of Clauses 18* [general requirements] *and 19* ["best practice"].
> *(2) Any protocols for environmental management relating to greenhouse gas emissions developed by the Authority in accordance with this policy will be consistent with any measures developed by the Government of Victoria for the management of greenhouse gases and energy efficiency.*
> *(3) The Authority will apply these protocols to generators of emissions subject to works approvals and licences, and in assessing the potential impacts of other development proposals."*

EPA published the Protocol for Environmental Management – Greenhouse Gas Emissions and Energy Efficiency in Industry[5] in 2002. The purpose of the "Greenhouse PEM" is to provide *"guidance for businesses on the SEPP (AQM) and its requirements for the management of greenhouse gas emissions and energy consumption - - -* [it] *specifies the steps that will need to be taken by business to demonstrate compliance with the policy principles and provisions of SEPP (AQM) related to energy efficiency and greenhouse gas emissions, and how EPA will assess compliance"*.

Relevant provisions of the Greenhouse PEM include the following:

- *"In assessing best practice, a range of environmental issues, in addition to greenhouse gas emissions and energy efficiency, will often also need to be considered"*.
- *"Assessment of compliance with the protocol will be on a case-by-case basis, considering individual businesses and their circumstances, and the context of the industry within which they operate."*

[5] EPA (January 2002). "Protocol for Environmental Management – Greenhouse Gas Emissions and Energy Efficiency in Industry". Publication 824.

- Applicants for a works approval "*will need to demonstrate - - that they have identified, and will be implementing, best practice in relation to energy use and greenhouse gas emissions*" by undertaking the following steps:
    - Step 1: estimate energy consumption;
    - Step 2: estimate direct greenhouse gas emissions;
    - Step 3: identify and evaluate opportunities to reduce greenhouse gas emissions; and
    - Step 4: document steps 1 to 3.

PART II. ASSESSMENT AGAINST SEPP PROVISIONS

This section sets out my assessment of the compliance of the demonstration project with EPA's air policies, and comments on EPA's assessment of the Works Approval application, under each of the subheadings set out in Part I of this statement.

The demonstration project involves a 600 MW brown-coal-fired power station, employing novel integrated drying and gasification combined cycle technology (IDGCC) developed by HRL. The project, which is detailed in the Works Approval Application prepared by SKM for Dual Gas Pty Ltd[6], involves the following combination of processes:

- coal pre-drying and air pre-heating;
- integrated coal drying and gassification to produce syngas;
- treatment of syngas to remove ammonia, particulates and reduce the moisture content;
- combustion of syngas (with or without supplementary natural gas) in gas turbines to generate electricity;
- combustion of particulates (removed from the syngas streams) in char burners;
- conversion of "waste" energy from hot exhaust gasses exiting the gas turbines and char burners into steam (supplemented by combustion of natural gas as appropriate);
- generation of additional electricity by directing the steam to a single steam turbine; and
- an air-cooled condenser (which will avoid the substantial water consumption associated with conventional power station cooling towers).

Dual Gas proposes to initially install one 300 MW IDGCC "train" and operate the second gas turbine on natural gas, while the second 300 MW IDGCC train will be installed after the technology has been proven at commercial scale. In the unlikely event that the IDGCC technology is not commercially viable, the facility will be operated as a 600 MW natural-gas-fired combined cycle power station.

The following air quality assessment is based on the assumption that both IDGC trains are operating continuously at the 600 MW facility.

3.1 Emission Limits

As noted above, SEPP (AQM) Schedule E emissions apply to new sources in the LV air quality control region.

[6] SKM (1 September 2010). "Dual Gas demonstration project – EPA works approval application".

3.1.1 My Assessment

The projected maximum emission rates from the demonstration project are set out in Table B1 of the November 2010 air quality modelling assessment prepared for HRL Developments[7]. These values represent the maximum projected emission rates (as g/s) based on the following factors:

- 600 MW demonstration project with two gasifiers operating on brown coal;
- operating at full output, with maximum supplementary natural gas duct firing;
- highest expected sulphur content for either Morwell or Yallourn North Extension coal; and
- no sulphur oxide (SO_x) emissions from the combustion of natural gas (because of its very low sulphur content).

The following table lists the maximum projected concentrations of NO_x and SO_3 calculated from Tables B2 and B3 of HRL's November 2010 report, and advice from DG that between 3% and a (very conservative maximum of) 5% of SO_x emissions from both the gas turbines (operating on syngas) and the char boilers will be in the form of sulphur trioxide (SO_3).

Projected maximum concentrations of NO_x and SO_3 emitted from the 600 MW demonstration project and the corresponding Schedule E limits

Source	**NO_x, g/m^3**	**SO_3 , g/m^3**
CCGT	0.075	0.023
Char Burner	0.411	0.015
Air pre-heater	0.090	0.000
Pre-dryer	0.041	0.000
all IDGCC sources	0.094	0.021
Schedule E limits	**0.5**	**0.2**

The maximum projected NO_x and SO_3 concentration for each individual source at the project complies with the relevant Schedule E emission limits.

It should also be noted that the maximum weighted average emissions from all sources at the project will be well below the relevant emission limits, representing only 19% of the NO_x emission limit and 11% of the SO_3 limit.

[7] HRL Technology Pty Ltd (November 2010). "Air quality modelling assessment – 600MW dual gas demonstration project in Latrobe Valley". prepared for HRL Developments.

3.1.2 EPA Assessment Report

EPA, in its Assessment Report[8] on Dual Gas' proposal, has elected to conduct its assessment of emissions (and best practice) by "benchmarking" individual components of the demonstration project. As discussed in the following section I disagree with this approach.

EPA assessed NOx emissions from the combined-cycle gas turbines (operating on syngas) against the Schedule E emission limit of 0.07 g/m^3 for large gas turbines operating on gaseous fuels. However, EPA acknowledges (on page 27) that Schedule E of SEPP (AQM) was developed before fuels other than natural gas were being used in gas turbines, and the 0.07 g/m^3 limit is not strictly applicable to syngas. I consider that the 0.07 g/m^3 limit is definitely not applicable to syngas-fuelled gas turbines, because this limit was derived on the basis that the gaseous fuel would be natural gas (containing no nitrogenous compounds).

Works Approval WA76043 exempts the demonstration project from compliance with the Schedule E NO_x limit (while it operates as a syngas plant) under the provisions of Clause 22 of SEPP (AQM).

I agree that this exemption is appropriate, for the reasons outlined by EPA, notwithstanding my view that the Schedule E NO_x limit of 0.07 g/m^3 is not applicable to any components of the demonstration project (including the gas turbine) because, as the plant is fired predominantly by brown coal, the relevant emission limit is a minimum of 0.5 g/m^3 and a maximum of 0.78 g/m^3.

3.2 Best Practice

Clause 19(1) of SEPP (AQM) requires *inter alia* that new sources of emissions must apply best practice to the management of those emissions. As noted earlier, best practice is defined in SEPP (AQM): "- - *the best combination of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity"* [my emphasis].

3.2.1 My Assessment

In my opinion, the correct application of Clause 19(1) in relation to this proposal is as follows:

- the relevant "*industry sector or activity*" is the generation of electricity from brown coal; and
- the demonstration project should be considered holistically under this clause (ie, whether it represents the best combination of techniques etc) in the industry sector, rather than considering each component of the plant individually) – the latter approach could potentially result in a miss-match of technologies, leading to a sub-optimal outcome.

[8] EPA (undated). "Assessment Report – Application WA 67043".

I am advised that the energy efficiency of the demonstration project (in terms of electricity produced per ton of brown coal) is at least 30% greater than for any existing brown coal-fired power station worldwide. The combination of processes which are integral to the project and which enable this outcome to be achieved are listed above (in the introduction to Part III).

I am further advised that the demonstration project is expected to play a critical role in the development of the Victorian Government's CarbonNet project, which aims to demonstrate the feasibility piping liquid CO_2 from the Latrobe Valley (LV) to Australia's premier potential geological carbon storage basin off the Gippsland coast. Implementation of the CarbonNet project requires a source of 1,000,000 tonnes/year of CO_2, which could be generated by pre-combustion carbon capture at the demonstration project, using proven technology (subject to a Government commitment to support establishment of the CarbonNet infrastructure). Space has been reserved at the demonstration project site for the future installation of pre-combustion carbon capture equipment.

DG expects that retro-fitting pre-combustion carbon capture at the demonstration project will enable the facility to achieve a greenhouse gas intensity (GGI) of approximately 0.3 t CO2-e/MWh. This is about one-quarter of the GGI achieved by the most efficient current brown-coal-fired power station in the LV, and about one-third of the GGI performance of typical black-coal-fired power stations.

An important "bonus" of implementing pre-combustion carbon capture (from the syngas stream) at the demonstration project is that the technology necessarily also achieves SO_2 removal, which will result in a very substantial reduction in SO_2 emissions.

No existing Victorian power station has been required to install equipment to reduce SO_2 emissions, while DG has advised that SO_2 emissions from the demonstration project will be substantially less than from other power plants (relative to electricity production). While I understand that technology is available for capturing SO_2 (alone) from syngas (at a substantial cost) this equipment would become redundant if CO_2 (and associated SO_2) capture is implemented as part of the CarbonNet project.

In any event, as discussed below, SO_2 emissions from the demonstration project comply with all provisions of SEPP (AQM) and will make essentially no contribution to maximum predicted SO_2 concentrations in the Latrobe Valley. Therefore, I do not consider that the installation of SO_2 removal technology can be justified at this stage.

In my opinion, the technology to be employed in DG's demonstration project clearly represents "best practice" in the relevant "industry sector or activity" (the generation of electricity from brown coal) in terms of minimisation of emissions.

I have not made an assessment of the complex technical and economic issues related to EPA's decision to not approve the second gas turbine, which is proposed to operate on natural gas, pending demonstration of the commercial scale IDGCC process and installation of the second IDGCC train.

3.2.2 EPA Assessment Report

EPA notes *inter alia* in its assessment report that: *"it is difficult to determine the relevant industry sector or activity against which the approach of "benchmarking" best practice can be exercised, given that this is new technology which has not been proven commercially and for which there is no direct counterpart. It is apparent that the level of emissions from syngas-generated electricity is favourable in comparison with traditional brown coal-fired power stations - - "*.

In terms of greenhouse gas emissions and energy efficiency, EPA's assessment report concludes that the demonstration project will have a lower greenhouse gas (GHG) emission intensity (GEI) than other power stations generating electricity from brown coal. This conclusion is based on three reviews which focussed on its energy efficiency:

- a literature review/synthesis conducted by EPA; and
- the advice of two independent technology experts retained by EPA (Maarten Van der Burgt[9] and Malcolm McIntosh[10].

In particular, EPA's assessment report notes Maarten Van der Burgt's advice that: *"presently the* [Dual Gas] *process is the best practice technology* [worldwide] *for generating power from brown coal with the lowest environmental impact"*.

In terms of SO_2 emissions, the EPA assessment report notes inter alia that: "*historically, SO_2 removal has not been required in Victorian power stations - - "* and that: *"Dual Gas estimates that a SO2 emission rate relative to [electricity] would be 45% less than other Latrobe Valley power plants, based on the superior efficiency*".

In light of my earlier comments, I do not consider that the installation of SO_2 removal technology can be justified for the demonstration project at this stage.

3.3. Management of Local Air Quality

As discussed in Section 2.3, the "local" air quality provisions of SEPP (AQM) are implemented primarily through the use of predictive air quality modelling to determine whether the Schedule A design criteria will be met following commissioning of the proposal. My assessment focuses on SO_2.

[9] Maarten Van der Burgt (May 2011). "Review of EPA Works Approval Application from Dual Gas Pty Ltd to build and operate the Dual Gas Demonstration Power Station". Report to EPA.
[10] Malcolm McIntosh (11 April 2011). "Review of EPA Works Approval Application from Dual Gas Pty Ltd to build and operate the Dual Gas Demonstration Power Station". Report to EPA.

3.3.1 My Assessment

Modelling of the implications of SO_2 emissions from the demonstration project (without capture SO_2 capture from syngas) has been conducted recently by HRL Technology (for HRL developments)[11] and by Consulting Air Pollution Modelling and Meteorology (CAMM) for EPA[12]. Both modelling exercises adopted the same input data (including emission rates from the demonstration project and existing LV power stations, and meteorological files) and model parameters. Importantly, EPA's assessment report notes on page 31 that the SO_2 emission rates used in the modelling are appropriate, based on the amount of coal to be combusted and its sulphur content.

I have based my assessment of the implications of SO_2 emissions from the demonstration project on "local" air quality on the findings of the CAMM report, which provides a more detailed analysis of the model predictions than the HRL report.

The Schedule A design ground level concentration (dGLC) for SO_2 is 0.45 mg/m^3 (as a 99.9 percentile 1-hour averaged value). The findings of my assessment are summarised below, referenced where appropriate to the CAMM report:

- the maximum predicted GLC attributable to the demonstration project emissions alone is 0.2198 mg/m^3, at a location approximately 750 m east-northeast from the plant (Fig 2.8 of CAMM report);
- the maximum predicted GLC attributable to emissions from both the demonstration project and existing LV power stations is 0.2554 mg/m^3, at a location approximately 850 m east-northeast from the plant (Fig 2.7 of CAMM report);
- the maximum predicted GLC attributable to emissions from the existing LV power stations is 0.4889 mg/m^3, at an elevated location approximately 900 m west-southwest from the Loy Yang power station (about 14 km to the east of the proposed demonstration project) – refer to Fig 2.4 of the CAMM report; and
- the maximum predicted GLC attributable to emissions from both the demonstration project and existing LV power stations is 0.4890 mg/m^3, at the same elevated location (Fig 2.5 of CAMM report).

The key conclusions which may be drawn from the above findings are:

- the maximum predicted SO_2 GLC in the general vicinity of the demonstration project (including significant contributions from the Hazelwood and Energy Brix power stations (both of which are likely to be decommissioned in the short to medium term) is 0.2554 mg/m^3, which is well below the Schedule A dGLC of 0.45 mg/m^3;

[11] HRL Technology Pty Ltd (February 2011). "SO_2 air quality modelling assessment – 600MW dual gas demonstration project in Latrobe Valley". prepared for HRL Developments.
[12] CAMM (February 2011). "External review of air quality modelling assessment conducted by HRL – additional results". Report No 1/11, prepared for EPAV.

- the maximum predicted SO_2 GLC in the Latrobe Valley attributable to emissions from existing power stations is 0.4889 mg/m^3, which exceeds the Schedule A dGLC of 0.45 mg/m^3 – the maximum predicted GLC is almost entirely attributable to SO_2 emissions from Loy Yang and occurs at a location about 14 km from the demonstration project;
- SO_2 emissions from the demonstration project make a negligible contribution to the maximum predicted GLC in the LV (only 0.0001 mg/m^3 or 0.02%); and
- assessment of the demonstration project in terms of the local control provisions of SEPP (AQM) provides no justification for requiring the application of SO_2 removal technology at this stage (particularly in light of the likely closure of the Hazelwood and Energy Brix power stations).

3.3.2 EPA Assessment Report

My comments on EPA's assessment report are included in the previous section.

3.4 Management of Regional Air Quality

As discussed in Section 2.4, SEPP (AQM) provides for the management of regional air quality primarily by reference to ambient air quality monitoring data. EPA's most recent air monitoring report (Publication 1331)[13] provides data from 1995 to 2009 for two monitoring stations in the LV. Both of these are "performance monitoring stations" which are appropriately located in the main population centres of Moe and Traralgon, in accordance with the provisions of SEPP (AAQ). I understand that EPA currently also operates ambient air quality monitoring stations at two other sparsely-populated locations (Rosedale South and Jeeralang Hill); however, I do not have data from these monitoring stations.

The ambient SO_2 data reported in Publication 1331 for the performance monitoring stations (as both 1-hour averaged and 24-hour averaged values) may be summarised as follows:

- no exceedences of the SEPP (AAQ) 1-hour SO_2 objective of 0.20 ppm were recorded at either Moe or Traralgon between 1995 and 2009;
- the highest 1-hour SO_2 concentration at Moe during 2009 was 0.054 ppm;
- the highest 1-hour SO_2 concentration at Traralgon during 2009 was 0.110 ppm;
- the highest 24-hour SO_2 concentration at Moe during 2009 was 0.011 ppm (the corresponding SEPP (AAQ) objective is 0.08 ppm);
- the highest 24-hour SO_2 concentration at Traralgon during 2009 was 0.013 ppm (the corresponding SEPP (AAQ) objective is 0.08 ppm); and
- no annual-averaged SO_2 data are reported in Publication 1331.

[13] EPA (September 2010). "Air monitoring report 2009 – compliance with the national Environment Protection (Ambient Air Quality) Measure". EPA Publication 1331.

3.4.1 My Assessment

My assessment of the above LV ambient SO_2 monitoring data may be summarised as follows:

- there has not been a single exceedence of the SEPP (AAQ) SO_2 objectives (1-hour and 24-hour averaged) at either of EPA's two LV performance monitoring stations between 1995 and 2009;
- the highest SO_2 concentrations in 2009 were recorded at Traralgon, but these represented only 55% of the 1-hour objective and 16% of the 24-hour objective; and
- the highest 1-hour averaged SO_2 concentrations recorded at Traralgon in 2009 were also well below the SEPP (AQM) Schedule B Intervention Level of 0.21 ppm (0.56 mg/m^3).

The ambient monitoring data reported in Publication 1331, which was recorded in the LV's two main population centres, in accordance with the provisions of SEPP (AAAQ), indicates that SO_2 concentrations are well below both the SEPP (AAQ) objectives and the SEPP (AQM) Schedule B intervention level. On this basis, there is no justification for the development by EPA of an air quality improvement plan, a neighbourhood environment protection plan nor a specific protocol for environmental management for the LV.

Nor do the performance monitoring station data suggest that new SO_2 emission sources in the LV airshed should be required to apply "better than best practice" SO_2 emission control technology under the provisions of SEPP (AAQ) or Schedule B of SEPP (AQM). The modelling predictions discussed earlier indicate that:

- the peak SO_2 concentrations in the LV are largely attributable to emissions from the Loy Yang power station;
- peak SO_2 concentrations in the LV typically occur in relatively small, elevated, sparsely populated areas as a result of power station plumes "grounding" on hillsides; and
- reducing SO_2 emissions from the proposed IDGCC plant will have a negligible effect (less than 0.02%) on reducing peak SO_2 concentrations in the LV.

3.4.2 EPA Assessment Report

EPA's assessment report refers to exceedences of the SEPP (AAQ) SO_2 1-hour objective on 29 days between 1998 and 2010 (an average of about 2.5 days per year). At least 83% of these exceedences occurred in the (sparsely-populated) Strzelecki Ranges, where the SEPP (AQM) SO_2 intervention level was also exceeded at least once each year.

If EPA considers that existing SO_2 levels in the LV air quality control region represent a significant issue, I consider that the EPA should prepare a specific air quality improvement plan or protocol for environmental management for the LV, which would identify any necessary measures to deal with the primary causes of these exceedences. In contrast, simply requiring the installation of SO_2 removal equipment on the demonstration project will achieve essentially nothing in terms of reducing the frequency of SO_2 exceedences in these at these relatively small, sparsely-populated areas.

3.5 Management of Global Air Quality Issues

The most relevant global air quality issue in this context relates to the contribution of CO_2 emissions from electricity generation to the enhanced greenhouse effect. Clause 19(1) of SEPP (AQM) requires that generators of greenhouse gases must apply "best practice" principles in terms of energy efficiency and greenhouse gas emissions. Section 2.5 (above) notes that EPA's Greenhouse PEM requires that:

- *"In assessing best practice, a range of environmental issues, in addition to greenhouse gas emissions and energy efficiency, will often also need to be considered".*
- *"Assessment of compliance with the protocol will be on a case-by-case basis, considering individual businesses and their circumstances, and the context of the industry within which they operate."*

The above provisions make it clear that decisions on whether new sources incorporate appropriate "best practice" principles for GHG reduction must take a broad, rather than a narrow, view of the proposal in terms of its implications for GHG emissions.

3.5.1 My Assessment

I consider that assessment of the demonstration project in terms of "best practice" related to energy efficiency and GHG emissions should take the following factors into account:

- the demonstration project's relevant "*industry sector or activity*" is the generation of electricity from brown coal;
- its should be considered holistically, rather than considering each component of the plant individually;
- EPA's assessment report concludes that the demonstration project will have a lower GHG emission intensity (GEI) than other power stations generating electricity from brown coal;
- Maarten Van der Burgt's advice to EPA that: *"presently the* [Dual Gas] *process is the best practice technology for generating power from brown coal with the lowest environmental impact"*;
- the fact that the demonstration project is "carbon capture ready", unlike all other Victorian power stations; and

- if pre-combustion carbon capture should be retro-fitted to the demonstration project in conjunction with the CarbonNet project, the project's GGI will be between 25 and 33% of currently operating coal-fired power stations.

On this basis, I consider that that the proposed demonstration project clearly complies with the "best practice" requirements of Clause 19(1) of SEPP (AQM).

3.5.2 EPA Assessment Report

The Works Approval does not permit the installation of the second (initially natural gas-fired) E-class combined cycle gas turbine. This decision is based essentially on the higher generation efficiency of F-class gas turbines (which cannot operate with syngas), and the possibility that the proposed power station may ultimately operate as a purely gas-fired facility (in the event that the IDGCC process does not prove to be commercially viable).

As noted earlier, I have not reviewed the complex technical and economic issues involved in this assessment, but understand that these issues extend well beyond a simple comparison of the relative energy efficiencies of Class E and F gas turbines.

PART III. COMMENTS ON DEA SUBMISSIONS

This section comments on submissions by Doctors for the Environment Australia (DEA), and specifically on the further particulars provided by DEA and dated 5 August 2011. DEA's submissions rely on five grounds, of which the first four are relevant to the scope of my statement, as discussed below.

DEA's particulars consist essentially of a series of assertions, generally without supporting technical documentation. I have summarised DEA's first four grounds below, followed by my comments in italics.

Ground 1. Definition of Industry Best Practice

Best Practice
DEA asserts that the proposal does not apply best practice to management of air emissions to atmosphere.

As DEA has provided no supporting information, I am unable to provide a specific response.

Exemption under SEPP (AQM) Clause 22
DEA claims that EPA's exemption [from the need to comply with the SEPP (AQM Schedule E NO_x emission limit of 0.07 g/m^3] under Clause 22 is unacceptable on the basis of health grounds.

As outlined earlier I agree that this exemption is appropriate, for the reasons outlined by EPA, notwithstanding my view that an exemption is not required, for the following reasons:

- *the relevant "industry sector or activity" for the proposed IDGCC plant is clearly the generation of electricity from brown coal;*
- *the Schedule E NO_x limit of 0.07 g/m^3 is not applicable to any components of the IDGCC plant (including the gas turbine) because the plant is fired predominantly by brown coal;*
- *the 0.07 g/m^3 emission limit is only appropriate for gaseous fuels (such as natural gas) which contains essentially no nitrogenous compounds); and*
- *the relevant emission limit for the proposed IDGCC plant is between 0.5 g/m^3 and 0.78 g/m^3.*

In any event, the exemption is entirely consistent with the provisions of Clause 22, and more specifically with clauses 22(1) (a) to (d).

DEA's suggestion that the Clause 22 exemption does not ensure protection of the beneficial uses listed under Clause 9 of SEPP (AQM) misinterprets the policy. The air quality indicators, design criteria and intervention levels described in Clause 10 have been defined to protect all of the beneficial uses listed in Clause 9 and underpin implementation of the SEPP.

Ground 2. Precautionary Principle and Intergenerational Equity

Principles of SEPP (AQM)
DEA asserts that "the principals of the SEPP (AQM) have not been properly applied", without any substantiation.

The Precautionary Principle
DEA claims that Clause 7(2) of SEPP (AQM) has not been properly applied to the assessment of health impacts of NO_x, SO_2 and particulate matter.

Clause 7(2) provides that the precautionary principle applies where there are "threats of serious or irreversible environmental damage". There is no evidence that the proposed IDGCC plant poses such a threat.

The Principle of Intergenerational Equity
DEA asserts that Clause 7(3) of SEPP (AQM) has not been properly applied in granting the Works Approval, on the basis that the emission of GHG and (unidentified) toxic compounds presents an unacceptable risk to maintain present standards of health for future generations.

I am unaware of any evidence that operation of the proposed IDGCC will present an unacceptable risk to future generations.

Ground 3. Exemption under SEPP (AQM) Clause 22

Refer to the discussion under Ground 1 (above).

Ground 4. No modelling of 24 h and Annual Concentrations

DEA appears to be confused about the operation of EPA's two air policies in relation to predictive modelling and monitoring.

The reality is that:

- *the design criteria to be used in assessing the results of predictive modelling are set out in Schedule A of SEPP (AQM). The dGLCs for both NO_2 (not NO_x, as stated by DEA) and SO_2 are defined as 1-hour averages;*
- *as set out in Section 2.4 (above) SEPP (AAQ) lists objectives based on 1-hour, 1-day, and 1-year for SO_2, and 1-hour and 1-year for NO_2;*
- *the SEPP (AAQ) objectives provide a basis for assessing ambient air quality monitoring data collected at "performance monitoring stations" (such as at Moe and Traralgon); and*
- *the SEPP (AAQ) objectives are clearly not intended to be used as a basis for assessing the effects of emissions from individual sources.*

PART IV. CONCLUSIONS

My key conclusions in relation to the proposed 600 MW dual gas demonstration project are summarised below.

1. The relevant "*industry sector or activity*" for purposes of assessing "best practice" under the provisions of Clause 19(1) of SEPP (AQM) is "the generation of electricity from brown coal".

2. The demonstration project should be considered holistically under Clause 19(1), rather than considering each component of the plant individually.

3. The demonstration project clearly involves the application of "best practice" in the relevant "industry sector or activity" in terms of minimising emissions.

4. The maximum concentrations of nitrogen and sulphur oxide emitted will comply with the relevant SEPP (AQM) Schedule E emission limits.

5. SO_2 from the demonstration project will make a negligible contribution to the maximum predicted SO_2 concentration in the Latrobe Valley, which occurs at a location about 14 km from the demonstration project, and is largely attributable to emissions from the Loy Yang power station.

6. Assessment of the demonstration project in terms of the local control provisions of SEPP (AQM) provides no justification for requiring the application of SO_2 removal technology at this stage (particularly in light of the likely closure of the nearby Hazelwood and Energy Brix power stations).

7. Ambient air quality monitoring, conducted in accordance with the provisions of SEPP (AAAQ) at EPA's two Latrobe Valley performance monitoring stations (at Moe and Traralgon) between 1995 and 2009, indicate that SO_2 concentrations are well below both the SEPP (AAQ) objectives and the SEPP (AQM) Schedule B intervention level.

8. The demonstration project will be "carbon capture ready", unlike any other Victorian power station - if pre-combustion carbon capture is retro-fitted to the demonstration project in the future, its Greenhouse Gas Intensity will be between 25 and 33% of that for currently operating coal-fired power stations.

9. On this basis, the proposed demonstration project will clearly comply with the "best practice" requirements of Clause 19(1) of SEPP (AQM) in relation to minimising greenhouse gas emissions.

10. The particulars provided by Doctors for the Environment Australia (DEA) essentially comprise a series of assertions, generally without supporting scientific documentation, while some points are based on misconceptions regarding the provisions of SEPP (AQM) and SEPP (AAQ).

(Dr) J T Bellair FVPELA FEIANZ

Attachment 1. Content of Report - Practice Note VCAT2

1. Name and Address

John Terence Bellair
Environmental Science Associates
117 Station Street
Carlton 3053

2. Qualifications and Experience

Refer to curriculum vitae (Attachment 2)

3. Areas of Expertise

I have worked as a full-time environmental science consultant since 1973. Over this period I have has played a key role in numerous assignments related to water and air quality management, pollution control, disposal of municipal and industrial wastes, environmental impact assessment, environmental audits, salinity control and the development of environmental policies. These projects have been carried out in all States and Territories of Australia, and in the USA, New Zealand, Thailand, Fiji and Kiribati.

4. Expertise to Prepare Report

Since serving as Project Manager of the consultant team which prepared the Victorian EPA's original SEPP (Air Quality) between 1979 and 1981, I have been involved in numerous air quality assessments covering a very wide range of municipal and industrial sources.

5. Instructions which Defined Scope of Report

I initially received instructions from Maddocks Lawyers, acting on behalf of Dual Gas Pty Ltd, by letter dated 15 July 2011. My instructions were to provide expert evidence on behalf of Dual Gas in relation to:

- the sulphur dioxide conditions imposed by the EPA on the Works Approval;
- the concept of good practice used in various policies that deal with implementing best practice; and
- the Doctors for the Environment Australia's appeal as detailed in its appeal document and further and better particulars.

6. Facts, Matters and Assumptions Relied Upon

- Numerous documents provided by Maddocks;
- Relevant EPA SEPPs, PEMs and Publications;
- NEPC publications

7. Documents taken into Account

Refer to (6) above.

8. Identity of Persons Undertaking Work

The undersigned (Terry Bellair).

9. Summary of Opinions

Refer to the Conclusions of my report.

10. Provisional Opinions

My opinions are not provisional except where specifically qualified.

11. Limitations of Expertise and any Incomplete or Inaccurate Aspects

I consider that the subject matter of my report falls within my area of expertise and that issues dealt with are adequately addressed for purposes of this hearing.

J T Bellair
22 September 2011

Attachment 2. Curriculum Vitae of Dr Terry Bellair

CEE CONSULTANTS PTY LTD

FIRST FLOOR · 90 BRIDGE ROAD · PO BOX 201 · RICHMOND · VIC 3121 · TEL 03 9429 4644 · FAX 03 9428 0021

J Terry Bellair – Environmental Science Consultant

Qualifications:

B Agr Sc (Melb) 1961
Ph D Biochemistry (Melb) 1966

Fellowships:

Fellow, Environment Institute of Australia and New Zealand
Fellow, Victorian Planning and Environmental Law Association

Professional Experience:

since 1984	Director, CEE Consultants
since 1984	Principal, Environmental Science Associates
1973-1983	Principal Scientist, Caldwell Connell Engineers
1969-1972	Senior Research Fellow, Medical Research Centre, Melbourne
1967-1969	Assistant Professor, University of North Carolina Medical School
1966-1967	Post-Doctoral Fellow (biochemistry) University of North Carolina

During his 38 year environmental consulting career, Dr Bellair has played a key role in numerous assignments related to water and air quality management, pollution control, disposal of municipal and industrial wastes, environmental impact assessment, environmental audits, salinity management and the development of environmental policies. These projects have been carried out in all States and Territories of Australia, and in the USA, New Zealand, Thailand, Fiji and Kiribati.

Dr Bellair was a founding committee member of both the Victorian Chapter of the Environment Institute of Australia and the Victorian Planning and Environmental Law Association. He has been appointed by the Victorian Government to conduct over 30 hearings into controversial environmental and planning issues. He has served as a member of the Victorian Mineral Water Advisory Committee and on the board of the North Central Catchment Management Authority. He elected to not renew his Victorian EPA accreditation as an Environmental Auditor (Industrial Facilities) in 2003.

He has been retained as an expert witness in over 350 tribunal, panel and court proceedings, mainly in Victoria, but also in NSW, Queensland, South Australia and Tasmania. He has first-hand experience in land and livestock management through the rehabilitation of a 25 ha property on the upper Loddon River at Glenlyon, and is an experienced pilot (in both gliders and powered aircraft).

Examples of projects in which Dr Bellair has played either the principal or key supporting roles are summarised under the following headings: (1) air quality management; (2) water quality management; (3) environmental impact assessment and resource management; (4) municipal and industrial waste disposal; (5) salinity management; (6) mining and quarrying; and (7) environmental audits and due diligence investigations.

Air Quality Management (including odour and dust)

- Project Manager for preparation of the original State Environment Protection Policy (the Air Environment) for the Victorian EPA This was the first air quality management policy to come into effect in Australia (in 1981).
- Retained by the Tasmanian Environment Protection Policy Review Panel in 2002 to assist in the Panel's review of the Draft Environment Protection Policy (Air Quality).
- Conduct of an environmental audit of the Coode Island bulk chemical storage facility for the Victorian EPA (focussing on air emissions).
- Conduct of an audit of emissions to atmosphere from the proposed Kingstream Steel Plant at Geraldton for the West Australian EPA.
- Modelling emissions from 12 diesel generator sets on Barrow Island (to be used during construction of the Gorgon gas plant).
- Conduct of an audit of odour management at a broiler farm in the Adelaide Hills for the South Australian EPA.
- Statutory audit (odour emissions) for a tannery in Hobart.
- Preparation of over 25 EPA Works Approval and Licence amendment applications for a wide range of industrial facilities.
- Investigation and evaluation of control options for atmospheric emissions (including odours and dust) from a wide variety of sources including power stations, paper pulp mills, refineries, petrochemical plants, food processing plants, abattoirs, by-products plants, piggeries, feedlots, poultry farms, cement plants, dye works, printing works, brick works, ferrous and non-ferrous foundries, scrap metal recyclers, wastewater treatment and disposal facilities, landfills, medical waste incinerators, mushroom composting operations, mineral sands separation plants, construction and demolition waste recycling facilities, and a range of chemical plants.

Organisations for which Dr Bellair has carried out air quality work include the following:

Chemical, Petrochemical and Waste Treatment Plants – Petroleum Refineries Australia Pty Ltd, Altona Petrochemical Complex, BP Australia Limited, Smorgan Consolidated Industries, Monsanto Australia Limited, Dow Chemical, Taubmans, Nufarm Chemicals, Cablemakers, Worth Environmental, Active Environmental, Kemrez Chemicals, A C Hatrick Chemicals, Megachem, ICI Australia, Dunlop Foam Products Group, Trident Technologies, Victorian Chemical Company, Hoechst Australia, Harpers Liquid Waste, Jennings Liquid Waste, Albright & Wilson, Visy Industries, Rhodia PMC, Nuplex.

Other Industries – Carlton & United Breweries, Geelong Wool Combing Ltd, Boral Insulwool, Boral Bricks, Australian Cement Limited, CSR Readymix, David Mitchell Limited, Mulwala Explosives Factory, Australian Newsprint Mills, Tennyson Textiles, Synthetic Dyeworks Industries, Toyota Motor Corporation, Colin Martyn Packaging, Bendigo Mining NL, Wimmera Industrial Minerals, Perseverance Mining NL, Heathcote Gold Project, Nonferral, Gatic (Australia) Pty Ltd, Pacific BBA, Delphi Automotive Systems, Cheetham Salt, Iluka Resources, Bonlac, Delta Demolitions, Alex Fraser Recycling, Visy Industrial Packaging, VisyPak, Murray Goulburn Co-operative, City Circle Demolitions, Dual Gas Pty Ltd.

Abattoirs and By-products Plants etc – S P Holman & Sons, Thomas Borthwick & Sons, RJ Gilbertson Pty Ltd, J H Ralph and Sons, Peerless Holdings, G & K O'Connor Pty Ltd, Mackay By-Products, Aspen By-Products, Bears Lagoon Piggery, United Meat Products, Australian Tallow Producers, Tallowmaster, ICM Farm Products, Tabro Meat, Castricum Brothers, Baybrick Pty Ltd, Master Renderers, Goulburn and Ballarat saleyards, various broiler farm operators (and objectors), Victorian Chicken Meat Council, Liberty Meats, Hazeldenes Chicken Farms, Blue Ribbon Products.

Government Authorities – Victorian, West Australian, South Australian, and Tasmanian EPAs, Urban and Regional Land Corporation, Victorian Solar Energy Council, VicRoads, Port of Geelong Authority, Sydney Water Board, Port of Darwin Authority, NT Works Department, NT Electricity, numerous municipal councils and water authorities in Victoria and Tasmania, Engineering and Water Supply Department (SA), Metropolitan Water Board (Perth), Northern Territory Electricity Commission, Hydro Electric Commission (Tasmania).

Water Quality Management

- Management of effluent re-use study of seven wastewater treatment plants for the Lower Murray Region Water Authority.
- Preparation of a detailed assessment of the effects of river regulation on "in stream" uses of NSW rivers and development of strategies to enhance these uses, for the Department of Water Resources.
- Assessment of the environmental water requirements of the Barmah and Millewa forest ecosystems and development of an appropriate water management strategy, for the Murray Darling Basin Commission.
- Planning and assessment of biological investigations of proposed ocean outfalls at North Head, Bondi, Malabar, Geelong, Wellington, Suva, Port Lincoln and Darwin.
- Specialist consultant engaged in the development of water quality management strategies for the Songkhla Lakes Basin in Southern Thailand.
- Conduct of a detailed analysis of water quality data for all river basins in Victoria, for the Department of Water Resources.
- Assessment of the effects of proposed pulp mill effluent on aquatic environments in Victoria and Tasmania.

- Investigation of the environmental and public health implications of three wastewater outfalls on Tarawa Atoll, Republic of Kiribati.
- Detailed investigations of the rate of bacterial die-off in receiving waters, and its implications for public health and the design of treatment and disposal systems (field studies conducted in Sydney, Port Lincoln, Geelong, Mooloola, Wellington and Suva).
- Investigation of the effects of land use and wastewater disposal on water quality in the Murrumbidgee, Wimmera, Georges and Shoalhaven rivers.
- Development of effluent treatment, storage and irrigation systems for tourist developments at Dinner Plain, Hanging Rock, Mt Macedon, Marysville, Mt Dandenong and Howqua.
- Assessment of water quality aspects of proposed marina and lake developments at Noosa and Moreton Bay (QLD), Patterson Lakes, Martha Cove, St Kilda, Werribee and Meetung.

Environmental Impact Assessment and Resource Management

- Responsible for the preparation of environmental impact assessments (EIAs) since 1975 for a wide range of proposals including power stations, major ports, wastewater treatment and disposal systems, landfills, wind farms, freeways, ocean outfalls, marina developments, industrial plants and forestry, mining, extractive industry and mineral processing projects.
- Served as Project Manager in preparation of EIA reports including: Illawarra Wastewater Strategy ($100 million sewerage project); Channel Island (coal fired) Power Station, Channel Island (gas turbine) Power Station, Darwin; Georges River wastewater treatment and disposal systems, NSW; East Arm Port development in Darwin, and a regional landfill at Port Latta, Northern Tasmania, Wonthaggi and Bald Hills Wind Farms, Lonsdale Golf Club Development Project.
- Provided major contributions to EIA reports including: Mulwala explosives factory; Wimmera Industrial Minerals mineral sand project; proposed Tasmanian coal-fired power station; ANM Albury pulp mill upgrading; Central Deborah gold mining project, Bendigo; Hampshire wood chip mill, Tasmania; Heathcote gold project, Victoria; Perseverance gold mine, Nagambie; Ferntree Gully quarry extension; Eastern and Southeastern freeways and Western By-Pass Road, Cranbourne By-pass, Hobart sewerage upgrade.
- Chaired Independent Panel which assessed the original Toora wind farm proposal by the (then) Victorian State Electricity Commission.
- Prepared EESs for two wind farm proposals in South Gippsland at Wonthaggi (10.5 MW) and Bald Hills (105 MW).
- Prepared environmental assessments and environmental management plans for numerous proposals in Victoria which were not required to undergo formal EIA assessment, but were reviewed through the Works Approval and Planning Permit processes – presented expert evidence in appeals relating to many of these.

- Preparation of a report for the Commissioner for the Environment on appropriate methods for monitoring the environmental impacts of past and present agricultural activities in Victoria, and assessing the sustainability of current farming practices.

Municipal and Industrial Waste Management

- Conduct of an industrial waste generation survey of Tasmania for the Department of Environment and Planning.
- Two surveys of industrial waste generation rates and disposal practices in Victoria for the EPA.
- Development of environmental control strategies for existing and proposed municipal landfill operations at South Clayton, Spring Valley, Broadmeadows, Preston, Colac, and in the Shires of Eltham, Diamond Valley, Colac, Flinders, Morwell, Alexandra and Upper Yarra (including assessment and control of odour emissions, pathogens, litter, dust, leachate, and birds).
- Preparation of environmental control strategies for management of odours, dust, litter, vermin and birds for existing and proposed commercial landfills at South Clayton (Pioneer, Allied Sands), Wollert (Pioneer) and Niddrie (Whelan the Wrecker and Quadry Investments), Badgerys Creek (NSW), Colac (CSR), and Burnie (Tas).
- Environmental review of proposed prescribed waste landfill and composting facilities at Werribee (CSR/Envirogreen).
- Investigations of odour emission rates from existing municipal, commercial and prescribed waste landfills and conduct of plume dispersion modelling to identify landfill gas management systems and operational measures necessary to avoid off-site odour problems (at seven sites).
- Preparation of a solid waste management strategy for the City of Devonport, including conduct of a waste generation survey and site selection investigations for a new regional landfill.
- Preparation of Development and Environmental Management Plans for two regional landfills in Northern Tasmania (at Port Latta and Dulverton), to serve the municipalities of Devonport, Circular Head and Wynyard in Tasmania.
- Review of the design, operation and potential environmental impacts associated with existing and proposed refuse transfer and material recycling facilities at Rosebud, Camberwell, Brunswick, Broadmeadows, Clayton, Niddrie, Morwell, Sunshine, Geelong, Devonport, Wynyard and Circular Head.

Salinity Management

- Chairman of the Loddon Murray Forum (2000-2003) which has overall responsibility for the preparation of the "2nd generation" Land and Water Management Plan for the Loddon Murray region of Victoria.
- Responsible for environmental aspects of the development of the Shepparton and Kerang Lakes Area Salinity Management Plans.
- Environmental assessment of the proposal by Cheetham Salt to increase salt production at its Lake Tyrrell operation to one million tonnes per year.

- Specialist consultant advising the Victorian Parliamentary Salinity Committee on the environmental implications of a range of salinity control options for Northern Victoria.
- Preparation of an assessment of the environmental implications of salinity management options in Victoria, and research and investigation needs, for the Ministry for Planning and Environment.
- Investigation of die-back of river red gums adjacent to a major evaporation basin near Loxton, South Australia, and development of an environmental rehabilitation strategy for the basin.
- Investigation of the feasibility of harvesting salt from the proposed Mineral Reserve Basin evaporation ponds and the environmental implications of the scheme for Lake Tuchewop.
- Review of the environmental implications of rice growing for the Australian Ricegrowers Association.
- Portfolio responsibility for management of floodplains and irrigation salinity as a board member of the North Central Catchment Management Authority.

Mining and Quarrying

- Chaired Independent Panel appointed by the Victorian Government to hear submissions on the Environment Effects Statement for Valdora Mineral NL's Ballarat East open cut gold mine proposal (one million ounces per annum) - this was the first project to be assessed following the 1993 amendments to the Mineral resources Development Act 1990.
- Independent review of potential air quality implications of Iluka Resources' proposed mineral separation plant near Hamilton.
- Preparation of technical submission on the Draft National Environment Protection Measure for PM_{10} (respirable dust) for the Extractive Industry Council.
- Investigation of potential environmental effects and control measures in connection with the Central Deborah gold mining project, including mine operation and dewatering, gold recovery plant and tailings disposal, for (the original) Bendigo Mining NL.
- Conduct of dustfall and meteorological investigations at a number of hard-rock quarries and sand mining operations, and associated crushing, lime and cement plants (for a number of clients including Rio Tinto, Pioneer, Boral, CSR, Australian Cement, David Mitchell Ltd, Barro Group, Lang Lang Holdings).
- Investigation of potential environmental effects and control measures related to development of the WIM 150 mineral sands deposit at Drung South.
- Investigation of environmental issues and development of environmental control and monitoring programs for Perseverance Mining NL's open cut gold mine and heap-leach treatment process at Nagambie.
- Provision of specialist environmental advice in relation to existing or proposed gold mining operations at Bendigo, Eaglehawk, Gaffneys Creek, Heathcote, Chewton, Tarnagulla and Moliagul.

- Environmental investigations of existing and proposed hard rock quarrying operations at Ferntree Gully, Lysterfield, Montrose, Tynong North, Kilmore and Neerim North, and sand mining operations at Lang Lang, Grantville and Bacchus Marsh.
- Environmental investigations at a number of concrete recycling facilities.

Environmental Audits and Due Diligence Investigations

- Conduct of numerous internal environmental assessments of industrial and public facilities over the past 25 years (commencing well before the development of formal environmental audit processes).
- Conduct of an environmental audit of the Coode Island bulk chemical storage facility for the Victorian EPA.
- Conduct of an audit of emissions to atmosphere from the proposed Kingstream Steel Plant at Geraldton for the West Australian EPA.
- Conduct of an audit of odour management at a broiler farm in the Adelaide Hills for the South Australian EPA.
- Statutory environmental audit of a major paint manufacturing operation in Victoria.
- Statutory audit for a tannery in Hobart.
- Environmental audits of 12 of the Sydney Water Board's wastewater treatment plants (including North Head and Bondi).
- Environmental audits of 18 waste paper recycling and paper mill operations throughout Australia.
- Environmental audit of a major non-ferrous metal recycling operation.
- Periodic audits of the air quality monitoring programme designed to assess the impact of vehicle emissions discharged from the Burnley tunnel vent stack.
- Due diligence environmental investigations of over 50 industrial sites for potential purchasers and lenders.