

AIR QUALITY ASSESSMENT OF THE CLINGCAST FOUNDRY PREMISES, BATH ROAD, KIRRAWEE NSW



Clingcast Foundry Site, 98 Bath Road, Kirrawee NSW

Prepared by:

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Date:

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#1	Draft issued for Comment	11/11/2019
#2	Issue post comments & corrections	12/11/2019

REVIEW SUMMARY

Clingcast Metals Pty Ltd commissioned Envirodyne Group P/L to conduct a Level 1 assessment of the air quality issues associated with the operations of their plant at 98 Bath Road, Kirrawee NSW 2232. The Clingcast operations consists of metals recycling that includes the recycling via foundry furnaces and casting of selected ferrous and non-ferrous materials. The prime issue recognised by stakeholders and environmental regulators is the conduct of the foundry and casting operations and how this may affect surrounding properties.

The findings of this assessment are:

- I. The operations conducted by Clingcast do not constitute the business being declared a Scheduled Premises under the NSW Protection of Environment Operation Act. The volumes of metals managed onsite and recycled to downstream users is well below the statutory limits applied. See discussion in Clause 4.1 (page 10).
- II. Clingcast have provided an extensive ventilation system to capture fumes from foundry and casting operations, along with providing a controlled environment within the building to minimise risk of fugitive emissions escaping the plant to surrounding properties. These captured fumes and associated contaminants are treated within an appropriate pollution control system for release into the atmosphere post treatment. (See photo #1, page 5).
- III. Clingcast commissioned accredited companies to undertake sampling and analysis of the ventilation and pollution control systems. The findings from this work are that residual emissions post treatment are well within statutory guidelines. Odours within the ventilation air have been analysed using prescribed olfactometry methods and found to be practically at ambient odour strength levels – similar to what would be found in an industrial estate. The measured odour levels indicate the foundry and castings operations are not significant odour generators. See discussions Clause 4.2 (page 10).
- IV. The assessment work also examined Clingcast operational methods and procedures in terms of how air quality issues are managed on a daily basis. Ventilation plant systems and sealing of the foundry and castings building have been carried out to minimise risk of impact on surrounding properties, along with a strict policy of not smelting contaminated metals that would potentially reduce castings quality. In this action, Clingcast also minimise the risk of contaminating materials (grease, paint, etc.) ending up in the airstream that would likely cause odour emissions. See discussions Clause 4.3 (page 11).
- V. The assessment revealed two issues that would further minimise the risk of odour impact on surrounding properties, and assist in how the company could manage any odour complaints made against their operations:
 - Increase the height of the pollution control system stack and the treated airflow exit velocity to minimise building plume effect on air discharges. See Clause 5.1 (page 12)
 - Implement an odour complaints register onsite using the weather data from the anemometer on site to examine time and place of the complaint correlates with the prevailing weather at the time. See Clause 5.2 (page 12).

This assessment indicates that the site operations are not expected to cause air quality nuisance issues beyond the boundary of the plant, provided the systems that are in place – the ventilation plant and management processes – are maintained in good working order as per the results obtained during testing, and that operational practices are also maintained and enhanced where possible and appropriate.

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1 INTRODUCTION

This document reviews and assesses the foundry operations and associated activities conducted by Clingcast Metals Pty Ltd [Clingcast] in terms of how these operations may impact on the air quality amenity of surrounding properties in accordance with the NSW Protection of the Environment Operations Act [POEOA].

The property is located within the industrial zoned area of Kirrawee near Sutherland NSW. The factory site address is 98 Bath Road Kirrawee NSW 2232.

Envirodyne Group Pty Ltd (EDG) was commissioned to conduct a Level 1 Assessment of the site and the operations conducted by Clingcast, and to ascertain potential impacts on surrounding properties which are industrial operations of various functions, ranging from warehousing to metals fabrication, auto servicing and repairs to timber and joinery.

Clingcast had previously – prior to the EDG engagement – commissioned EKTIMO to conduct sampling and analysis of captured ventilation air after it had passed through the pollution control plant onsite. Refer to Photo #1 (below).



Photo #1 – Reverse pulse type dust collector at eastern end of Clingcast site

2 SCOPE OF WORK

The scope of work undertaken and reported in this document is as follows:

- Review the data collected from the EKTIMO work to determine if there is a potential odour impact from the Clingcast operations on nearby properties,
- Inspect the operations of the pollution control systems onsite to assess efficacy,
- Review current operational practices onsite to assess if there are opportunities to improve these to mitigate any potential odour release.

The EPA “Technical Framework – Assessment and Management of Odour from stationary sources in NSW” is the guideline this assessment will use for the Level 1 assessment work. The overall assessment will be consolidated around the sampling and analytical work done by EKTIMO on the ventilation and pollution control plant.

Site visits were also used to assess effectiveness of the ventilation systems, the operational practices and to meet with plant management to provide information on how odour complaints against the plant maybe responded to. Site visits were conducted at times when the foundry and casting operations to assess work practices used in operations. It was considered that these operations would be the likely cause of odour generation and emissions that had the potential if untreated and managed, to impact on surrounding properties.



Photo #2 – Molten metal ready for discharge into distribution crucible



Photo #3 – Molten metal pour underway

Note: the use of an odour neutralizing spray (3 X 200L drums with nozzles) to mitigate odour from the furnace operations during the pour.

3 REVIEW & ASSESSMENT

3.1 The Clingcast Site - Overview

1. Clingcast operate on a site (address 98 Bath Road Kirrawee NSW) that is some 3,400 m² in area.
2. The plant is a metals recycling operation and an ingot manufacturer of copper alloys – recovered through recycling – and a manufacturer of ferrous - iron and steel - castings. The tonnages per month of ferrous and copper alloys processed is 15-20 tonnes/month and 20-30 tonnes/month respectively. No greased or painted metals are accepted for recycling into ingots or castings. Those metals are onsold to other metal recyclers (e.g; SIMSMETAL).
3. A second part of the onsite operation is electrical transformer reclaim and recycling. Transformers containing oil coolants must be PCB¹ free and the oil is held onsite from the transformers when drained in 2 X 20 kLitres bunded storage tanks. The transformer oil is onsold to certified transformer oil manufacturers and re-users. Stripped transformers are then sold to metal recyclers. No burning of electrical windings lacquer or paper is allowed onsite. Note: the copper in transformer windings is not used in any ingot manufacturing.
4. There are up to 12 staff employed onsite.

3.2 The Foundry and Casting Plant - Ventilation

1. The smelting operations for either copper alloys and ferrous materials are carried out usually every day. A ventilation system has been provided consisting of capture hoods over furnaces and casting areas to collect fumes coming off all parts of the operation.
2. The ingot and casting plant area has been sealed as part of the establishment of the ventilation system in order to prevent escape of fugitive emissions and to ensure make-up air drawn into the building is controlled.
3. The ventilation system operates continually while the smelters and furnaces are in operation and during the casting work into moulds. The system would only be shut down when the ingot and casting plant is not operating.
4. The extraction ventilation system in the ingot and casting plant is connected to hoods that can be extended during casting work to enclose work operation during the transfer of molten metal from crucibles to moulds. EKTIMO has conducted airflow measurements to determine the efficacy of the ventilation system to generate a negative pressure on the ingot and casting plant to minimise risk of fugitive emissions occurring. Refer to Clause 3.4 (page 8) for discussion.
5. Clingcast have provided an odour neutralising agent spray system to mist into the atmosphere above personnel and to mitigate any residual odour from operations.

¹ **PCB** - PolyChlorinated Biphenyl - an organic chlorinated compound once widely deployed as dielectric and coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids. Regarded as highly toxic to the environment and does not readily break down.



Photo #4 – Retractable hood over casting area. Note: hood can be extended to fully enclose moulds to ensure extraction ventilation system minimises fugitive air escape during casting

3.3 The Reverse Pulse Dust Collector/Baghouse

The baghouse is installed to operate under negative pressure with the main exhaust fan downstream of the baghouse. This arrangement minimises risk of air leakage under fan pressure from the ductwork and the baghouse. The following Table is a summary of the testing carried out by EKTIMO on the system².

Pollutant	Units	Limits under PEOA Regulations		Measured Value
		Group C ^a	Group 6 ^b	
Total Solid Particles	mg/m ³	100	50	4.9
Smoke	Ringelmann	1	1	0
Aggregate Types 1 & 2 substances	mg/m ³	-	1	<0.019
Cadmium	mg/m ³	-	0.2	<0.0005
Mercury	mg/m ³	-	0.2	<0.0003
Nitrogen oxides	mg/m ³	-	350	<4
Volatile Organic Compounds	mg/m ³	-	40	0.68
Odours	OU			<30

Table #1 – Summary of Treated Air characteristics exhausted from Baghouse

- a- Group C Limits as per NSW POEO Act – Clean Air Regulations as applicable to Clingcast operations
- b- Limits derived from NSW POEO Act – Clean Air Regulations. These are not considered to apply to Clingcast & are presented for comparison purposes only.

² EKTIMO Report to Clingcast (No R007620) 'Emissions Testing Report' dated 28/08/2019

3.4 Fan Performance & Pressure Tests on Foundry & Casting Plant

Exhaust Duct Diameter	Airflow	Air Velocity
1355 mms	18 m ³ /sec	13 m/sec (vertical)

Table #2 – Measured Exhaust Duct Diameter, Airflow & Velocity: Baghouse

Further testwork was carried out by EKTIMO to assess the negative pressure the exhaust ventilation system provided in the ingot and casting plant. The results showed that the sealing of the building and the operational processes in place that required closure of doors and accessways produced a significant negative pressure in the plant room, minimising the risk of fugitive emissions escaping the process area during smelting and casting³.

³ EKTIMO report (No 007621-1) dated 11/07/2019

4 DISCUSSION OF OUTCOMES FROM REVIEW PROCESS

4.1 The Site

The site is located within an industrial estate and adjoins other industrial activities ranging from auto maintenance and repairs shops – including panel beaters and spray painting – to warehousing and carpentry and joinery shops. The site is slightly elevated to other properties to the north and the west.

The free space between the buildings is limited and several of the buildings are in close proximity to each other. In some cases, distances between buildings on neighbouring blocks are approximately 2m. Consequently, there is no effective buffer zones between properties to help reduce odour dispersion and impact. These features contributed to Clingcast's decision to seal the plant area associated with the foundry and casting processes to minimise risk of fugitive emissions impacting on close neighbours. The added benefit of carrying out this sealing of the building was to be able to control where the make-up air for the ventilation system would be drawn from. This also ensured that the foundry and casting plant room would be under negative pressure that minimised potential for fugitive emissions. These actions by Clingcast were primarily undertaken to address possible odour impact from plant operations on neighbours.

Given the material volumes handled and manufactured onsite, the premises the plant do not qualify under Schedule 1 of the Act to be classified as a Scheduled Premises. The Schedule for Metallurgical Activities states:

- *Schedule 1 of the Act calls for premises to be scheduled for (ferrous) iron and steel production from scrap at a minimum of 10,000 tonnes per annum, and for non-ferrous materials the minimum throughput is 10,000 tonnes per annum.*
- *The (overall) plant and process to be scheduled under the Act is if the site has the capacity to process more than 30,000 tonnes per annum – if not carried out wholly indoors.*

While the Clingcast site under these prescribed product volumes, as per discussions in Clause 3.1 (page 7), the company is still obliged to conduct business and practice appropriate management functions to comply with the emissions requirements of the Act and its Regulations.

4.2 The Ventilation & Pollution Control System

EKTIMO's testwork on the ventilation system verified the following:

1. The ventilation system provides a good negative pressure environment within the foundry and casting plant room to minimise fugitive odour release beyond plant boundaries.

2. The baghouse operations appear effective – based on sampling and analysis of odours and gas speciation – in ensuring contaminants are well within regulatory guidelines. Refer to Table #1 (page 7). The odour analysis work indicated odour levels at less than 30 Odour Units (OU), which approximates ambient background odour levels in an industrial estate. These levels are also at the very low end of olfactometers used to measure odour strengths. The value given in the analytical work of less than 30 OU demonstrates odour measurement did not produce an absolute value due to likely olfactometry machine error/variance at these low levels of measurement.
3. Measurements taken on the vertical airflow in the stack indicated a duct velocity of 13 m/sec. The guidelines recommended by the EPA for vertical stack discharge is a minimum of 15 m/sec. Additionally, the stack is truncated close to the overall height of the baghouse itself (see Photo #1, page 4), which could cause some eddy airflow and turbulence around the baghouse, resulting in disruption of the upwards air discharge from the stack and causing possible downdraft of the exhaust air in certain weather conditions. An extension of the stack would help mitigate problems with stack discharge, while a cone or nozzle arrangement can be designed, fabricated and installed to increase airflow exit velocity above 15 m/sec. Additionally, the cone discharge end and greater stack height would reduce risk of eddy flows and turbulence from the surrounding close buildings. See this issue discussed below in Clause 5.1 (page 11). Better dispersion of the discharge would be provided with these measures, with the outcomes being a reduced risk of random odour impacting on neighbouring properties from the Clingcast site operations.

4.3 Process Management Practices & Procedures

1. Clingcast adhere to a set of Operating Procedures within the foundry and casting room that firstly provides proper Occupational Health and Safety practices, and secondly provides measures that are aimed at mitigating risk of odour generation and escape that may impact surrounding properties.
2. Clingcast deploys an Odour Neutralising Agent (ONA) as shown in Photos 2 & 3 (page5) during the molten metals discharge from the furnace into the crucibles for then pouring into the moulds. However, the materials used in the foundry are not generators of odour, albeit there can be a slight detectable low strength odour associated with foundry operations. What would be more of a concern would be the contaminant levels of heavy metals in the vapour phase captured by the ventilation system. EKTIMO's testwork indicated that the treated levels discharged from the baghouse are well within guidelines as per NSW EPA Clean Air Regulations. Refer to Table #1 (page 7). Clingcast are very clear in their practices to not utilise any greased, painted or galvanised metals in their foundry work, as these materials would potentially impact on the quality of castings. This selective practice in the use of smelting materials provides an additional benefit with respect to air quality issues in the foundry operations. The rejection of contaminated feedstock metals minimises risk of certain materials escaping the furnaces in the vapour phase and possibly causing odour issues.

5 CONCLUSIONS

5.1 Treated Air Discharge Plume

The air discharge from the baghouse would always potentially be the prime source of air emissions from the site. Based on the data generated by EKTIMO from their testwork, this baghouse meets the Clean Air Regulations of the Act as administered by NSW EPA.

The points made in clause 4.2, item 3 (page 10) would be an advised modification to the plant that would reduce risk of errant odour due to turbulence, etc.

The following is a short discussion on the nature of air movement around buildings, the turbulence that can be caused due to the structure, and how that effects air that is exhausted from the building. The following points are made:

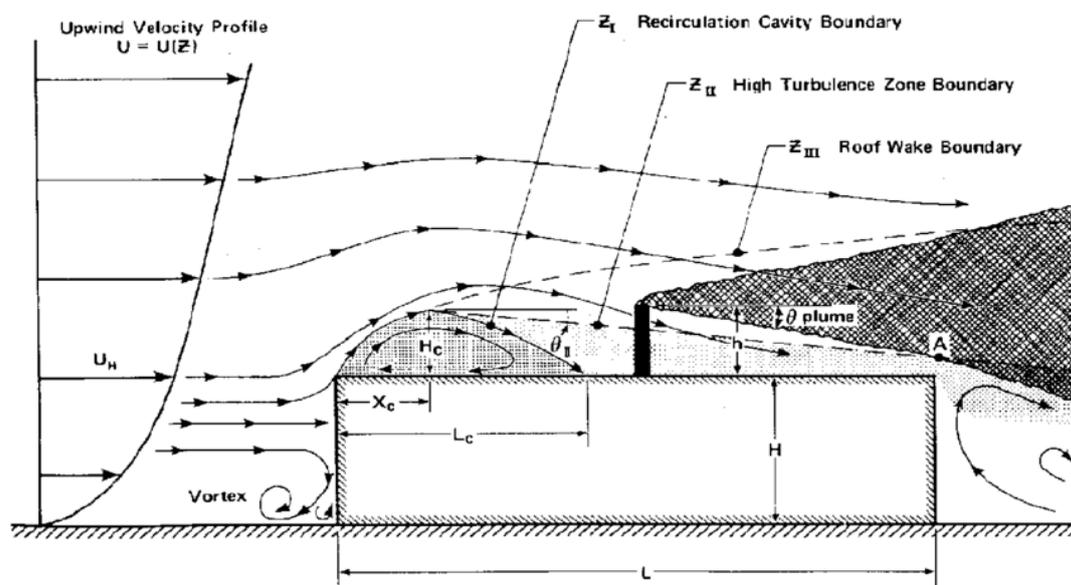


Diagram #1 – Effects of Airflow around a building

- Diagram #1 illustrates how airflow around a building can impact the exhaust from building ventilation of plant processes. There is an eddy zone caused by the airflow hitting the side of the building, and consequently the dispersion of exhaust air from the building, if caught in this eddy zone may result in contaminants building up on the roof or being drawn into the areas where air pressures are less on the lee side of the building away from the airstream. This can result in building emissions being brought down to ground level resulting in complaints from neighbours of odours and contaminants in the air descending onto their premises.
- These airflow conditions and building wakes as discussed occur in mild or slow wind conditions that prevent residual odours and contaminants in air to readily disperse. At higher velocities, dilution and dispersion occur more readily and this helps mitigate against odour complaints.

- The intent of good stack design is to ensure that the exhaust air is discharged vertically from a high stack with the exit velocity ensuring the air is released into airflow least affected by the building or surrounding structures. Often a tapered nozzle will be fitted to a stack to ensure that the exhaust velocity is sufficient to prevent air being caught in an eddy zone at or adjacent to the building. Exit velocities for such stacks are recommended by NSW EPA Guidelines at 15 metres/second - as a minimum.
- Studies in airflow around buildings and building plumes have shown that the eddy zone can be as much as 2-2½ times the building height⁴.
- A feature that is not recommended for discharge stacks is the installation of caps or weather cones that purport to stop rain entering the stack. There has been considerable research conducted on this matter, and it has been found that rain won't enter a stack with the exit velocities used as recommended. The cap or cone causes disruptions to good airflow and if stack drains are necessary due to (say) intermittent usage of the stack, then appropriate drainage connections for any collected stormwater should be used.
- The use of high exhaust stacks is sometimes considered an eyesore by neighbours who pressure the plant owner and regulatory authorities about the visual 'pollution' of such plant systems. It is clear that most complainants do not appreciate the functions of stacks and how their design and construction is conducted to prevent them being exposed to undesirable air quality issues emanating from the plant. Hence a discussion and clarification of the reasons for such stack design is necessary while the plant designers need to ensure wherever possible, the stack design is aesthetically pleasing, and perhaps the stack can even be made as an architectural feature.

5.2 Management Practices & Plant Operating Procedures

The review of management practices and plant operating procedures highlighted the following:

- The plant ventilation system has been shown through testing to minimise risk of any fugitive emissions escaping the plant during foundry and casting operations. Testing of the treated air discharge from the baghouse demonstrated the plant's capability to perform well within Clear Air Regulatory Guidelines. Odours are a minor component of the overall matrix of the captured ventilation air and good discharge and dispersion from the pollution control plant stack as discussed above would be enhanced by the suggested increase in stack height and exit velocity.
- The plant management policy of not utilising contaminated metal feedstock in the foundry process also contributes to decreasing the risks of unwanted contaminants and associated odours in the airstream. Values obtained for odour strengths if representative of the continual process, are similar to background or ambient odour levels found in industrial estates.

⁴ 'Airflow around Buildings' – John H Clarke, Union Carbide Food Products Division

- The site management have installed weather monitoring equipment that can be used to examine if odour complaints are made against their operations, with the time and date of the complaint assessed as to whether the emissions may or may not have originated from their site. It is recommended the company formalise this process as part of standard management practice, and appropriate records in the form of an odour complaints register be kept as part of being able to respond to community concerns.
- The issue of possible cumulative impacts is unlikely due to the nature of the operations. The source of contaminated air is only from the foundry and casting plant, and unless site operations were to change – which would be a required amendment to their Development Application and site permits – this issue is not expected to occur.

APPENDICES

Envirodyne Group – Air & Water Quality Specialists

The following is a CV of the work conducted by EDG on Air Quality issues.

Experience in Air Pollution Control Work

The following is a resume of the undersigned in air pollution control work undertaken within Australia on boiler plant emission systems, dust collection, and gas scrubber emissions control particularly sulphur based gases, and the conduct of air emissions and air quality studies, including predictive dispersion modelling for regulatory compliance and verification of plant performance.

1) (Examples of) Air Quality Studies

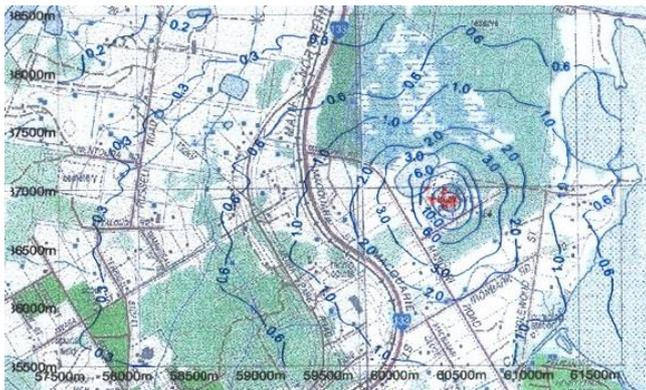
- Airshed study for the relocation of Vesuvius refractory plant to Port Kembla NSW – involving the prediction of dust emissions from new plant on existing airshed including adjoining local community.



Dust emissions modeling results for dispersion in micrograms/m³ for 99.5 %-ile impact as required by regulations. Work undertaken in 2011

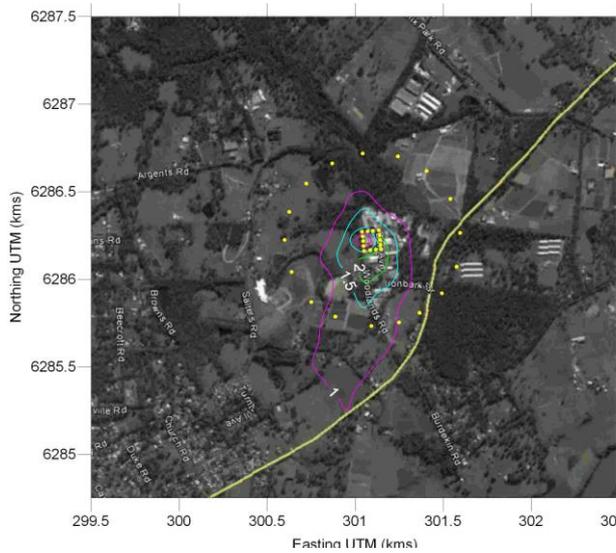
EDG can provide modelling in AUSPLUME or CALPUFF depending on client's requirements.

- Airshed study for odour emissions from upgrade work on sewage treatment plant – Dora Creek NSW.



Odour emissions study for Dora Creek STP upgrade as required for environmental compliance requirements. 99%-ile impact. Work undertaken in 2010

● Emissions Impact from Hypro Pet Food Products from new plant, Wilberforce NSW



- CALPUFF Modelling utilising 300 99%-ile criterion for odour impact.
- The model isopleths indicate no odour impact beyond the 500 metre reference line.
- Work undertaken in 2015-16

2) (Examples of) Sulphide Gas Scrubbing

● Malabar STP (NSW): optimisation of scrubbers to 99% removal of sulphide gases using sodium hydroxide and sodium hypochlorite.



*Scrubber system: 225m³/sec of air off wastewater treatment and solid waste processing – 6 scrubber units (5 online, 1 standby)
 Plant power requirements: 1 MW,
 Chemical consumption: NaOH: 10 tonnes/day, NaOCl: 7 tonnes/day,
 Performance: 99% removal of organic and inorganic sulphides*

● Pimpama STP (QLD): design installation & commissioning of scrubbers at Gold Coast STP



*Scrubber system: 20 m³/sec off wastewater treatment and solids waste processing.
 Performance: 95% removal of sulphur based odours 99%-ile impact*

● Warriewood STP (NSW): installation & commissioning of scrubbers



*Scrubber system: 30 m³/sec off wastewater treatment and solids waste handling and treatment.
Performance: 95% removal of sulphur based odours
99%-ile impact*

● Other Sulphur based odour scrubber systems:

- Liverpool Organics Waste Handling & Treatment Scrubbers (NSW),
- Castle Hill STP (NSW) Scrubbers,
- Coniston STP (NSW) Scrubbers,
- VISY Waste Handling Plant Boilers Station: Scrubbers & Dust Collectors (Smithfield NSW),
- East Melbourne (VIC) WWTP Scrubber Upgrade Investigation & Report,
- ICI Botany (NSW) sulphur scrubbing for naphtha cracking and processing,
- Coombabah (Gold Coast QLD) WWTP: scrubbers for Organic Waste Processing

● Hydrocarbon Removal Systems

- ICI-Dulux: Control hydrocarbon emissions from Tank Farm Pumping and Transport Loading
- Hypro Pet Care Products: Control of Acetone and other hydrocarbons from Grain Cooking

3) Other Matters

The undersigned has been a practicing professional engineer since 1979 after graduation with a Bachelor Degree in Engineering, from the University of NSW.

The undersigned has delivered papers on air quality issues to local and international forums with subjects as follows:

- ❑ *Sulphur based Foul Air Scrubber Optimisation (WEFTEC Conference, Dallas Tex. 1996),*
- ❑ *Monitoring Systems for sulphur based emissions monitoring, and the application and adaptation of existing technologies to very low level (ppb) monitoring requirements (WEFTEC Conference, Singapore 1999)*
- ❑ *the evaluation and control of sulphur based corrosion in industrial plant & wastewater systems (SWC -1998)*
- ❑ *the application of automated online monitoring systems in remote applications for Environmental Risk Management purposes (BESA 2009, Sydney)*
- ❑ *Carbon Emissions Trading Markets – the implications of proper auditing processes (BESA 2010, Brisbane)*
- ❑ *Water Treatment Issues for the Developing World (BESA 2011, Sydney)*

The undersigned is a member of Australian Water Association, Waste Management Association of Australia, and is a Fellow of the Institute of Minerals, Mining and Materials (London).

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Mike O'Brien - CV

The following is a CV for the report's author and his work as a Director in EDG.

CURRICULUM VITAE

Michael O'Brien

- Environmental Consultant
- Air & Water Quality Specialist
- Project Manager
- Company Director



Career Summary:

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Education:

- Mech. Eng. Certificate
(Sydney Tech. College, 1972)
- B.Sc Eng. (Mech.Eng), (Uni NSW,
1979)

Professional Affiliations:

- Waste Management Assoc. Aust. (WMAA),
- Aust. Water Assoc. (AWA),
- Clean Air Soc. Aust & NZ (CASANZ),
- Fellow Inst. Minerals, Mining & Metallurgy
London (IMMM)

- Experience across public utilities and commercial enterprises in mechanical services, environmental compliance, asset management and project delivery,
- Team leadership on projects involving innovation to improve industrial plant and utilities systems performance, improve operational integrity and reduce risk of breaches in environmental compliance,
- Conduct of research and development projects into environmental compliance through better monitoring, improved water and wastewater treatment with reduced capital expenditure and emissions,
- Liaison with corporate and utilities management in policy development and strategies to achieve effective use of resources with minimal negative impact on communities.

Key Highlights

Engineering Research & Development

Self-managed programs and assistance to associated companies in air and water quality management:

- Patented **HydroSentinel™** remote automated monitoring systems to reduce risk management on plants of exceeding environmental compliance limits. Product deployed successfully in water utilities to monitor Trade Waste discharges to sewers. (2007 to 2010)
- Collaboration on the Introduction of **Mycelx™** oily water treatment technology from USA into improved industrial wastewater treatment. (2008 til now)
- Collaboration with **Zeolite Australia P/L** into the effective use of zeolite based media for water filtration and wastewater treatment. (2010 til now)
- Development of **EnviroSil™** non chlorine based disinfectant for use where traditional disinfectants (e.g chlorine) are not preferred. (2015 to 2016)
- Development of an automated **packaged solar powered water treatment system** that can be readily and quickly deployed in remote locations. Plant is remotely monitored and controlled by **HydroSentinel™** technology. Product currently producing 3,500-4,000 Litres/day in demonstration phase prior to full commercialisation. (2016 til now)
- Engaged as a visiting Research Fellow at Western Sydney University, project managing development work on novel water treatment technologies (2019).

Project Management & Delivery

Clients:

- Kelloggs Botany NSW
- Assoc. Pulp & Paper Mills
- Minter Ellison Lawyers
- Sydney Water
- Other Water Utilities (listed)

- Team Leader in Sadcam Holdings delivering mechanical services in the refurbishment of the Kelloggs cereal plant, Botany NSW. (1984 to 1987)
- Project Management, Bomaderry Paper Mills - responsible for paper waste handling plant installation, paper embossing plant installation, development of new coal handling facilities and wastewater treatment plant. (1990 to 1991)
- University of WA vs WA Water Corporation - providing technical support to Minter Ellison Lawyers for mediation/litigation matters surrounding malodour emissions impacting the Uni of WA land by the Subiaco WWTP. (2000 to 2004)
- Delivery of engineering solutions into Sydney Water Sewage Treatment assets for air emissions (odour) control and sewer corrosion. (1995 to 2003). *Note: this work lead to similar work in Melbourne Water, Gold Coast Water, Brisbane Water (now QUU), & consulting with Worley Parsons, United Water, Parson Brinckerhoff (1998 to 2010).*

Plant & Business Management

Clients:

- ICI - Dulux
- Folded Web Beams
- ICI Aust

- ICI Paints - Dulux (Cabarita) - Site Engineer responsible for project and maintenance operations. (1980 to 1984)
- Folded Web Beams P/L - (Operations Manager) - help to establish and operate a patented light weight fabricated steel beam business in Mittagong, NSW (1987 to 1989) – development of supplier networks, production/fabrication teams, onsite assembly and management.
- ICI Australia - Botany site - *Plant shut down project management* (1989 to 1990)

Technical Publications & Presentations

- *Foul Air Scrubber Optimisation (WEFTEC Conference, Dallas Tex. 1996),*
 - *Monitoring Systems for waste handling processes, and the application and adaptation of existing technologies to very low level (ppb) monitoring requirements (WEFTEC Conference, Singapore 1999)*
 - *the evaluation and control of corrosion in wastewater systems (SWC 1998)*
 - *the application of automated online monitoring systems in remote applications for Environmental Risk Management purposes (BESA 2009, Sydney)*
 - *“Carbon Emissions Trading Markets – the implications of proper auditing processes” (BESA 2010, Brisbane)*
 - *Water Treatment Issues for the Developing World (BESA 2011, Sydney)*
 - *Water Treatment Technologies & Applications for South East Asia (Jakarta 2014)*
 - *CHEMECA Environmental Conference (Perth 2014)*
-