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Karl Fetterplace
Department of Planning, Industry and Environment
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12 May 2020

Reference: 22201

Dear Karl,

Subject: Hanson Glebe Island Concrete Batching Plant – Response to TAS Air Quality Review

Please find detailed below our responses to the Todoroski Air Sciences (TAS) commentary on *Hanson Glebe Island Concrete Batching Plant Air Quality Assessment*, ('the AQIA') as conducted by ERM, (formerly Pacific Environment), (PE, 2018).

The TAS commentary is documented within *Glebe CBP – Review of Response to Submissions* (TAS, 2020). For ease of context, we have incorporated prior commentary on the issues raised, with the following formatting:

- *Prior PE Response (as quoted within TAS, 2020) – Light grey italic font.*
- *The most recent TAS response (TAS, 2020) – Light blue italic font.*

Note that there are key aspects of the TAS commentary that we are in full agreement with, namely:

"*in general, concrete batching plants can operate with relatively low emissions, the project is well located relative to residential receptors and thus it is likely that the requested information may confirm the project could operate without undue impact"* (TAS, 2018); and

"based on our experience with such plants, we consider that it is reasonably likely that with adequate controls the plant would be acceptable" (TAS, 2020).

The above opinions are additionally supported by the review by the NSW EPA Air Technical Advisory Service Unit (ATASU) in 2018, where no material issues with the assessment were raised. This was additionally confirmed in the letter from February 2020 that states that the EPA has no further comments regarding air quality.

The latest correspondence from TAS is not outcome-focussed and, save for the above sentence, lacks perspective in terms of environmental risk.

The following clarifications are intended to provide the DPIE with adequate assurance that the PE, 2018 assessment is both appropriate and technically robust.

In the event that DPIE wish to seek further resolution of residual air quality assessment issues, we respectfully request that a meeting be arranged with DPIE and the NSW EPA ATASU to discuss.

We hope that this provides appropriate clarification of the outstanding issues raised. Please do not hesitate to contact me should you have any questions.

Kind regards,

D.A. Roddis

Damon Roddis
Partner – Air Quality and Greenhouse
Certified Air Quality Professional (CAQP)
Certified Environmental Practitioner (CEnvP)

1 Choice of model in context of unlikely representative meteorological data availability

The reviewer suggests that an alternative model should be selected based on the site's 'coastal location'. Glebe Island is in no way a coastal location, and neither are its adjacent inner-west residential suburbs of Pyrmont and Rozelle. It is acknowledged that the OEH Rozelle meteorological data do not meet the siting requirements of AS 2923—1987 (Guide for measurement of horizontal wind for air quality applications). However, the data represents a long-term local data set in the vicinity of the facility, shows winds from all directions under all seasons, and importantly, shows calm wind speeds (i.e. winds <0.5m/s) in excess of 20% year-on-year. On this basis, it is considered that both the meteorological data and the dispersion model selected are fit for purpose (the purpose being to conservatively evaluate potential off-site PM impacts from a relatively minor source, dominated by non-buoyant fugitive sources, with line of sight from source to receptor).

This response does not adequately address the issues raised in the independent review and is based on factually incorrect or misleading assertions in regard to the key matters. For example, Figure 7-2 in the AQA presents the 2015 windroses for Rozelle. The annual and seasonal windroses do not show "winds from all directions under all seasons". The figure clearly shows almost no winds from the southwest to west which indicates that there is likely sheltering from the very large, nearby tree in this direction.

These data significantly bias the wind data used in the assessment and will lead to invalid results when used with AERMOD. This issue could be overcome by the use of an alternate model such as TAPM, CALMET and CALPUFF, which is more suitable for dealing with the locality. The lack of supporting evidence for selecting the 2015 year to be representative of conditions is not responded to.

The updated TAS commentary is not supported. As shown in the wind roses, a balance of winds across all directions is captured across all of the seasons. It was not intended to state that all wind directions were captured within each individual season.

To provide context on the suitability of these winds, a comparison against the Bureau of Meteorology (BoM) Sydney Airport automatic weather station data was undertaken for the year 2015. These data are shown in Figure 1 (in green) as annual and seasonal wind roses alongside date from the DPIE Rozelle data (blue).

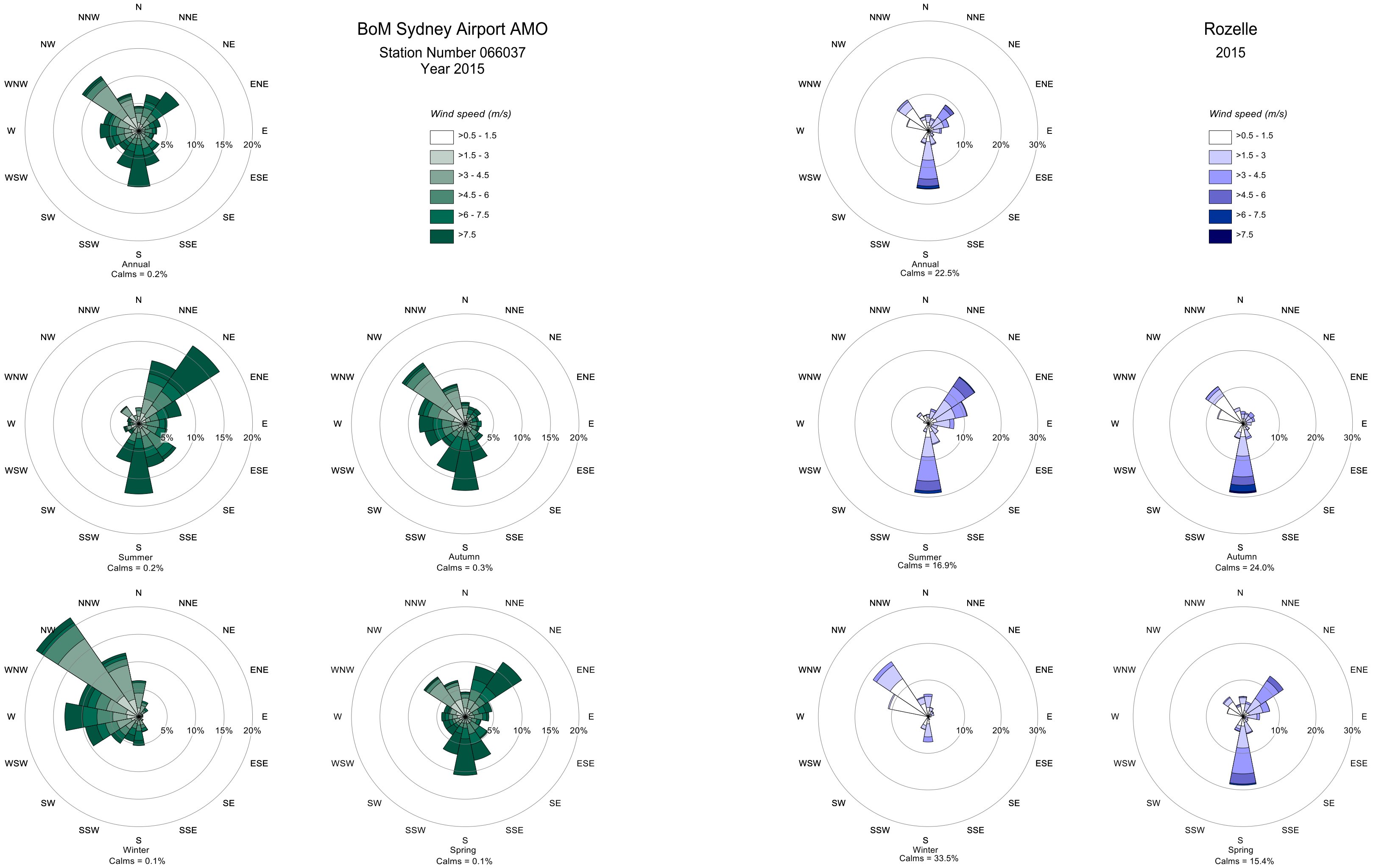

Figure 1 – Comparison of 2015 Wind Roses – BoM Sydney Airport and DPIE (formerly OEH) Rozelle

Given the highly exposed nature of the Sydney Airport weather station, wind speed frequency distributions at the airport are not considered representative of the DPIE Rozelle Air Quality Monitoring Station (AQMS) or the Site. However, data from this location is instructive in identifying dominant wind flows within the Sydney region, as defined by regional terrain and land use influences in conjunction with the balance of synoptic conditions experienced across the year. Visual differences in representation of non-dominant winds are due to the higher proportion of calm winds at Rozelle (as expected in a non-coastal urban setting). Calm winds (of less than 0.5 m/s) are excluded from the wind rose charts.

Figure 1 shows a consistency in dominant winds across annual and individual seasons as per the following:

- Dominance of north-easterly and southerly winds in summer (both Sydney Airport and Rozelle charts)
- Dominance of north-westerly and southerly winds in autumn (both Sydney Airport and Rozelle charts)
- Dominance of north- westerly winds in winter (both Sydney Airport and Rozelle charts)
- Dominance of southerly and north-easterly winds in spring (both Sydney Airport and Rozelle charts)
- Low frequency of south-westerly winds (both Sydney Airport and Rozelle charts).

On this basis, the statement "*These data significantly bias the wind data used in the assessment and will lead to invalid results when used with AERMOD*" is not supported, noting that agreement with regional winds is shown both annually and seasonally. Further, the low frequency of south-westerly winds is considered representative of the region, and not due to the presence of a tree near to the DPIE Rozelle AQMS.

Notwithstanding the above analysis, it is also noted that within AERMOD, dependence on wind direction is significantly diminished during calm conditions (which represent the worst case dispersion for non-buoyant volume sources). This is since under low wind speed conditions up to 95% of the emission mass is allocated into a uniform radial (meander plume) that is independent of wind direction.

Furthermore, it is also noted that there are no sensitive receptors to the north east, hence any under-representation of south-westerly winds (although not present) would not influence the outcomes of the assessment.

With respect to the comment on the selection of modelling year, the assessment presents and considers five years of meteorology on the basis of wind speed and wind direction frequency distributions. Within this process, 2015 is nominated as being absence of anomalous wind conditions. The above approach is consistent with standard practice and the processes nominated within *The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2016), ('the Approved Methods').

2 Omission in the modelling of site dust emissions

The reviewer claims that air assessment states "the building will be ventilated to ensure that the inside of the building complies with WHS air quality standards, filters will be applied to the ventilation system to ensure the expelled air is able to meet EPA standards". The air assessment makes no such statement, and it is unclear why the reviewer has included this commentary. No such commitment has been provided for the purposes of assessment. In any event, it is not *anticipated that any additional PM emission source associated with post-filtration air from the building would make a material difference to the air assessment outcomes.*

There was a typographical error in the TAS independent review, the quoted statement is made in Section 3.1.2 of the EIS (not the AQA). The statement in the EIS confirms that the AQA omits this point source of emissions (i.e. a stack or vent) in the modelling. This omission is unacceptable as it means that the emissions and impacts from the facility have been underestimated. It is especially problematic in this case due to the presence of significantly elevated receptors (apartments) nearby, which are more likely to be impacted by emissions from a point source, than from the modelled types of sources.

For clarification, the referenced comment (within the EIS) states that ventilation will be filtered to ensure emissions are compliant with EPA standards, and do not adversely impact the surrounding occupational environment. It does not commit to the technology, which at its simplest may comprise a fabric sock or other filtration device.

Within the AQIA, a ventilation emission stream has been modelled at an assumed concentration of 50 mg/Nm³, equivalent to the regulatory emission limit contained within the NSW *Protection of the Environment (Clean Air) Operations Regulation, 2010*. This source is documented in Appendix A as “residual from de-dusted air loading cement and fly ash”.

The original intent of this source was to emulate the baghouses at the top of cement and fly ash silos, which will periodically discharge (fabric-filtered) silo air upon silo filling. However, given this source is assumed to be operational continuously within the modelling, it could equally represent the source that the reviewer considers is absent.

Given the occupational Time-Weighed Average (TWA) worker exposure standard of 10 mg/m³, dust concentrations within the building will be necessarily managed to below (five times below) the assumed emission standards, and would thus not require filtration prior to release to atmosphere.

The reviewer’s concern for impacts upon ‘significantly elevated receptors’ is unfounded. The reviewer appears to confuse the (likely horizontal) discharge of air at effectively ambient temperature with the impact potential of a thermally buoyant industrial combustion source. To be clear, there is no thermally buoyant combustion source associated with the building in question.

3 Omission in the modelling of… ...potentially significant ship main engine emissions

As noted in Section 6.4 of the air assessment, Emissions from the main engine have not been included as this would only be engaged intermittently, and on approach / departure from the site. Consistent with other similar assessments completed within Sydney Harbour, it is thus considered beyond the geographic scope of the assessment of the Project.

The AQA also appears to apply incorrect assumptions about how ships are required to operate. It is our understanding that for safety reasons the main engine of a berthing ship is required to be running until the ship has berthed, this process generally takes approximately 15 to 30 minutes. It is also understood that it is necessary for the main engine to be running for approximately an hour before leaving the dock, in order to allow enough time to reach operating temperature.

No evidence to back up the contrary ERM assertion is provided in the ERM response. Thus, we advise that the main engine emissions are potentially a significant source of emissions, and have not been included in the AQA.

The AQIA has focused on emissions from the auxiliary engines and boiler on the basis that these comprise the key emission sources, and are anticipated to operate on a near continuous basis when ships are at berth.

Limited detail is available regarding the specific operating practices of the ships that are proposed to service the Project. The study *Exhaust Emissions from Ships at Berth* (Cooper, 2003) details emission measurements and estimates for six large ships at berth, including three passenger ferries, and three cargo vessels, inclusive of a chemical tanker of 115 m length, which is consistent with the scale of bulk carrier that is anticipated to service the project.

The study concludes:

> "*Besides Auxiliary Engine (AE) emissions, other emissions from boiler use and possible Main Engine (ME) warmup prior to departure were in general considerably less than those from the AEs, but can be significant especially for SO_2 if different fuel qualities are used.*"

Within Cooper (2003), main engine warm-up emissions[1] were estimated at 1.2% of total NOx, 15% of total PM and 33% of total SO_2 over average berthing durations in the vicinity of 10 hours.

Noting the implementation of low sulphur fuels under MARPOL Annex VI since 2020, the SO_2 commentary is not considered of significance. This is since the MARPOL fuel standards have resulted in a substantial reduction in SO_2 emissions from ships in berth compared to that detailed within Cooper (2003). To further investigate this issue, an emission estimate was undertaken for warm-up using the emission methods referenced in the AQIA (ICF, 2009).

Assuming 5% load during warm-up, operation on marine gas oil, and main engine capacity of 3,384 kW (CSL Elbe), NO_x emission rates during warm-up would be moderately (50%) higher than the auxiliary engine emissions modelled at a much higher frequency in the AQIA, whilst PM and SO_2 emissions are estimated to be approximately 50% and 28% of those assessed from auxiliary engines in the AQIA. Emissions from idling during arrival are expected to be of the same scale, albeit shorter in duration.

Given the short-term, intermittent nature of these operating conditions, and the small scale of key pollutant emissions, the potential for these emissions to produce adverse air quality impacts is considered minor, and insignificant in the context of existing port use.

4 A detailed emissions inventory needs to be provided

The emission inventory developed for the project is covered in appropriate and sufficient detail for the purposes of technical review within Section 6.

As stated in the independent review, the total estimated emissions for the Project appear to be generally sensible however we cannot comment on the accuracy of the emissions estimations for the Project due to a lack of basic information.

Assumptions regarding parameters such as vehicle kilometres travelled (VKT), gross vehicle mass, moisture content etc have not been provided and thus the calculations cannot be reviewed or verified. It is noted that other aspects of the assessment cannot be checked due to a lack of basic

[1] For ships capable of warming up at berth. Large ships of a fixed propeller shaft design were noted to be incapable of warming up at berth.

information and an emissions inventory. For example, wind erosion from exposed areas is listed as a significant source of dust in Appendix B1.1 of the AQA however this source does not appear in the emissions estimation in Section 6 of the report.

A summary of the modelled particulate matter (i.e. non-combustion source) emission inventory has been provided in Appendix A. Combustion source emissions are as documented within Section 6 of the AQIA.

5 How vehicle exhaust emissions were calculated/ derived should be set out

The approach to vehicle exhaust emission estimation is provided in sufficient detail for the purposes of technical review within Section 6.3 of the air assessment.

The data provided do not contain sufficient information with which to check the calculated emissions. For example, the available public information referred to in the AQA does not contain the emission factors used in the assessment.

Furthermore, there are also issues with the truck numbers and this impacts the emissions calculations. Please refer to comments below specifically regarding the uncertainty around truck numbers.

The only conclusion that can be made with the available data is that there is a significant error in the AQA emissions calculations, and a large potential for underestimation of the emissions and hence impacts.

The adopted vehicle emission factors have been documented in the assessment. This has been based on the NSW EPA's vehicle emission spreadsheet. Assumed vehicle distances (VKT) have been provided in the detailed emission inventory (Appendix A). Please refer to Response 7 for the clarification of the modelled truck numbers.

6 Clarify if and how emissions associated with raw aggregates dispatched from the site have been taken into account

As noted in Section 2.2.1.3 of the air assessment, Aggregates not used in the batching of concrete on the Site will be dispatched from the storage silos by conveyor directly for loading to an aggregate truck for dispatch to another concrete batching plant. These truck movements are accounted for within the stated truck movement numbers.

The above response simply asserts that truck movements associated with aggregate dispatch have been accounted for and no information, explanation or evidence is provided to show how this has been done.

It remains unclear whether potentially significant sources of emissions have in fact been included in the modelling. For example, Table 6-1 lists "material handling – conveyor to aggregate storage bin" and does not present emissions for conveying aggregate to trucks.

As it stands, the available information indicates that significant emissions were not included and presently it can only be concluded that the assessment has underestimated a significant source of emissions, and hence underestimates the potential impacts.

Trucking volumes associated with this operation have been captured in the emission inventory, which has focused on the concrete production stream. In view that aggregate truck loading will occur within an enclosed building, any particulate matter emission associated with aggregate transfer process is anticipated to be minor in the context of the site operations, already accounted for within the emission inventory conservatism, and thus not material to the assessment outcomes.

7 Clarify the apparently incorrect truck numbers in Table 6-2 of the AQA

Truck numbers are not incorrect; rather, within the table 6-2, a maximum of 24 Peak operational days have been assumed, and the Peak trucks per day have been multiplied by this value. For Normal trucks per day, the annual truck values have been derived by multiplying by 365. It is noted that, in any event, no assessment of Peak day impacts has been provided on an annual basis, since this is not a reasonable scenario for assessment.

While it is stated in Section 6.2 of the AQA that "For the peak operational 24 hour assessment it is assumed that the peak production rates will occur for every day of the year" it is not clear that the peak scenario has adequately assessed truck numbers.

Consistent with the statement in Section 6.2 of the AQA, in order to model the maximum daily number of trucks for any day of the year, the daily maximum truck numbers should be multiplied by 365 days when input into the emissions inventory (i.e. for concrete trucks 7,576 x 365 = 2,765,240). This is necessary to prevent underestimation of the hourly emissions rate when modelling this situation as is claimed i.e. "…for every day of the year".

However, only a "trucks per year" value has been presented for peak operational days and this is based on truck activity on only 24 days of the year (7,576 x 24 = 181,824) not every day of the year, and the value is not representative of the trucks per year for either the normal or peak scenarios.

Also, Figure 6-1 of the AQA presents the hourly truck profile for the peak operational day scenario. This figure is inconsistent with the trucks per day presented in Table 6-2. For example, it is stated that there are 7,576 concrete trucks per day for the peak scenario however the figure indicates that there are only approximately 700 concrete trucks per day for the peak scenario, an approximate tenfold underestimation of a key source of emissions.

It thus appears that there is a large underestimation in the quantum of activity that should have been modelled, hence it appears that there is also a large underestimation in the emissions and impacts assessed in the AQA.

Based on the available data, it is not possible to verify that the correct truck numbers have been modelled for the peak scenario. The assessment and response do not provide adequate information to clarify or explain the issue.

As there appears to be large inconsistencies in the data presented in Section 6.3, it is concluded that the peak daily emissions from trucks may have been significantly underestimated in the modelling, and this would lead to underestimated impacts.

Review of the documentation has indicated an error in tabulated trucking volumes within the AQIA. It is noted that the volumes applied in the dispersion modelling correctly reflect the traffic estimates provided by Hanson, hence the reported dispersion modelling predictions are considered appropriate. Table 1 summarises the modelled trucking volumes, as reflective of the data provided by Hanson, and consistent with the modelling parameters used in the AQIA.

Table 1 – Summary of modelled traffic volumes

Activity	Normal Day		Peak Day	
	Trucks per year	Trucks per day (Average)	Annualised Trucks Per Year	Trucks per day
Concrete trucks	181,818	498	251,485	689
Cement tanker trucks	8,439	23	12,775	35
Sand trucks	27,211	75	87,965	241

8 Potential underestimation of impact at elevated receptor locations

As noted in Table A-1, several discrete receptor locations have been awarded significant elevation (e.g. Balmain Public School; 42m AHD). Assessment at these elevated receptor locations will adequately capture the potential for elevated impacts at nearby receptors.

The response does not adequately respond to the issue that was raised, which is about a failure to adequately model the impacts at nearby high-rise apartments.

The potential for elevated impacts particularly from point sources has not been adequately assessed at the high-rise residences in Pyrmont (noting the additional factor of the omitted point source of emissions from the site, as discussed above).

Receptor R2 at Pyrmont was modelled at an elevation of 15.4m, however the residential apartment buildings in this area are up to approximately 20 storeys tall (approx. 60m) and therefore the maximum potential impact has not been adequately considered.

These nearest high-rise receptors are approximately 250m away and are approximately 20 stories high, whereas Balmain Pubic School is approximately 1,000m away and is 3 stories high, or approximately 10m high. The School is on ground that is approximately 40 to 45m high (depending on the source of height data).

Modelling a school as a ground level receptor point in a location approximately 1,000m away and in a different direction to the nearby approximately 20 storey apartments, in the context of omitting point source emissions at the site is not adequate to capture the potential for Project impacts at the nearby high-rise receptors.

To assert that the modelling in the AQA is adequately dealing with the issue raised in this regard can only be a serious lapse of competency or otherwise a deliberately misleading statement.

The modelling has included receptors across the modelling domain inclusive of a range of elevations. Noting the non-buoyant diffuse nature of the assessed emission sources, elevated receptors are not considered to be of key relevance.

As noted above, the reviewer appears to confuse the near-ground level discharges at effectively ambient temperature with the impact potential of a thermally buoyant industrial combustion source.

The suggestion that particulate concentrations associated with a non-buoyant source some 250m away may be greater aloft (e.g. at the height of a 20 storey apartment building) is not considered credible.

9 Selection of background data, and apparent omission of some site emissions, and existing industry, shipping and residential pollutant levels in the cumulative assessment

As noted within the assessment, and acknowledged by the reviewer, existing operations nearby are accounted for in the background air quality measurements referenced. The reviewer has queried the use of Rozelle monitoring data over WBCT data; ultimately the former has been referenced since it represents a much larger, yet representative, data set, indicative of background air quality. ERM maintains the WBCT monitoring station and provides monthly reports in the public domain that include instrument performance relative to OEH Rozelle. Mindful of this information, it is not anticipated that the outcomes of the air quality assessment will be materially affected through using this alternative data source. As the reviewer concludes; "in general, concrete batching plants can operate with relatively low emissions, the project is well located relative to residential receptors and thus it is likely that the requested information may confirm the project could operate without undue impact".

ERM has not provided any reasonable explanation as to why the actual, on-site WBCT data have not been used for background PM2.5. It is not clear why being mindful of ERM's maintenance of the WBCT monitor, or a baseless assertion that using a year of data taken from a set of longer term more distant data is better than using a year of actual site data would have any bearing on the outcomes of the AQA.

Also it is unclear why the local on-site data nearest to the receptors in question would be the "alternative data" in preference to more distant data which do not represent the local unmodelled sources of emissions that are represented in the local on-site data.

This adopted approach is contrary to the EPA Approved Methods (2016), which state: "The background concentrations of air pollutants are ideally obtained from ambient monitoring data collected at the proposed site. As this is extremely rare, data is typically obtained from a monitoring site as close as possible to the proposed location where the sources of air pollution resemble the existing sources at the proposal site."

While the data set at the Rozelle monitor is "larger" this does not make it more representative than the local WBCT station data which are collected near to the closest receptors north of the project and include the local sources of air pollution that resemble the existing sources at the proposed site, and are part of the existing background air quality levels at nearby receptors.

Issues raised in the review regarding the selection of the background data are not answered in the response, for example:

- *why the full year of WBCT data are not used, and instead another limited two-week period of data is used for evaluating the suitability of the Rozelle data;*
- *an explanation of the non-sensical "cake and eat it too" logic used in the AQA to select the Rozelle data. Regarding the WBCT monitoring station, the AQA states; "the data recorded by this station may also be considered representative of the air quality in the study area" but then selects a station further away, contrary to the Approved Methods Guidelines.*
- *Why the presence of domestic wood heaters at the WBCT station (which are only potentially present on one side of the station), is somehow not representative of the air quality receptors.*

More importantly, closer inspection however also reveals that the AQA has not used the correct Rozelle data values in making its assessment. The background particulate data in Section 5 of *the air quality assessment have been reported without decimal places and underestimate the actual value.*

The annual average PM2.5 background level in the AQA is stated to be 7µg/m3 for both 2015 and 2016 at Rozelle, but the actual data for 2015 are not valid and should not be used (less than 75% data completeness in each calendar quarter) and the annual average value in 2016 is 7.4µg/m3, not 7 µg/m3. This is also contrary to the note below the table in the AQA which sates "Adopted background is based on the highest measurement below the criterion to evaluate the potential for additional exceedances in accordance with the Approved Methods".

If the correct value for the PM2.5 background level of 7.4µg/m3 (not 7 µg/m3) had been used in the assessment, it would show exceedances of the applicable annual average PM2.5 criterion at R4, R7 and R8 under the "normal day" scenario. Section 3.2 of the AQA outlines that these sources are sensitive receptors, specifically: R4 and R7 are the Harbour utilities area, and R8 is the Iron Cove Bridge.

The impacts are likely to be higher if the assessment had included what appear to be missing emissions sources and apparent underestimated emissions.

There is an apparent misconception that the WBCT data is "on-site data". It is not. The monitoring data is collected at Adolphus Street, Balmain, some 850m from the assessment location, and is maintained for an entirely separate purpose, on behalf of the Port Authority of NSW.

The WBCT monitor is located for the designated purpose of monitoring ambient air quality in the direct vicinity of cruise terminal operations that are located adjacent to residences, the closest of which is approximately 8m from the monitor. Data from this monitor are considered representative of air quality in the immediate vicinity of the monitor and adjacent cruise terminal operations, but contains marked localised woodsmoke influences that likely bias the data high, and render it unrepresentative of the broader urban background upon which cumulative estimates are based, thus limiting the usefulness of the study in assessing the potential for the Project to adversely influence ambient air quality. Accordingly, the potential extension of these data to the modelling domain is not considered appropriate.

The DPIE data (collected some 1,900m away) are considered a long-standing robust publically available data source that are commonly applied in air quality impact assessment. The DPIE Rozelle monitoring location is classified as a "Generally Representative Upper Bound" (GRUB) for community exposure, as defined within the National Environment Protection Measure (NEPM) for Ambient Air Quality. This, along with its proximity to the site, should provide the reviewer with adequate assurance this it is an appropriate reference to conservatively characterise background air quality.

The WBCT data is discussed in PE, 2018 in detail appropriate to demonstrate that it is unrepresentative, hence forming a secondary source of local $PM_{2.5}$ data within the assessment.

As identified within the dispersion modelling, the influence of the project on annual ambient $PM_{2.5}$ concentrations is small and primarily confined to the areas of the port in which the Project is located. The suggestion that the Harbour utilities area and a point upon the Anzac Bridge (not the Iron Cove Bridge) are sensitive receptors, per the definition within the Approved Methods, is considered questionable.

10 References

PE 2018, *Hanson Glebe Island Concrete Batching Plant Air Quality Assessment*, Pacific Environment, 15 March 2018.

TAS 2020, *Glebe CBP – Review of Response to Submissions*, Todoroski Air Sciences, April 2020.

Cooper 2003, *Exhaust Emissions from Ships at Berth*, D.A. Cooper, IVL Swedish Environmental Research Institute Limited, May 2003, http://www.medecine-maritime.fr/pdf/biblio/toxico/Exhaust%20emissions%20from%20ships%20at%20berth.pdf (accessed April 2020).

ICF 2009, *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*, https://www.epa.gov/sites/production/files/2016-06/documents/2009-portinventory- guidance.pdf (accessed April 2020).

Appendix A – Detailed Emissions Inventory

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Normal Operations - TSP

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	479	27211	trucks/year	0.070	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0704761	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	191	8439	trucks/year	0.091	kg/VKT	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0914845	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	2691	181818	trucks/year	0.060	kg/VKT	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.059931	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	13	1000000	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	13	1000000	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	510	300000	t/y	0.05	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	8439	truck/y			0	%control
Total	**3897**																

Normal Operations - PM10

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	92	27211	trucks/year	0.01	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0135279	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	37	8439	trucks/year	0.02	kg/VKT	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0175605	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	517	181818	trucks/year	0.01	kg/VKT	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.0115038	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	6	1000000	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	6	1000000	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	510	300000	t/y	0.05	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	8439	truck/y				
Total	**1167**																

Normal Operations - PM2.5

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	22	27211	trucks/year	0.00	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0032729	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	9	8439	trucks/year	0.00	kg/VKT	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0042485	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	125	181818	trucks/year	0.00	kg/VKT	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.0027832	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	1	1000000	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	1	1000000	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	29	300000	t/y	0.0028	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	8439	truck/y				
Total	**186**																

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Peak Day Operations - TSP

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	1550	87965	trucks/year	0.070	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0704761	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	289	12775	trucks/year	0.091	kg/VKT	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0914845	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	3723	251485	trucks/year	0.060	kg/VKT	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.059931	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	56	4380000	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	56	4380000	t/y	0.0013	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	772	454151.25	t/y	0.05	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	12775	truck/y				
Total	**6445**																

Peak Day Operations - PM10

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	297	87965	trucks/year	0.01	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0135279	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	55	12775	trucks/year	0.02	kg/VKT	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0175605	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	715	251485	trucks/year	0.01	kg/VKT	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.0115038	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	26	4380000	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	26	4380000	t/y	0.0006	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	772	454151	t/y	0.05	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	12775	truck/y				
Total	**1892**																

Peak Day Operations - PM2.5

Activity - Annual Average	Emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units		Source
Number of sand delivery trucks onsite	72	87965	trucks/year	0.00	kg/VKT	36.8	payload (tonnes)	42.2	Gross vehicle mass (tonnes)	0.25	km/trip	0.0032729	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of flyash and cement delivery trucks onsite	13	12775	trucks/year	0.00	kg/t	35.6	payload (tonnes)	54.5	Gross vehicle mass (tonnes)	0.247	km/trip	0.0042485	kg/VKT	0.4	g/m2 silt loading	0	%control
Number of concrete product trucks onsite	173	251485	trucks/year	0.00	kg/t	12.7	payload (tonnes)	36	Gross vehicle mass (tonnes)	0.247	km/trip	0.0027832	kg/VKT	0.4	g/m2 silt loading	0	%control
Material handling - trucks to aggregate storage bins	0.0	0	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - ships to conveyor	4	4380000	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Material handling - Conveyor to aggregate storage bin	4	4380000	t/y	0.0001	kg/t	1.08	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %							99	%control
Residual from de-dusted air loading cement and fly-ash	43	454151.25	t/y	0.0028	g/Nm3	34	Nm3/minute	1	minutes/tonne	35.6	t/truck	12775	truck/y				
Total	**310**																