OPAM Consulting
Odour Process Audit Management

Peer-review

Operational Odour Emissions – Impact Assessment

Smartstream Technologies: Cardup roto-moulding facility

Prepared for:

Shire of Serpentine Jarrahdale

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Project:	Peer-review Operational Odour Assessment – Impact Assessment
Scope of Work	Smartstream Technologies: Cardup roto-moulding facility
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1 Glossary

COU	chemical odour unit
OAV	odour activity value
ODT	odour detection threshold
ppb	part per billion
ppt	part per trillion
VOC	Volatile Organic Compound

2 Introduction

2.1 Context

In 2018 the Shire of Serpentine Jarrahdale (**The Shire**) approved a development application for a Plastic Production Warehouse (Smartstream Technologies) subject to several conditions.

Subsequently, the applicant has applied to delete/amend some conditions of this approval including condition 9 of the Notice of Determination related to odour assessment and detailed below:

Condition 9 of the approval is as follow:

Within 90 days of occupation, an updated Odour Impact Risk Assessment is required to be submitted to the satisfaction of the Shire. The applicant or operator is to attain agreement from the Director of Development Services for the appointment of a suitably qualified consultant to undertake the Odour Impact Risk Assessment. The testing shall include air testing, all potential sources of odour and the efficiency of odour controls. After this date, quarterly reports for the following 2 years will be required to be submitted to the Shire of Serpentine Jarrahdale after which annual reports will be required.

The applicant provided an odour report (**the Report**) dated September 2021 to support the proposal.

2.2 Scope

The Shire contracted OPAM Consulting to peer-review the Report.

The document was drafted in September 2021 by Environmental & Air Quality Consulting Pty Ltd (**EAQ Consulting**) and was titled "*Operational Odour Emissions – Impact Assessment, Smartstream Technologies: Cardup roto-moulding facility*".

The scope focused on the review of what was undertaken by EAQ Consulting and how it was performed with a discussion about the robustness of the data and the conclusions stated in the Report. The review does not discuss best practice but highlights possible gaps in the odour impact risk assessment.

It includes discussions about:

- The content of the report compared to the requirement of condition 9 of the approval;
- The odour emissions impacts (section 2.1 of the Report);
- The chemical emissions and odour potential (section 2.2 of the Report);
- The determination of the odour risk (section 2.3 of the Report);
- The conclusion of the odour assessment (section 3 of the Report);
- The use of information to support the removal of condition 9; and,
- Possible gaps in the Report about other assessments that would have informed the odour impact risk of this operation.

3 Roto-moulding operation

The plastic production process occurs using a Roto Moulding Machine (RMM) which is a technology specifically used to produce hollow plastic products. The RMM involves five distinct stages of production: loading, oven press, pre-cool, cooling and unloading. A diagrammatic layout of the RMM to be used is shown in **Figure 1**.

Figure 1: Roto-moulding machine used at Smartstream Technologies

The plastic material is placed into a mould which is then rotated and evenly heated in an oven in this instance (generally within the range of 250-290°C). Following this stage, the mould is moved to a pre/cool stage before reaching the cooler phase which is facilitated by fans and light water spray and finally the location where the product will be removed from the mould.

The RMM is located within a shed with three large doors from the RMM footprint. On the roof, a circular stack exhausts hot gases from the oven and another vent exhausts cooled gases from the cooler operation(see **Figure 2**). The approximate footprint of the RMM within the hall is also presented in **Figure 2**.

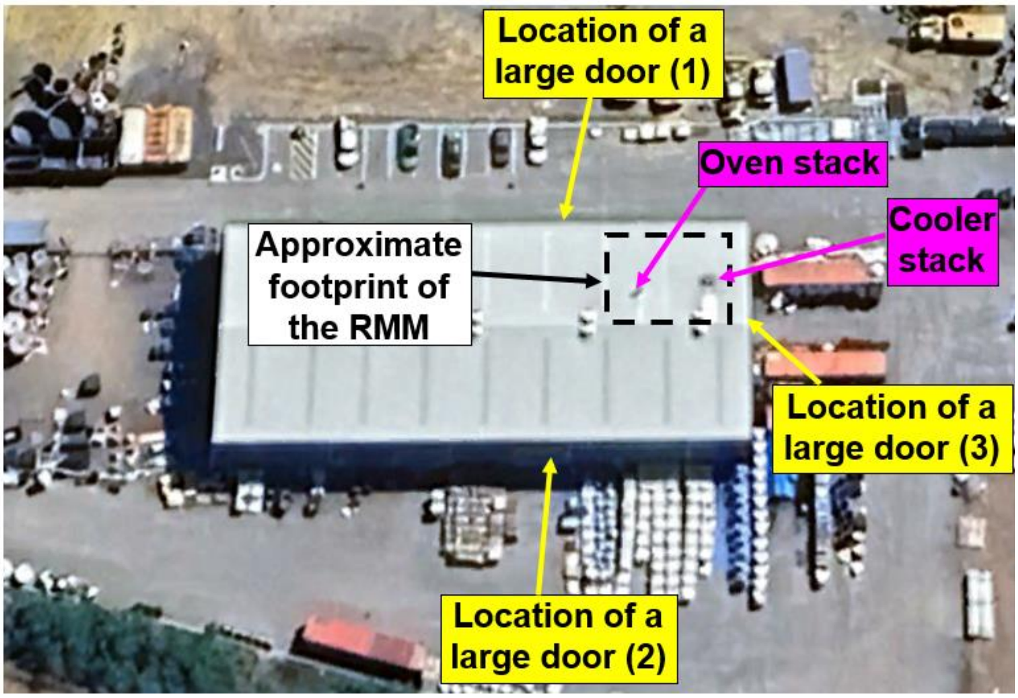


Figure 2: Smartstream Technologies building with stacks and large doors

4 Review of the EAQ Consulting report

It is indicated in the Report (section 1.1) that "*The purpose of this OEA (Operation Emissions Assessment) is to confirm the quantitative emissions from the Sites' process stack and determine the Risk of offsite odour and amenity impacts on nearby sensitive receptors based on the quantitative results.*"

The consideration of the emissions from the oven stack (process stack) and the risk of offsite odour impact from these emissions **only** is significantly restricted compared to the requirement of Condition 7 which stipulates that "*the testing shall include air testing, all potential sources of odour* and *the efficiency of odour controls."*

Although this operation is not a prescribed premises under Part V, Division 3 of the Environmental Protection Act 1986 (EP Act), the odour risk assessment should have followed the source-pathway-receptor approach recommended in the DWER Guideline: Regulatory principles (***DWER, 2017***).

In addition, tools that can be specifically used for an odour risk assessment have been provided in the DWER Guideline: Odour Emissions (***DWER, 2019***).

Tools of the DWER Guideline: Odour Emissions and work undertaken by EAQ Consulting are compared and discussed in Table 1.

Table 1: DWER Guideline: Odour Emissions and EAQ Consulting work

DWER Guideline: Odour emissions Tools	EAQ Consulting work
Operational Odour Analysis (OOA)	there are limited discussions about the process and no identification of all possible odour sources and no discussion about the efficiency of odour controls
Odour Source Assessment (OSA):	a unique sample was collected at the oven stack, but no other odour sources were discussed
Location Review:	no discussion about the location, topography, features that may impact the plume trajectory, wind conditions, etc
Odour Field Assessment (OOA):	no ambient testing (environmental/offsite odour testing) was carried out to verify the presence of offsite odours from the operation
Odour complaint analysis:	no review of odour complaints received by the premises or by the Shire.
Community surveys Comparative dispersion modelling Comparison with similar operations	secondary here compared to the above tools

The partial work undertaken by EAQ Consulting is discussed in the following sections as well as the information that should have been included in the odour risk assessment.

4.1 Odour emission sources and pathways

This section would comprise the OOA, OSA and location review as tools that could have been used by EAQ Consulting for the scope of the condition 9 of the Notice of Determination.

Section 2.1 of the report refers to the odour concentration of a sample collected at the oven stack on 26/08/21 at 11.15am and analysed between 8.30 and 10.30am on 27/08/21.

4.1.1. Limitation No 1 – no duplicate samples

Only one sample was collected while it is recommended to collect some duplicate samples in AS 4323.3:2001 standard.

4.1.2. Limitation No 2 – underestimated odour concentration

Although the sample was analysed within 30 hours from the sampling time as per recommendation of the AS 4323:3.2001 standard (***AS/NZS, 2001***), the **odour concentration measured was underestimated**.

Assuming the sample was appropriately collected, the preservation and transportation of the sample is a phase where losses occur due to the duration between sampling and analysis, conditions in which the sample is kept, the type of pollutants expected in it, the type of material used for the sampling bag and the risk of loss due to diffusion through the sampling bag and adsorption on the wall of the bag or possible condensation, etc. Accuracy of the pre-dilution factor, if any, when sampling is another operation that adds uncertainty on the final odour concentration.

A survey presents some tests that were carried out with samples collected in some Nalophan bags (***Bakhtari, 2015***). The odour concentration was measured just after sampling and used as reference. The bags were appropriately kept in a cool and dark environment, with no airplane transportation. Odour concentration of the sample was then measured at different periods of time. Although there were no samples related to roto-moulding operations, it was shown that for other operations (composting, wastewater treatment facility, etc), the odour concentration in Nalophan bags (likely used for this case at Smartstream Technologies) was down to 70% of the initial odour concentration after 2 hours and only 50% after 10 hours.

For the present case, **the sample was collected at 11.15am (table 2-5 of the Report) and analysed about 21+ hours later (Ektimo report)**.

Finally, the analysis of the sample at an olfactometric laboratory with panellists can return an uncertainty up to 50% - 80% on the odour concentration result.

The average odour concentration at the oven stack indicated in the Report is 640 ou with a confidence interval of 440-940 ou.

With the losses between the sampling time and the analysis and considering the uncertainty, it is likely that the average odour concentration would be above 1,000 ou with an estimated confidence interval of 700-1,500 ou.

Although the odour concentration is likely higher, the odour emission rate remains low due to the limited volumetric air flow rate at the stack. Therefore, the stack is part of the whole emissions from the operations (see limitation No 6) but not the major which may cause, by itself, possible offsite impacts.

4.1.3. Limitation No 3 – pre-dilution requirement due to high temperature

The sample delivered to the olfactometry laboratory had an average odour concentration of 640 ou. The Report indicates that the emission at the oven stack had an odour concentration of 640 ou which means that no pre-dilution was undertaken at the time the sample was collected and no dilution ratio is indicated in the results table of the olfactometry laboratory (Ektimo report).

According to the AS 4323.3:2001 standard – section 10.3.2.1 (**AS/NZS, 2001**), "*pre-dilution can be applied if the sample is very hot and needs to be cooled before entering the sample container*". The level of moisture of the stream in the oven stack is unknown. However, pre-dilution shall be applied to avoid condensation in the bag if there is such a risk.

In this instance and from OPAM Consulting's experience, it is unclear how a sample from a stream at a temperature of 266°C could have been collected without any pre-dilution to decrease the temperature in the bag and possibly limit condensation.

4.1.4. Limitation No 4 – limited buoyancy and plume dispersion

The Report claims that *"the exit temperature of approximately 266°C provides a high level of thermal buoyancy, in particular during those early morning and late afternoon timeframes, further supporting improved dispersion during the colder seasonal periods."* The oven stack is equipped with a China cap for rain. It does mean that the plume impacts this feature. Therefore, the rise of the plume due to the buoyancy only would be limited with an increased risk of odour impacts at ground level.

4.1.5. Limitation No 5 – downwash and wake effects

Both stacks (oven and cooler) have a limited height above the roof level. They are both equipped with either a plate (cooler stack) or a China cap (oven stack) . **Figure 3** shows the two stacks.

Figure 3: Cooler stack (left) and oven stack (right)

With these features, both plumes are likely dragged into the cavity formed above the top of the building by the wind and then driven down to ground level at close distance from the production shed (see **Figures 4** and **5**).

Figure 4 presents a visualisation of the wind streamlines above a building hit by the wind. A cavity is formed at the top of the building before going down at the back of the building (building wake).

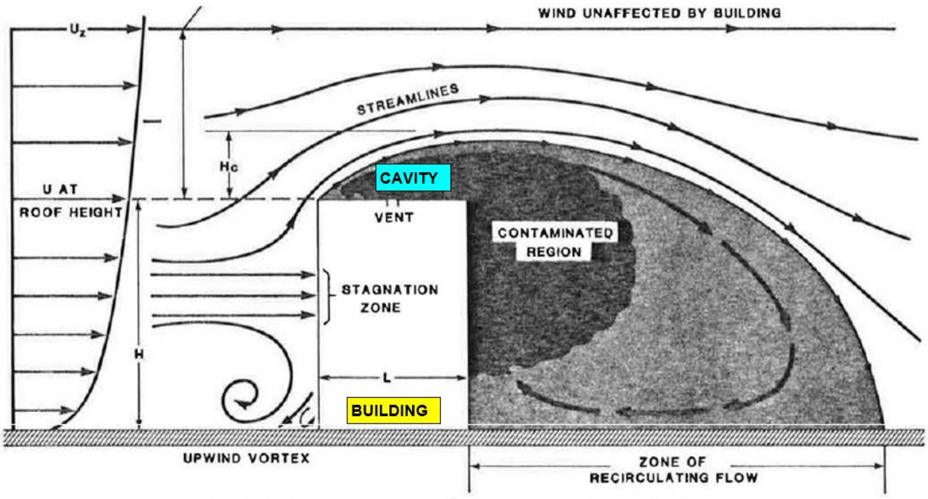
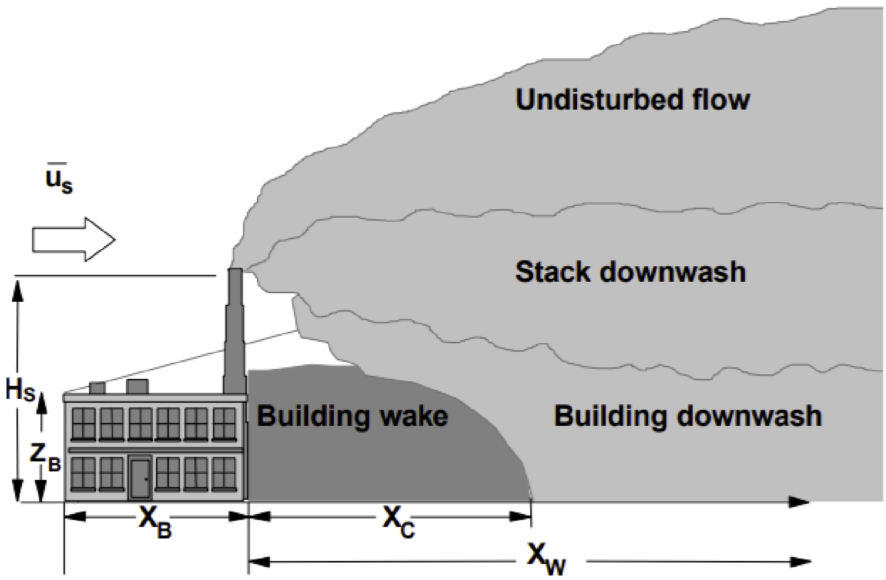


Fig. 1 Centerline Flow Patterns Around Rectangular Building[1,2]

Sce: 1981 Fundamental Handbook – Chap. 14, Airflow around buildings

Figure 4: Downwash effect when wind impacts a building

When a stack is installed on the roof of a building, stack downwash and building downwash occur downstream when they are hit by wind. An illustration of this phenomenon is provided in **Figure 5**.



Sce: Jaakko Kukkonon, Fininish Meteorological Institute, A dispersion modelling system for urban air pollution, January 1997

Figure 5: Stack and building downwash effect

An analysis of the prevailing winds in the area and the topography would have provided further information about the risk of possible offsite odour impacts.

4.1.6. Limitation No 6 – other sources of odour emissions

From a site visit on 05/04/2022, OPAM Consulting witnessed that the large door (1) (see **Figure 2**) was partly opened, large door (2) was fully opened as well as the large door (3) (see **Figure 6**).

Figure 6: Cooler station close to the large door (3) fully open

Assuming this is a normal operating conditions, it does mean that under SE (southeasterly) to NE (northeasterly) winds, large volumes of air enter the building by doors (1) and (2) and exit by the large door (3).

Due to the heat of the air in the mould and its expansion, fugitive emissions occur from the mould and these emissions are loaded with various pollutants coming from the resin which is heated and melted into the mould. The result of a chemical sampling at the oven stack is presented in Table 2-2 of the Report.

Although the oven is enclosed and most of the hot gases exhaust by the stack, there are also fugitive odorous emissions from the oven in the building and then from the mould in the building while at the pre-cooling location and then when it reaches the cooler. (see **Figure 1**).

A photo of the cooler station at Smartstream Technologies (**Figure 7**) shows that the system is open to the atmosphere of the building, with two fan blowing the building air to cool down the mould. This air is loaded with fugitive odour emissions from the mould. An extraction fan directs part of the cooling air to the roof stack.

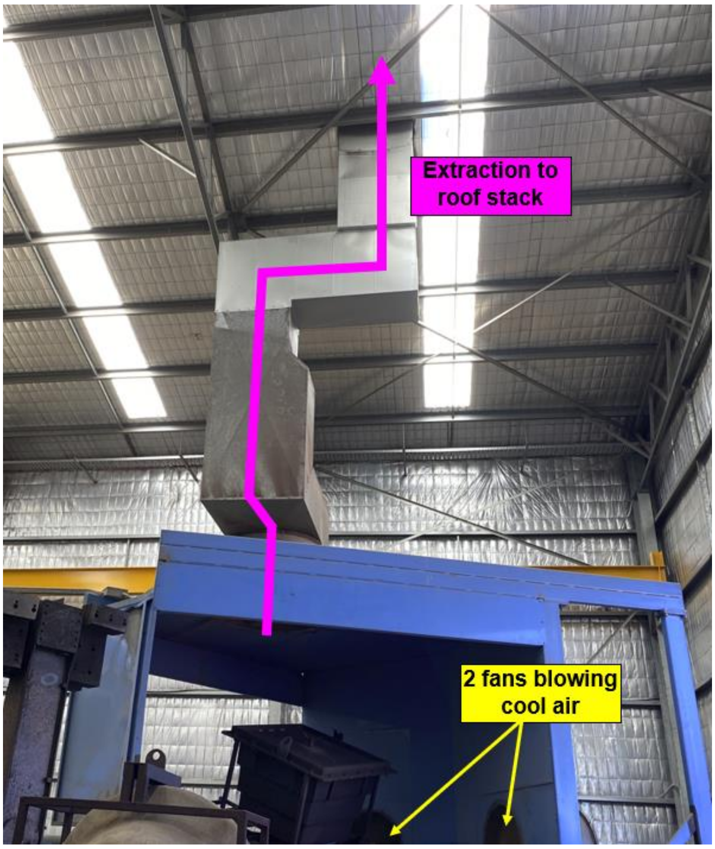


Figure 7: cooler station at Smartstream Technologies

A large fraction of the air blown by the two fans and then loaded with odour from the fugitive emissions from the mould is not captured by the stack extraction. NE to SE winds flushing the building load with this odorous fraction and large volumes of odorous air exit the building by the large door (3) – see **Figure 6**.

If the large doors (1) and (2) are closed, the cooled but still hotter air than the building atmosphere rises to the whirlybirds installed at the roof apex. The odorous air emitted by the whirlybirds can be dragged into the cavity formed above the top of the building by the wind and dragged at ground level. Due to the lower pressure than atmospheric pressure within the building wake (see **Figure 5**), large volumes of odorous air from the building are “sucked out” from the building and also dragged by the building downwash (see **Figure 5**) at ground level. Then odorous plumes from the stacks and whirlybirds as well as from the bulk of the building can be pushed in the direction of the South Western Highway and sensitive receptors.

4.1.7. Conclusions about odour sources and pathways

Sections 4.1.1. to 4.1.6. showed that:

- Only one sample was collected at the oven stack instead of a duplicate;
- The odour concentration of the sample is very likely underestimated;
- Emissions at the stacks (oven and cooler) undergo limited dispersion due to the presence of a plate (cooler stack) or China cap (oven stack) at the stack;
- The sample at the oven stack should have been pre-diluted when collected considering the high temperature of the airflow; However, there is no reference about pre-dilution in the Report;
- Dispersion of the plumes from the two stacks is impacted by the downwash and wake effect that may occur over the roof and at the eastern side of the building resulting in close impacts of an odorous grounding plume.
- Although a source of odour emissions, the oven stack should represent a limited fraction of the odorous volumes of air that can escape the building when considering the cooler stack and the three large doors kept open during the RMM operations.

4.2 Chemical emissions and Odour Potential

EAQ Consulting have used the chemical odour unit (**COU**) and the combined derived chemical odour unit also called odour activity value (**OAV**) to estimate the role of two pollutants (acetaldehyde and formaldehyde) that they considered as being *"those of the most interest with respect to odour impacts from the site."*

IMPORTANT NOTE:

This method is flawed and must not be used.

OPAM Consulting has, below, detailed how this method works and listed the issues to explain why this approach is intrinsically incorrect and unusable.

No other method should be used.

How does it work?

The COU reflects the amount by which the concentrations of odorous pollutants that have been detected in the sample exceed their respective odour detection threshold (**ODT**) concentrations. In other words, the COU for a pollutant is the ratio of the chemical concentration of this pollutant by its ODT. The ODT is the lowest concentration of pollutant for which 50% of the population will identify the odour in comparison with odourless air.

The OAV or combined derived chemical odour unit as called by EAQ Consulting is defined as the sum of the COU for each compound (pollutant) of the odorous mixture.

In this instance, EAQ Consulting found a COU of 15 chemical odour unit (ou) for formaldehyde and 19.6 chemical ou for formaldehyde. The OAV was then equal to the sum of the two COUs, i.e. 34.6 chemical ou.

Why is such a method generally attempted?

The COU and derived OAV are attempts to correlate chemical concentrations of **very few pollutants** within a **controlled mixture composition** to an odour concentration of the mixture.

However, this method was implemented with very few pollutants among a large number in a complex mixture **when it is not possible to get access to the measurement of the odour concentration of the mixture**.

In this instance, it was completely unnecessary to attempt such approach because a sample could be collected, and its odour concentration measured.

The reasons for not using this approach with complex mixtures of odorants include:

4.2.1. Reason 1: limited number of pollutants identified/measured

A key limitation of many of the chemical sampling processes is that they rely upon the sampling method used and the choice of medium which determines the chemicals that can be detected. The sampling at the oven stack was made in bag samples for analysis of aldehydes and ketones only.

4.2.2. Reason 2: analytical limit of detection

Another key limitation of many analytical methods is that some pollutants, and especially Volatile Organic Compounds (**VOCs**), which are responsible for the odour properties of a gaseous mixture, are present at concentrations in the range of the part per billion (**ppb**) or even part per trillion (**ppt**), which is lower than some instrumental detection limits (**Carmen, 2020**).

For the sample collected, EAQ Consulting acknowledged that there were *"many targeted compounds not detectable above the laboratory lower detection limits"* (section 3 of the Report).

Although EAQ Consulting raised this important reason, there was no discussion about the limitation that it has in the conclusion.

4.2.3. Reason 3: wide range of concentrations for single pollutant ODT

Values of ODTs for a single pollutant often differ by **several orders of magnitude**.

For formaldehyde, odour detection thresholds have been reported varying from 0.05 to 0.5 mg/m^3 (**Van Gemert, 2003**) and Ruth (**Ruth, 1986**) reported an odour threshold for acetaldehyde ranging from 0.0001 to 2.3ppm (four order of magnitude).

It does mean that the COU can also vary by several order of magnitude depending on the choice of the ODT value which makes it unreliable.

4.2.4. Reason 4: assumption of additivity of the COUs

The method by which OAVs are calculated assumes that the COUs of the pollutants of the gaseous mixture are additive.

Even if this above assumption was correct, the OAV of a gaseous mixture would never be correct with only a limited number of odorants measured from a gaseous mixture (limitations A and B).

In addition, synergic or masking effects between pollutants may occur which tend to either exacerbate or annihilate the power of the odour for the whole mixture (**Jarauta, 2006**).

4.2.5. Conclusion

The COU and OAV approach:

- is flawed for complex mixtures of odorants;
- is not based on olfactory science;
- is not recommended in any standards or guidelines;
- MUST NOT be used for an odour impact risk assessment;

Finally, the use of the COU and OAV of the mixture at the oven stack is **irrelevant** because the odour concentration of the gas could be measured from a sample collected at the stack.

It is also why no other method should be used.

The conclusion for EAQ Consulting was that this OAV was insignificant and was contributing to the sample matrix.

It appears that the COU and OAV approach was used by EAQ Consulting to provide, with limited work, a low concentration of some sort to justify a low odour risk.

Figure 2-1 of the Report presents odour emission rates of the gas mixture at the oven stack and concentrations of the two targeted pollutants for four years. It appears that this figure was provided to support the use of the COU and OAV approach versus the odour concentration. However, there is no discussion about the trends likely because results do not show any relevant trend.

4.3 Offsite odour impact assessment

OFAs and odour complaint analysis are two tools that should have been used to review the risk of offsite odour impacts.

It is possible that the Shire and the proponent have lodged some odour complaint allegedly pointing at Smartstream Technologies as the source of odour.

Some OFAs could have been carried following the recommendations detailed in the DWER Guideline: Odour Emissions.

OPAM Consulting had the opportunity to be downwind the facility on the South Western Highway and could recognised the odour from the Smartstream Technologies operations under an easterly wind.

A more formal OFA program may have demonstrated some frequent odour impacts in the vicinity of the operation that would have provided valuable information for the odour risk assessment required in Condition 9 of the Notice of Determination.

4.4 Determination of the odour impact risk

EAQ Consulting has rated the risk for odour impact as low based on:

1. Low odour emission rate at the oven stack

   However:

   - The odour concentration is higher than the odour concentration from the sample collected in a Nalophan bag and measured almost 24 hours later;
   - It is unclear how the sample was collected with no pre-dilution;
   - The odour emission rate at the oven stack represents a fraction of the total odour emission rate from all other odour sources including the oven stack but also the cooler stack, and the openings of the large doors;
   - Downwash and wake effects likely occur with the consequence of dragging the plumes from the two stacks down to ground level and extracting large volumes of odorous air from the large door (3) that can be pushed towards the South Western Highway and sensitive receptors.

2. High exit temperature

   However, the buoyancy and the plume elevation are limited with the plate and China cap over the two stacks, limiting the dispersion and dilution of the plumes from these sources.

3. The negligible chemical and theoretically derived chemical odour units

   However, this calculation is flawed, unequivocally not representative of the real emissions from the operation and must not be used.

4. OPAM Consulting had the opportunity to be downwind the facility to recognise the odour from the Smartstream Technologies operations.

When considering the above points, OPAM Consulting would rate the likelihood and the consequence as follow according to the DWER risk assessment matrix:

Likelihood: **“Possible”** and Consequence: **“minor”** to **“moderate”**

Risk: **MEDIUM**.

5. Conclusion

The EAQ Consulting report dated September 2021 provided limited information on a fraction of the total odour emissions from the RMM operations with underestimated results for odour concentration and odour emission rate and incorrect and irrelevant use of the chemical odour unit and the odour activity value.

The partial or irrelevant work undertaken by EAQ Consulting at one of the odour source only did not cover the scope of work nor meet the requirements of Condition 9 and triggered an underestimated risk for odour impacts.

Therefore, it is the view of OPAM Consulting that the Report does not contain any robust and relevant information that would:

- show the implementation of efficient odour controls and appropriate odour management at the Smartstream Technologies operations; and,
- support the withdraw of Condition 9 of the Notice of Determination.

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