OPAM Consulting
Odour Process
Audit Management

Alcoa of Australia

New Residue Storage Area (RSA) 10

Works Approval

Odour Risk Assessment

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Project: New Residue Storage Area (RSA) 10 Works Approval

Scope of Work Odour Risk Assessment

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Executive Summary

Alcoa is planning to build a new Residue Storage Area 10 (RSA10 – dry storage area) to maintain the required surface area for drying residue mud. The works approval application for this project requires the inclusion of an odour assessment that meets the requirements of the Department of Water and Environmental Regulation (DWER) *Guideline: Odour Emissions* (**DWER, 2019**).

Alumina extraction generates wastes and residues that are sent to the Residue Area to be stored in a controlled environment. The Residue Area is located west of the refinery and has two different areas including Refinery Water areas and the Dry RSAs.

Residue mud is thickened prior to the residue mud being depositing in layers in the RSAs which are dried through solar evaporation. The process is assisted by physically turning over the mud, and produces a high-density, stable stack of residue upon which the next mud layer can be placed.

As the mud elevation in RSAs increases over time, perimeter embankments progressively move inwards, and the net available drying area reduces. Therefore, to maintain the minimum drying area required to dry mud it is necessary to periodically construct new RSAs.

In the *DWER Guideline: Odour Emissions*, the odour screening distance for Category 46 (bauxite refining) is determined on a “case-by-case” basis. In this instance, a detailed analysis is required.

The detailed analysis included an operational odour analysis (OOA), the location review, an odour complaint analysis, an odour field assessment, and a comparative odour impact footprint.

These RSAs have a large surface area limiting odour mitigation options. There aren’t any specific odour mitigations for the Residue Area. However, management actions are in place that minimise odour emissions as much as possible.

The refinery is at the base of the Darling escarpment and as a result is subjected to strong easterly “foothill winds”. However, from the two Alcoa-owned weather stations on Bancell Rd and Bancell West Rd, the respective 7-year wind roses show prevailing SW/S and E/SE winds. SW winds will tend to direct the plumes emitted by the Residue Area towards several dwellings and the town of Hamel.

Historical odour complaints have been received from some sensitive receptors, relating to the Alcoa Refinery and Residue Operations. However, following a significant decline in odour complaints over the last six years, only four complainants living just outside Areas A and B (Wagerup Land Management Plan) have lodged since 2019. Except for one odour complaint, all complaints for the whole 2021 year and up to May 2022 were lodged by a unique complainant on Buller Road.

An odour field assessment was carried out between October 2021 and March 2022. Seventeen odour field assessment (OFAs) and eight odour patrols (OPs) have been carried out. Odour field surveys including OFAs, and OPs were performed under

different atmospheric conditions (with no rain) and different periods of the day. Odour surveys were also conducted under different operating conditions at the Residue Area.

Notably, during March 2021 to June 2021 the Superthickener was offline for a major maintenance overhaul and the mud was mixed with flocculant and pumped directly to the RSAs resulting in RSAs that were wetter and remained wet longer than usual which would represent a worst-case scenario from a source and emissions point of view.

OFAs were undertaken following the standard EN 16841 Part 2:2016 (plume method) and OPs following a DWER endorsed methodology. The Residue Area odour was described by odour panellists as “Wet Cement” odour. In order to focus on the areas where there is a potential impact to community members, mainly the NW to NE and S to SW sectors were patrolled. Based on the results of the 25 odour surveys, the footprint of the odour impacts from the Residue Area emissions was determined for the sectors that have been patrolled and investigated.

In summer (hot period), the maximum extent of the existing odour footprint north and south of the Residue Area has been estimated at a distance of 3,200m (for obvious odour intensity levels) and 3,700m (for subtle odour intensity levels) from the northern and southern boundaries of the Residue Area.

The winter period (cooler period of the year) may show some atmospheric conditions that may be more conducive to odour impacts at further distances. When accounted for, the extrapolated odour footprints over a yearly period are predicted to be in the vicinity of 3,650m for obvious odour intensity levels and 4,250m for subtle odour intensity levels.

Finally, a similar reasoning to the comparative dispersion modelling (one tool recommended in the *DWER Odour Emissions Guideline*) was used to project the possible future odour footprint with the new proposed RSA10. No odour modelling was performed but simple power function ratios derived from steady-state Gaussian plume modelling were used. The residue mud drying area at the time of this odour assessment was 195.8 Ha. Just prior to RSA10 commissioning, the residue mud drying area will have decreased to approximately 178.4 Ha due to the walls of the RSAs coming inwards like a pyramid when RSAs increase in height. Immediately following RSA10 commissioning, the residue mud drying area will increase to 221 Ha and it is estimated that the odour footprint will increase by a maximum of 7% (refer to the 2017 Alcoa Wagerup Alumina Refinery LTRMS). This odour footprint will then decrease to return to 194.5 Ha (current 2022 residue mud drying area) during the operational life of RSA10. The odour footprint will decrease accordingly to return to the estimated 2022 distances.

Several sensitive receptors live within the zone likely impacted by the Residue Area odour emissions. However, from the outcomes of all the tools used for the detailed analysis, the risk of odour impact with the future proposed RSA10 should remain low.

1. Introduction

1.1 Background

Alcoa of Australia (Alcoa) operates the Wagerup Alumina Refinery currently licenced to produce 2.9 million tonnes of alumina per annum (Mtpa).

Alumina production is performed under both Part IV (Ministerial Statement MS 728 and as amended) and Part V (Licence L6217/1983/15) environmental approvals.

Alumina extraction generates wastes and residues that are sent to the Residue Area to be stored in a controlled environment. The Residue Area is located west of the refinery and has two different areas including Refinery Water areas and the Dry RSAs.

Residue mud is thickened prior to the residue mud being deposited in layers in the RSAs which are dried through solar evaporation. The process is assisted by physically turning over the mud, and produces a high-density, stable stack of residue upon which the next mud layer can be placed.

As the mud elevation in RSAs increases over time, perimeter embankments progressively move inwards, and the net available drying area reduces. Therefore, it is necessary to periodically construct new RSAs to maintain the minimum drying area required to dry mud.

Alcoa proposes to build a new RSA (RSA 10) to replenish drying area to maintain drying area availability and sustain ongoing operations.

1.2 Objective

Alcoa is planning to build a new RSA (RSA10 – dry storage area) to maintain the required surface area for drying residue mud. The works approval application for this project requires the inclusion of an odour assessment that meets the requirements of the *DWER Guideline: Odour Emissions* (**DWER, 2019**).

The Alcoa Wagerup Part V Licence identifies the refinery under the Prescribed Premises Category 46 – Bauxite Refinery. According to the Odour Guideline, for category 46, a detailed analysis is required to provide enough information that will be used by DWER officers to assess the odour risk related to this new RSA10.

1.3 Scope

For this engagement and in accordance with the DWER Guideline: Odour Emissions, OPAM Consulting has:

- Conducted field visits to the Residue Area and the surrounding Alcoa Farmland Area to better understand the operations and sources of odour emissions, controls in place, dimensions of the various lakes and RSAs, the topography and possible accesses;

- Performed a Detailed Analysis;
- Assessed the potential changes in odour footprint expected with the new RSA10 based on the findings of the Detailed Analysis.

2. Detailed analysis

The Guideline provides recommendations about the type and levels of information expected by DWER to perform their odour risk assessment.

The works approval is sought for a **change to the existing Residue Area** which is the operation to be reviewed. The Refinery and its emissions will not change as a result of the proposed RSA10. The existing Refinery and residue operations are regulated under the current operating licence L6217/1983/15.

Appendix 1 presents an aerial photo (dated April 2020) of the Residue Area.

Appendix 2 presents a flow chart of the Residue Area operations.

For Category 46, the Guideline requires that the screening distance is determined on a case-by-case basis.

According to the Alcoa report (Figure 4, **Alcoa 2021**) and OPAM Consulting surrounding reconnaissance, some discrete sensitive receptors are located at distances less than 1,000m.

Figure 1 presents a map which shows:

- The odour activity boundary of the Residue Area (yellow contour); the activity boundary is the area within a convex polygon that includes all current or proposed industrial operations/sources which are a source of odour;
- The proposed new RSA10 (blue rectangle);
- The locations of the closest sensitive receptors (yellow stars);
- The locations of the two complainants who lodged complaints in 2021 (yellow stars with red contour).

For the detailed analysis, OPAM Consulting has gathered information by using the following recommended tools from those listed within the DWER Guideline: Odour Emissions:

- An operational odour analysis (OOA);
- A location review;
- A complaint analysis;
- Some odour field assessments (OFAs).

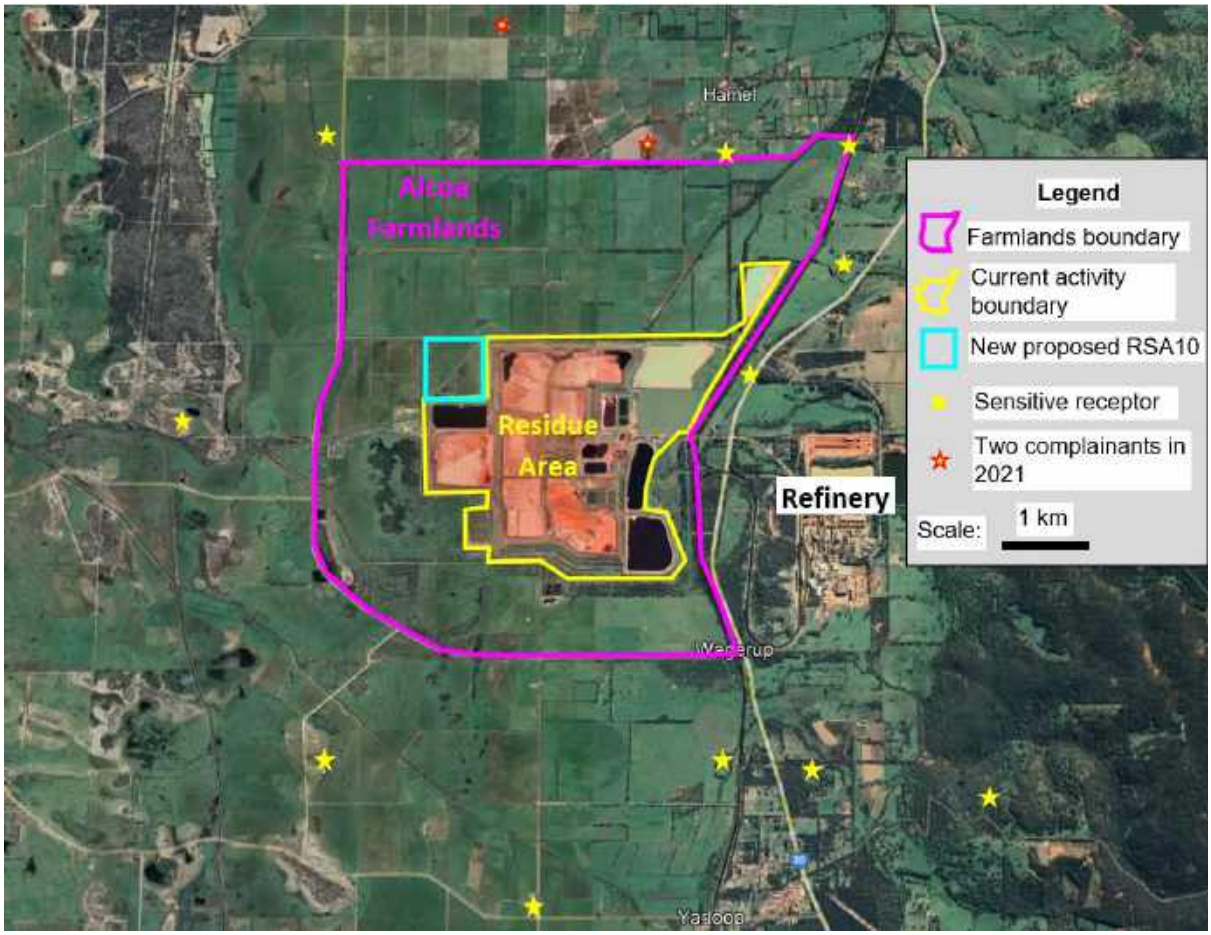


Figure 1: Activity boundary and closest sensitive receptors

2.1 Operational Odour Analysis (OOA)

The Operational Odour Analysis (OOA) is a priority tool recommended in the DWER Odour Emissions Guideline.

This tool provides information about the operations likely to emit odours, their monitoring, triggers for corrective actions and details of these actions. In addition, a possible evaluation of these corrective actions is also to be provided as well as the contingency actions.

The Residue Area has a large surface area exposed to atmosphere, limiting odour mitigation options. However, management actions are in place to minimise odour emissions as much as possible.

Table 1 is the DWER template providing the information regarding the Operational Odour Analysis (OOA) for the operations at the Alcoa Wagerup Residue Area.

Table 1: Operational Odour Analysis (OOA) for the Residue Area

Odour emission operations review		Operational Condition
Residue Area: Refinery Water Areas / Dry Storage Areas		**Normal (1)**
Odour sources and emissions	The Residue Area also includes the Superthickener which receives the mud slurry from the refinery. This is a source also open to atmosphere with low volumes of emissions (wind transport) and elevated odour intensity. The lower dam was also included as a source to be investigated during the odour surveys. Three assessments were carried out and only once a subtle level of odour was found. This source was not considered as a source of odour that may contribute to offsite impacts. **Refinery Water Areas** The Refinery Water Areas contain liquid used or produced in Alcoa's alumina refining process. The Refinery Water typically contains caustic and water as the main components. Composition and concentration can evolve with time, season and refining process. Areas containing Refinery Water are outlined below: **Sand Storage Lake**: The Sand Lake is used to collect sand pumped from the refinery when the sand Booster system is unavailable. The "Bypass sand" is deposited into position through two mobile cannons attached with flexible pipeline and shifted from time to time as required. It allows the sand to compact and then the liquor with sand siphons off to the decant area and returns to the Cooling Lake. The Sand Lake Area is also used to collect overflow from the Superthickener and flow from the main Superthickener sump pump. *Due to the origin of the material received at the Sand Lake and following some odour assessments on the edge of these ponds during this project, it is confirmed that this lake is a source of odour emissions. The odour character for this source is "wet cement".* **The Cooling Pond**: The Cooling Pond is used to cool Refinery Water for supply back to the refinery for use predominantly in the barometric condensers, heat exchange in precipitation and oxalate removal and for hose water use throughout the refinery. This pond is fed with various streams (mainly with caustic) that may be at a higher temperature than the atmospheric temperature. The surface area of the liquid in the Cooling Pond is used to provide this cooling and hence it is critical that this lake always be available. *Due to the characteristics of the streams and following some odour assessments on the edge of this pond during this project, it can be*	

confirmed that this lake is a significant source of odour at the Residue Area. The odour character is "wet cement".

ROWS Pond (Run Off Water Storage Pond):

The ROWS Pond is used to collect runoff/storm water that has not been contaminated with caustic from the Refinery. The ROWS Pond also receives some caustic contaminated water from Run Off Collection Ponds 2 and 3. The ROWS Pond can also receive water from the Harvey Pump Back system during the designated pumping period to ensure plant-operating water supply for the summer months.

Most of the water received by this pond does not contain caustic and following some odour assessments on the edge of these ponds during this project, it can be confirmed that this pond is not a significant source of odour at the Residue Area.

Oxalate Storage Ponds (OSP1, 2, 3 and Spent Liquor Pond):

These four ponds are designated for oxalate storage. The oxalate is trucked directly from the refinery.

Odour assessments downwind these ponds during this project have shown that these ponds are not a source of odour at the Residue Area.

Run Off Collection Ponds 2 and 3 (ROCP 2 and 3):

It should be noted that ROCP 1 has been decommissioned.

These lakes are used to collect runoff from the dry disposal beds. ROCP 3 collects runoff from RSA 3, 4, 5, 7 and 9 while ROCP 2 collects runoff from RSA 6 and 8 and the Sand Lake.

Volume collected in ROCP 3 pond is transferred to two possible locations:

- the ROWS Pond; or,
- the Cooling Pond.

The volume from ROCP 2 is transferred to four possible locations:

- straight into the Cooling Pond,
- the suction side of the cooling water return pumps,
- the ROWS Pond; or,
- to the suction side of the sand booster pumps for flushing.

Due to the nature of the streams received in ROCP 2 and 3 and following some odour assessments on the edge of these ponds during this project, it is confirmed that these ponds are among the odour sources with the highest odour intensity experienced at the Residue Area (similar odour intensity level to the Superthickener).

Detention Ponds (DP 1 and DP 2) and the Borrow Pit NE of DP 2:

These ponds receive fresh water from the Black Tom Brook and the Harvey Pump back. DP2 also receives water from the Lower Dam, which is co located with the Refinery.

Due to the nature of the streams received and following some odour assessments on the edge of these ponds during this project, it is confirmed that these ponds are not an odour source at the Residue Area.

Residue Storage Areas (RSA 3 to 9)

There are seven operational Active Mud Drying areas used namely RSA 3, 4, 5, 6, 7, 8 and 9.

RSA 1 is currently not operational. RSA 2 is currently being used for sand stockpiling only.

The dry disposal areas receive mud slurry from the Superthickener mud disposal pumps. The mud is pumped to droppers running along the perimeter of the drying areas and allowed to settle on a slope. The settled mud consolidates, and the liquor collects in the decant ponds where it is collected and returned to the refinery with liquor from the underdrainage system.

The mud droppers are operated in sequence within the same RSA so that the RSA surface is progressively covered with residue.

As the residue in the RSAs dries and consolidates over time, liquor within the residue along with rainfall seeping is collected by an underdrain system and recycled back to the Refinery via underdrain pumps and the Run Off Collection Ponds.

Underdrains from the dry disposal areas RSA 1 and 2 report to the Sand Lake.

Underdrains from RSAs 3, 4, 5, 7 and 9 report to the underdrain header which sends the water to either the Cooling Pond or the ROWS Pond.

Decant systems from RSA 3 report to the ROWS pond.

Decant systems from Drying areas RSA 4, 5, 7 and 9 report to ROCP3.

Decant systems from RSA 6 and 8 report to ROCP2.

Due to the nature of the streams received and following some odour assessments on the edge of these RSAs during this project, it is confirmed that these ponds are a significant source of odour. ***It was found that the odour intensity of the wet cement odour character was higher under sections of ponds that are wet compared to sections that are dry.***

Use of waste oil as dust suppressant

Waste oil collected from the Refinery and Mine-site can be used as an effective form of long-term dust control for internal, unsealed roads within the lined area of the Residue Area. Bitumen is also used for this purpose.

Oil is stored in 1000L pods. Bitumen is stored in steel and poly tanks on

	the east of the Spent Liquor Lake. This storage area is a source of fugitive emissions and can be recognised up to 50-100m on-site and will have a negligible role in the cumulative emissions that can be transported offsite. Oil is mixed at 7% v/v and tar at 20% v/v with water. This mixture is applied on limestone, sand and gravel road with a water cart where it helps to stabilise the road materials by aggregating the particles and limiting the risk of airborne particle generation. Following odour assessments within the Residue Area, it is confirmed that this operation can be recognised up to 200-300m from the location where the mixture is applied. However, *the bitumen/oil/hydrocarbon odour character was NEVER recognised in the Farmlands and offsite* Alcoa boundary during any of the numerous odour surveys carried out during this project. Roads and walls are not considered as a source of odour emissions.

Process controls	**The significant number and large surface area open to the atmosphere limits gaseous and odorous emission mitigation options.**
	
	There aren't any specific odour mitigations for the Residue Area. However, management actions are in place to minimise odour emissions as much as possible.
	
	Alcoa operates the minimum required residue drying area to sustain the operation by limiting the area of wet slurry exposed to air that will still guarantee a quick drying of the slurry. In doing so, it enables the use of adjacent areas of the same RSA for future pouring. This will also play a role in limiting the surface area with higher odour emissions (wet areas).
	
	• The Residue Area has a high density of sprinklers to wet the surface area of the dried residue with water from DP 1 and DP 2. The sprinkler systems, when activated are either turned on automatically based on preselected time settings, wind speed or can be run in a continuous cycle. The sprinkler system has various settings:
	  ○ **Damp Down Mode** which is a pre-wetting cycle that may be run to combat the expectations of high winds,
	  ○ **High Wind Mode** which is activated when the wind strength reaches the set point, and
	  ○ **Emergency Wet down Cycle** which allows the sprinklers to be directed to a selected RSA for an Emergency Wet Down to combat dust issues.
	
	• Daily and 3-day weather forecasts are produced every day with wind direction and speed and a dust risk rating (low/medium/high dust risk) to inform a proactive dust management response.
	
	Although the role of these sprinklers is to control dust emissions, they have a potential role (limited) in managing odour emissions by creating a water curtain through which odour plumes will go and be washed,

	decreasing the odour plume concentration driven offsite by the wind; Physical parameters such as density, and moisture levels of the thickened mud are controlled at the Superthickener to limit the volume of liquid sent to the RSAs. Higher volumes of process liquid are associated with higher levels of odour emissions. The wetter an RSA, the longer the duration of higher level odour emissions. Dry RSAs are associated with much lower levels of odour emissions.
Triggers and corrective actions	Most of the triggers will NOT be related to the recognition of excessive odour (intensity and/or duration and frequency) by staff members in this type of environment (large surface areas and similar odour from different sources) but by the review of "*surrogate" information* obtained from monitoring and assessments made at the site for some operations. The main controls used as triggers and the related correctives actions are detailed below. **Farmlands Alcoa personnel recognised strong Residue Area odours:** The staff member will contact the Residue Area Superintendent as soon as practical to inform him/her about the observation. A location at which odours can be recognised in the Farmlands is provided. The Residue Area Superintendent will attempt to identify a specific zone within the Residue Area that would be aligned with the wind direction for the Farmlands staff to be downwind. If such a zone can be identified, then the Superintendent will investigate thoroughly the zone to identify the cause of the high levels/volumes of odour emitted. Corrective actions may include the use of sprinklers. **Superthickener is under maintenance and not operational:** Any RSA can be used to store mud slurry direct from the refinery when the Superthickener facility is unavailable. Mud slurry is dry stacked so that the majority of the caustic solution with the mud returns to the decant area. The risk associated with this configuration is a higher volume of liquid to be managed which remains in contact with the atmosphere longer with odour emissions occurring. An attempt is made to plan any maintenance on the Superthickener during the summer period. The superthickener operation is critical to minimising liquid levels within the RSAs and therefore instances of non-operation are infrequent. *It should be noted that an odour survey was carried out during a time when the Superthickener was out of service and the mud slurry was directly sent to a RSA. This information was provided to OPAM Consulting post-survey. There has not been any higher intensity or more frequent impacts or impacts at further distance than usual experienced during this survey. It is not possible to conclude that this event would not be the source of higher emissions, but it may not be the only pre-requisite*

	and possibly some specific atmospheric conditions including wind should be present for higher or further impacts than usual. **Thickened slurry parameters (density, moisture) are out of the normal ranges:** Specifications of the mud slurry from the refinery will be reviewed to identify any variations in its composition that would be the origin of these abnormal readings. The flocculant, its dosage, point of delivery, contact and its appropriate mixture with the slurry will be checked to identify whether the flocculant is the cause of the readings.
Corrective action evaluation	Most of the operations that would potentially create larger than expected odour emissions have corrective actions that will suppress these. Consequently, ground odour impacts will also disappear and there will be no need to evaluate the effectiveness of these corrective action. In addition, it is difficult to isolate a source among all these large surface area sources on the side of each other and verify that this specific source is not emitted post corrective actions.
Contingency actions	**Parts of the Superthickener are out of service and it must stop operating:** As for the corrective action related to a planned maintenance operation, the mud slurry will be directly sent to some RSAs. Mud slurry is dry stacked so that the majority of the caustic solution with the mud returns to the decant area. Plans will be developed to dispatch the mud slurry on RSAs that have the capacity to absorb the additional load and to minimise the thickness of the wet mud layer on any one RSA so that the mud can dry as quickly as possible. **Failure of water delivery at some sprinklers:** Sprinkler availability is managed on an ongoing basis. An internal target is set for sprinkler availability. Sprinkler failures and maintenance activities are incorporated into routine activities with escalation procedures if internal targets are not met.

Residual odour impact potential			
Operation / odour source	**Consequence**	**Likelihood**	**Impact potential**
Residue Area: Refinery Water Areas / Dry Storage Areas	Slight	Unlikely (2)	Low (2)

(1) It is recommended that a separate table is created for foreseeable abnormal conditions. For this activity, there is no abnormal operations that are foreseen per se but disruptions or inappropriate conditions within the process that could lead to odour emissions. These have been listed in the above table.

(2) Information about the likelihood and the impact potential also relies on information from the location review and odour complaint analysis in the following sections. Classifications for consequence and likelihood refers to the DWER risk matrix (Guidance Statement: Risk Assessments, February 2017).

2.2 Location review

The location review includes some discussions about sensitive receptors in the vicinity of the operation, and the topography and meteorology that can influence odour dispersion.

2.2.1 Location and nature of sensitive receptors

Most of the sensitive receptors are dwellings.

Except for two locations, most of the sensitive receptors are located at distances greater than 1,400 m from the activity boundary (see **Figure 1**). It must be noted that the two closest sensitive receptors are within 1,500m to 2,500m from the most emissive sources among the Residue Area (see section 3.4.25 and the OOA – section 3.1).

2.2.2 Local Topography and Meteorology

In the report (**Alcoa, 2021**) dated August 2021, a detailed review of the topography and the meteorology has been provided by Alcoa. OPAM Consulting has verified the information provided and concluded that they appear to be correct and still current. Part of this Alcoa report has been reproduced in this report.

Figure 2 shows the topography of the local area and the location of the two Alcoa weather stations at Bancell Rd and Bancell Rd West.

Figure 2: Topographical map displaying 5m contours and weather stations

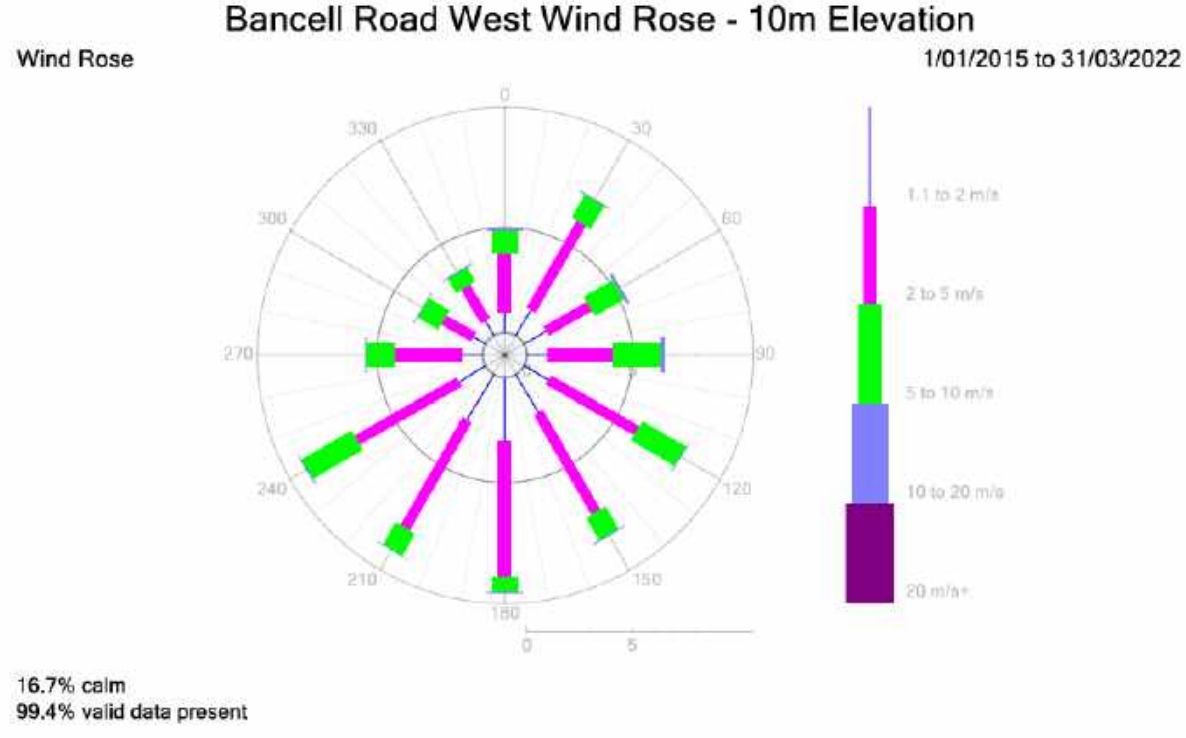
The Wagerup Refinery is located in the Swan Coastal Plain, 25 km from the Indian Ocean and to the immediate west of the Darling escarpment (scarp), approximately 130 km due south of Perth. The climate of the area is Mediterranean with hot dry summers and cool wet winters.

The winds in the region are controlled by the synoptic weather patterns and local features such as the topography, and sea and land breezes. In the summer the passage of high-pressure systems to the south generates synoptic easterlies over the region, whilst in the winter months the passage of cold fronts and low-pressure systems results in more frequent westerly synoptic flows between periods of lighter winds. For the Wagerup Refinery, at the base of the Darling escarpment (scarp), topographical features are critically important in modifying these larger scale winds. **Figure 2** shows the topography of the local area.

These topographic features tend to:

1. Generate local strong winds during summer, principally at night and in the early morning which are known as "gully winds" or "foothill winds";
2. Create rotors or wind reversals near the foothills under easterly winds;
3. Channel or deflect westerly winds near the base of the scarp; and
4. Create light drainage (katabatic flows) down the scarp.

Figure 3 indicates 6-minute average wind rose meteorological data for the period 2015 – 2022. This data is sourced from the two Alcoa meteorological stations.



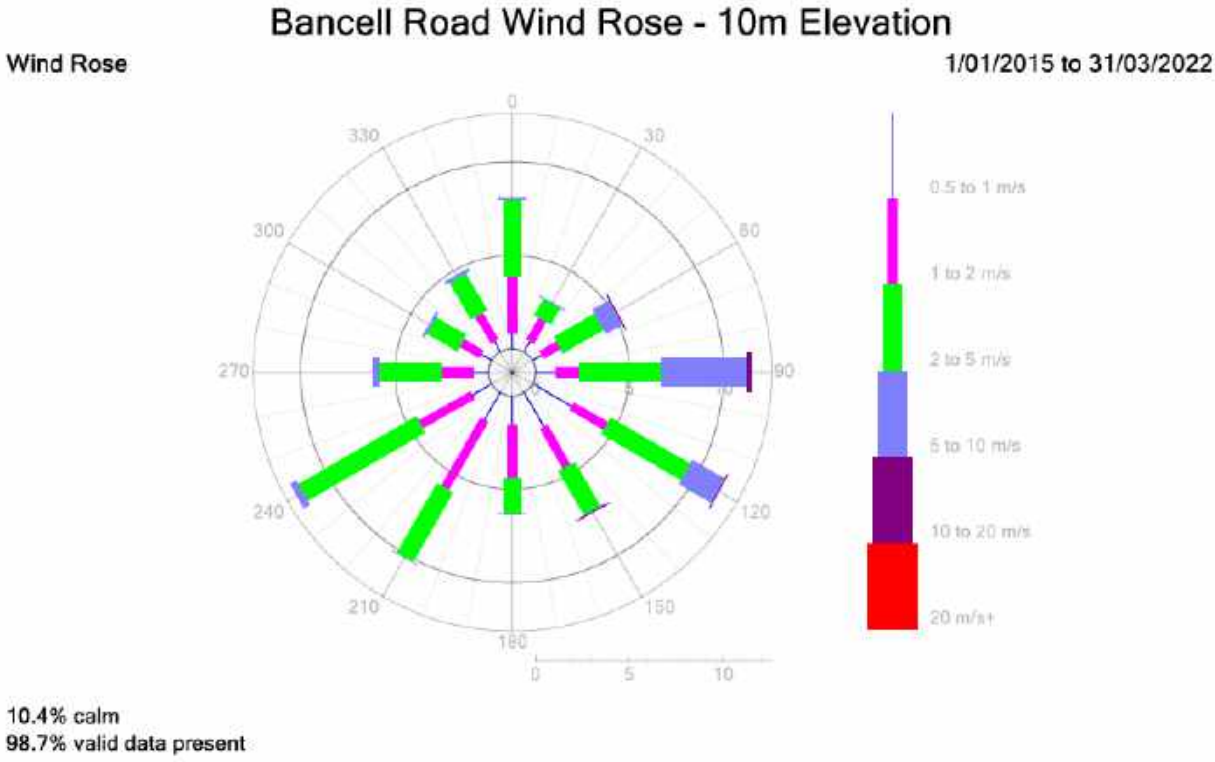


Figure 3: Wind roses 2015-2022 for Wagerup (Sce: Alcoa weather stations)

2.3 Odour complaints analysis

In the Alcoa report (**Alcoa, 2021**), there is a discussion about the odour complaints received by Alcoa and DWER. No complaint was received by the Shire of Waroona or the Shire of Harvey for the period January 2019 to March 2022.

Table 2 presents a partial reproduction of Table 4 of the Alcoa report (**Alcoa, 2021**) completed by the information received for odour complaints between September 2021 and March 2022.

Table 2: Odour complaints summary (January 2019 to March 2022 [(1)])

	2019	2020	2021	2022
Total no. odour complaints	**2**	**4**	**23**	**5**
Directed to Alcoa	0	4	**23**	5
Directed to DWER	2	0	**0**	0
No. of properties lodging single complaint to Alcoa	0	1	**1**	0
No. of properties lodging more than one complaint to Alcoa	1	1	**1**	1
No. of new[(2)] instances where properties lodged more than one complaint to Alcoa	0	1	**0**	0

[(1)] Total number of odour complaints includes complaints made directly to Alcoa and complaints made to DWER. In some cases, complainants will lodge complaints for the same event to both Alcoa and DWER.

[(2)] New indicates a complaint where historical complaints have not been received in previous years from that property or individual

In the Alcoa report (**Alcoa, 2021**), a review of odour complaints from January 2015 to August 2021 has been performed and showed that the number of complaints per year decreased from 16 (2015) to two and four complaints respectively in 2019 and 2020.

In 2019, one complainant lodged two complaints in April. In 2020, two complainants lodged respectively two complaints each with three complaints submitted in April and one in August 2020.

In 2021, 23 complaints were lodged by the two residents shown in Figure 4 (two yellow stars with red contour).

In 2022, five complaints were lodged by the resident located on Buller Rd.

A review of the wind conditions on the days of the complaints for 2021 and 2022 (data from the two Bancell Rd weather stations) showed that the two complainants (yellow stars with red contour in **Figure 4**) were most of the time likely downwind of the Residue Area and not downwind of the refinery.

In 2021, out of the 23 complaints received by Alcoa, **22 of them were lodged by the same complainant on Buller Rd**. This long term resident of Buller road started lodging odour complaints in late 2020, while he has been living at this address for several decades.

In 2021, one complaint was lodged by the resident living in McClure Rd (20/03/2021). Therefore, the resident from Buller Rd lodged eleven complaints between April 21 and October 21. This period represents roughly the cool period during which atmospheric conditions (stability, thermal inversion) may be conducive to more odour impacts.

This resident lodged four complaints in March 2021 and twelve complaints between November 2021 and March 2022. It does represent 16 complaints during the hotter period with less occurrences of conducive atmospheric conditions than in cooler period.

While it was possible that this community member could recognise the odour from the Residue Area on those days according to the wind conditions' review, a number of points should be considered regarding these complaints:

1. While living at this address for several decades, odour complaints started late 2020 onwards while the Refinery and the Residue Area have not gone through significant changes from an odour emission/source point of view for this period;
2. This community member has almost been the unique complainant about Alcoa odour for the whole 2021 year and has been (up to March) the unique odour complainant for 2022.

3. With the findings of the odour surveys (section 3.4), Buller Rd was the maximum distance at which Alcoa Residue Area odour could be recognised at subtle odour intensity level. It is possible that this resident may be hypersensitive or has developed a hyper-sensitivity to this odour (recognition at very low level of odorant concentrations in the air).

Figure 4: Odour complaints (January 2019 – March 2022)

Overall, complaint data showed a significant decline in odour complaints over the last six years while there were no significant odour sources removed or shut down especially at the Residue Area.

Note for odour surveys in the vicinity of Alcoa boundaries:

In the Alcoa report (**Alcoa 2021 –** Figure 7), the graph shows a monthly distribution of the complaints over the 7 years (2015 – 2021) with the period March to August being the period when most of the complaints are lodged.

Thermal inversion events with low speed winds tend to provide prevailing meteorological conditions conducive to odour impacts. These events occur at sunrise and sunset periods and mainly happen during cooler months (end of autumn up to mid-spring, i.e. March-April to October period).

The highest frequency of odour complaints between March and August appear to align with this thermal inversion phenomenon.

This is an observation to be considered when analysing the odour survey results (section 3.4). These surveys were carried out within and outside the Alcoa Residue Area boundaries between early October 2021 and end of March 2022.

2.4 Odour Field Assessment (OFA)

The fourth tool from the recommended list in the DWER Odour Emissions Guideline is the assessment of the potential odour impacts from the Residue Area activities in its neighbourhood and its odour footprint.

The baseline offsite odour assessment including some Odour Field Assessments (OFA) and Odour Patrols (OP) has been implemented to:

- Assess odours in the area under different meteorological conditions;
- Identify the source(s) of any odours detected;
- Assess the extent of the plumes under normal and abnormal operating conditions at the Residue Area.

2.4.1 Methodology

The OFAs were performed following a modified method based on the EN 16841 Part 2:2016 standard. This standard is commonly used in Australia and New Zealand to perform such surveys and was derived from the VDI 3940: Part 2 for Odour Plume Impacts Assessments. This method establishes the contour of the grounded odour plume in the field.

The purpose of OFAs undertaken was to determine the extent of the plume and distance at which the odour can be recognised from the facility under specific meteorological and operating conditions.

The width (contour) of the plume is not relevant as no odour modelling is or will be undertaken.

The Department of Water and Environmental Regulation (DWER) does not recommend any odour modelling for an existing site. It does not support any odour criterion modelling especially for complex sources such as a Refinery and its Residue Area.

Historically, the distance at which odour impacts are likely to occur have been estimated by computer modelling of odour emission rates from various sources at the Residue Area. OPAM Consulting has extensive experience in odour monitoring and assessment of modelling odour impacts. The accuracy and reliability of modelling to predict odour impacts is very low and rarely aligns with actual offsite odour impacts.

Odour emission rates from open area sources (fugitive emissions) such as those at the Residue Area are extremely difficult to accurately measure, and results have a high level of uncertainty.

Accordingly, OPAM Consulting believes that an odour assessment tool like OFAs that use observational and empirical data is of higher value than a theoretical approach (modelling) for this project. This is also in accordance with the DWER recommendations for undertaking odour impact assessments.

All OFA undertaken are performed by odour panellists who have been tested to meet the requirements of ANZ 4323.3:2001 standard.

OFAs can be carried out following two methods:

- Stationary plume method is a short period survey repeated under similar and different meteorological conditions. Odour panellists stay at a fixed position for 10 minutes to assess the presence or absence of an odour every 10 seconds;
- Dynamic plume method is a short period survey repeated under similar and different meteorological conditions. Odour panellists assess the presence or the absence of odour downwind relative to the source to evaluate the plume extent. Panellists move following a certain path which crosses the location of the plume.

If the odour panellist recognises an odour, they provide information on the following:

- An odour intensity level which describes the strength of the recognised odour;
- The characteristic of the odour (what the odour smells like).

The stationary plume method was implemented once only as it was found that the dynamic plume method allowed more points to be covered within a short period of time with similar wind and atmospheric conditions (limited probability that the wind suddenly changes significantly in direction and speed).

The dynamic plume method requires access to large areas of public land which is not readily accessible around the Residue Area. This can result in the investigation area being restricted to access point such as roads. Therefore, the Zig-Zag Pattern (as recommended in the standard EN 16841 Part 2:2016) for the surveys was undertaken considering the road network offsite the Alcoa Farmlands and Residue Areas in order to remain within public areas.

Three odour panellists are required to perform the stationary plume measurements. Two experienced odour panellists are required to perform the dynamic plume measurements. Each measurement session takes approximately 1-2 hours and comprises of several single measurements.

Table 3 presents the individual threshold estimation (ITE) of all odour panellists who were involved in the 6-month program. It indicates per panellist the ITE with the month they have been tested or re-tested. A panellist should be re-tested yearly. The ITE is presented in ppb of n-butanol. N-butanol is the reference material used to assess the panellists' sensitivity. To be an odour panellist, the person must have his/her individual ODT between 20 and 80 ppb of butanol.

Table 3: odour panellists' individual threshold estimation (ITE)

ID	PN	BK	MT	AL	TK	CM	LL
Date	Nov 21	Nov 21	Apr 21	Jul-21	Jul-21	Dec-21	Apr 21
ITE	72	55	31	36	47	52	70

The odour panellist names are not listed but only the initials. Should they be required, names can be provided under confidential agreement.

The OFA program considered odour emissions under various wind and atmospheric conditions. It also considered operational conditions at the Residue Area. Assessments were most of the time undertaken under normal conditions. Abnormal conditions are rare but occurred for two surveys in early March based on information provided by Alcoa when upset conditions occurred.

In addition to the OFAs, OPAM Consulting also undertook odour patrols (OPs).

The odour patrol's method is based on the methodology developed by OPAM Consulting's director while employed at the Department of Water and Environmental Regulation (DWER). It is similar to the dynamic plume method assessment of the EN 16841.Part2 standard except that only one experienced assessor performs the assessment. Where possible, an onsite assessment is undertaken to identify the source of odour detected offsite.

Table 4 summarises key elements of the methodology discussed above with additional information about variations from the standards.

Table 4: Details and variations of the methodology from the standards

Method item	**Details**	**Information / variation**
Odour panellists	People selected as per AS.NZS 4323.3:2001 standard (odour sensitivity tested on annual basis) and trained with recognition of the Residue Area odours (section 6.2 EN 16841 Part 2:2016 standard)	All odour panellists are re-assessed on an annual basis
Field operator	Experienced person for odour field assessment. Coordinator of the odour panellists and operations in the field. (section 6.1 of the EN 16841 Part 2:2016 standard)	OPAM Consulting director has 20+ year experience in performing odour field work.
Stationary plume method (section 8.2 EN 16841 Part 2:2016)	Stationary plume method used for several surveys with minimum 2 panellists and the field operator	Measurement of the odour at one point per panellist, extraction of percentage of time per odour at this point (section 10.2.1 EN 16841 Part 2:2016). No consideration about this percentage being above or below 10% as per EN standard – no requirement in WA or for the purpose of this project.
Dynamic plume method (section 8.3 EN 16841 Part 2:2016)	Method used for most of the surveys with a tentative to apply the zig-zag pattern when the zone was clear enough to implement it. Otherwise, path	Pre-located points on a map accessible by the panellists on their phone allowed them to travel from point to point according to a defined path or depending on the odour findings at the points. Measurement at a point for 20-30 seconds before moving to the next point

Method item	Details	Information / variation
	implemented with the purpose of remaining on public areas.	
Meteorological data (section 7.3.2 EN 16841 Part 2:2016)	Wind speed and wind direction were mainly recorded as well as temperature.	Wind data was received from Alcoa after being extracted from their two weather stations at Bancell Rd. Relevant wind conditions were also extracted from the Department of Primary Industries and Regional Development (DPIRD) weather station located 4.3km north of the Residue Area. With the large surface areas of the Residue area at ground level, it may be expected that the plume emitted from the various sources of the Residue Area may remain close to the ground. The DPIRD weather station is a 3m high mast and provide data close to ground data that will complement the 10m data collected at the Bancell Rd weather stations. The purpose is to verify whether the plume emitted from the Residue Area sources is likely more influenced by ground level or higher level wind conditions. With all surveys carried out during end of spring – summer - early autumn, the likelihood of thermal inversion is very low and although the cloud cover was registered during the odour survey, there wasn't any attempt to determine the atmospheric Pasquill-Gifford (P-G) stability class. In addition, the determination of a theoretical atmospheric stability class using for instance, the USEPA Solar Radiation/Delta-T Method is not expected in Western Australia and for this 6-month project because: 1. Large uncertainties are attached to any estimated atmospheric stability class; 2. the recommendation to estimate an atmospheric stability is completely inherent in the purpose of the EN 16841 Part 2:2016

<table>
<tr><th>Method item</th><th>Details</th><th>Information / variation</th></tr>
<tr><td></td><td></td><td>standard of which the goal is to perform some odour modelling for which stability is required. This is not a purpose in WA and even less for this project.</td></tr>
<tr><td>Odour plume contour (extent) identification

(section 5 EN 16841 Part 2:2016)</td><td>This was not implemented for this survey as it was not the purpose of the measurement campaign.</td><td>The campaign was performed to establish the general odour footprint and maximum distances of odour impacts from the Residue Area emissions under different operating and meteorological conditions.

The contour of the plume recommended in the standard is again for the purpose of odour modelling.</td></tr>
<tr><td>Odour intensity scale</td><td>OPAM Consulting has used the VIC EPA 3 level scale instead of the 7-level scale from the VDI 3940 Part3 2010.</td><td>This was performed following the approval from the Air Quality Branch from DWER. This scale is less ambiguous and less subject to misinterpretation than the VDI 3940 scale. DWER have indicated to OPAM Consulting their intention to provide an addendum in the Odour Emission Guidelines. It will propose the use of either scale and a correspondence between the respective odour intensity levels. This correspondence will rely on the agreement that the odour recognition level is below level 1 (VDI 3940 standard) and below the Subtle level of the VIC EPA scale(1).
The correspondence will be as follow:
<table>
<tr><th>VDI 3940 Part 3</th><th>VIC EPA</th><th></th></tr>
<tr><td>0</td><td>No odour</td><td></td></tr>
<tr><td>Levels 1 & 2</td><td>Subtle</td><td></td></tr>
<tr><td>Levels 3 to 6</td><td>Obvious</td><td></td></tr>
</table>
</td></tr>
</table>

(1) Email from Anthony Stuart (DWER Air Quality Branch, Science Investigation manager) to OPAM Consulting dated 01/02/2022.

OPAM Consulting reviewed any possible odour sources near the facility that may produce odours with similar characteristics to those of the Residue Area.

Some operations at the Refinery may also create impacts with similar odour characters as the Residue Area. However, very limited odour surveys (including OFAs and OPs) have been carried out when the odour panellist could have been experiencing odour from both the Residue Area and the Refinery at the same time. Therefore, it is not expected that there would be any other sources that would have a similar odour character as the “wet cement” odour type used for the Residue Area, as described by the odour panellists for this study.

This odour character does not vary over the year.

As a general principle, convective effects tend to vertically displace and disperse the plume and therefore may limit more ground level impacts during summer periods (high temperatures) than during winter (cooler periods). During colder conditions, the plume (cool air) is transported and dispersed closer to ground level. The thermal inversion phenomenon trapping the cool air at ground level and restricting the level of dilution happens at a higher frequency from late spring to early autumn.

Therefore, it is expected that the impacts of variations at the sources of the Residue Area would be minimal, and seasonal variations regarding atmospheric stability and thermal inversion phenomenon will have more consequences in odour impacts.

End of Autumn and winter periods with low wind speeds, cool temperatures, higher levels of relative humidity, significant frequency of thermal inversion events and lower inversion layer height provide worst-case scenarios. These scenarios may have occurred during early morning and early evening surveys carried out during the initial field surveys in October and possibly late surveys in March but remained limited.

More generally, the cooler period just before and after sunrise and sunset during spring and summer periods are also conducive periods for off-site odour impacts under low wind speed and stable atmospheric conditions, which have been the case for several odour surveys performed during this project.

2.4.2 Other odour sources

Agriculture

The surrounding areas include numerous paddocks containing herds of cattle including the Alcoa Farmlands area. Some measurement points could be downwind of these herds on some survey days. The odour characteristics could have been “Livestock” or “Manure”.

Vegetation

Odours from the surrounding vegetation was recognised as a dominant note at several points during this period of end of spring, summer and early autumn. It was characterised by “Vegetation”.

Others

Several odours described as “sweet” were detected without being able to attribute a source.

Odours of wood smoke have been attributed to:

- Bushfire in the vicinity of the surveyed area;
- Some dwellings during early autumn when evening temperatures were becoming cooler.

2.4.3 Presentation of the results

For each measurement session (each day with an OFA or an OP) odour maps are presented that depict the findings of the odour panellists in the field.

A. Odour intensity

The odour intensity indicates the strength at which an odour is recognised.

OPAM Consulting has not applied the German Odour Intensity Scale from the VDI 3940.Part3:2010. This scale has created a lot of confusion for years among odour specialists and regulators. Therefore, and with the approval of the DWER Air Quality Branch specialists, OPAM Consulting has been rating odour intensity by implementing the Odour Intensity Scale used by Victoria EPA (VEPA, 2019). This scale is defined in **Table 5**.

Table 5: Odour intensity scale.

Obvious	Odour is easy to recognise and always noticeable without any effort or focus on it. Odour can be described and may be attributed to a source.
Subtle	Odour is recognised, can be described, and may be attributed to a source. However, you may need to focus by standing still, inhaling into the wind, and concentrating to recognise it.
0	• No odour • Odour is below the recognition threshold in the field.

B. Odour characteristics

From all OFAs and OPs, odour characteristics that were identified are:

- *Alcoa Residue Odour (described as “wet cement” by panellists):*
  - Red colour code for “obvious” odour intensity level
  - Yellow colour code for “subtle” odour intensity level
- *Other natural or anthropogenic sources:*

- Agriculture (manure / livestock): blue colour (no intensity distinction)
- Vegetation odour: green colour (no intensity distinction)
- Other odours (sweet, wood smoke): grey colour (no intensity distinction)

During an assessment, where no odour was recognised or an odour has been detected but could not be recognised and described, it is considered as "No odour" and a white colour-code has been assigned.

A colour-coded representation of the odour characteristics used on the odour maps in this report is presented in **Table 6**.

Table 6: Colour Code for odours recognised in the vicinity of the Residue Area.

	ALCOA		**Natural or other anthropogenic odours No odour**			
Odour character	Residue Area		Agriculture	Vegetation	Other	No odour
Colour	**Subtle**	**Obvious**				

C. Meteorological information

Data is presented per period or for the whole survey (dynamic method) or per single measurement (stationary method).

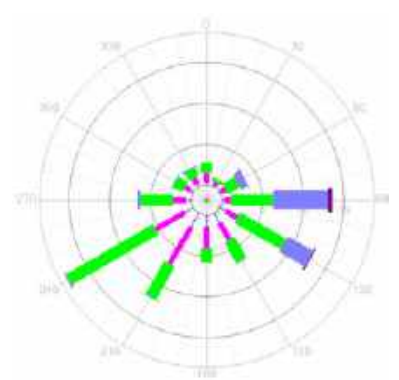
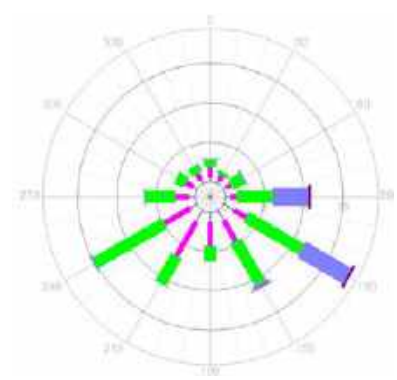
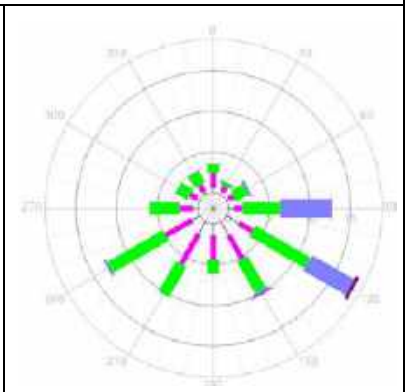
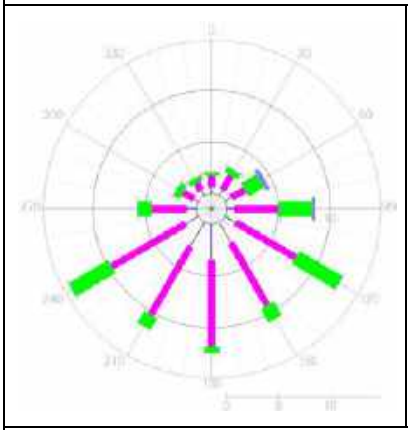
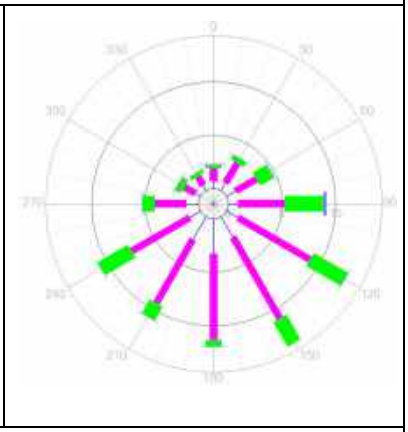
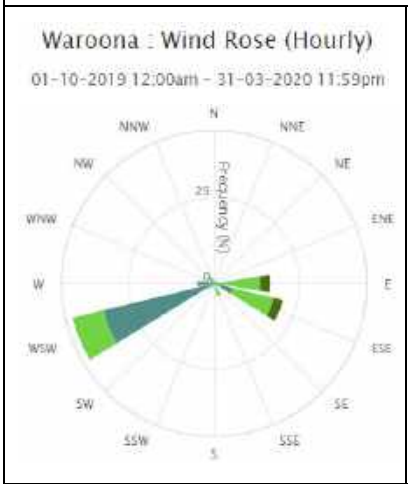
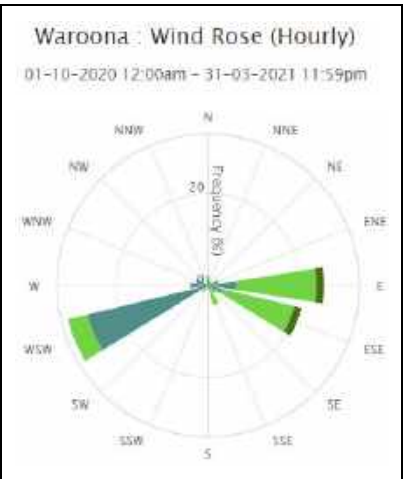
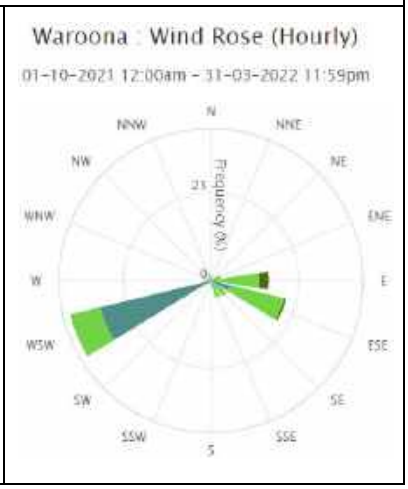
Wind cones are presented on the odour maps. The wind cone represents the sector of the wind directions during:

- Each 10-min single measurement (stationary plume method);
- The duration of the odour measurement per period or for the whole survey (dynamic plume method).

Wind cones from both Bancell Rd weather stations (10m) and the wind cone from the DPIRD weather station (ground level – 3m) are presented on each odour map. This will help in understanding the role of low levels and higher levels wind conditions on the plume's behaviour from the Residue Area.

To confirm that the wind conditions during the period of the 6-month odour campaign Oct-21 to Mar-22 were representative of normal conditions, the wind rose for this period was compared with the wind roses for the periods Oct-20 to Mar-21 and Oct-19 to Mar-20. **Table 7** presents the three wind roses from the two Bancell Rd Alcoa weather stations and from the DPIRD weather station.

Table 7: Oct-Mar wind roses (Alcoa Bancell Rd, Bancell West Rd and DPIRD)

Oct-19 to Mar-20	Oct-20 to Mar-21	Oct-21 to Mar-22
Bancell Rd		
		
Bancell Rd West		
		
DPIRD		
		

Wind roses presented in **Table 7** show that, per weather station, the relative variations of the wind patterns are limited between October 2021 and March 2022 (period of the odour field surveys) and the two previous years. The patterns are also relatively similar among the various weather stations. Therefore, it is possible to confirm that the results of the odour surveys undertaken during this period of October 2021 – March 2022 were representative of a normal year.

D. Operating conditions at the Residue Area and colour code

Although the major odour sources are related to fugitive emissions from all large areas exposed to atmosphere, there are also other operations that may create more disturbance of material and increase the levels of emissions.

It is not possible to quantify the role of these operations in relation to the total odour emission rate (OER) of the whole Residue Area.

Operations that have been identified with possible higher active odour emissions compared to the passive fugitive odour emissions from surfaces of lakes or undisturbed RSA surface areas are:

- *Sand pouring activity*:

The sand pouring on the different RSA is for embankment wall construction.

The sand is odorous and can be considered a source of odour.

Depending on the requirements, a schedule is planned for every week for each hour of the day. On this schedule is indicated where the sand will be poured (Sand Lake or any RSA) and where the sand has been eventually poured and the number of hours it took per location.

On every OFA and OP odour map, the area with the sand pouring is highlighted with a white line.

- *Bitumen operations:*

Waste oil collected from the Refinery and Mine-site and bitumen can be used as an effective form of long-term dust control for internal, unsealed roads on the Residue Area. This source of odour is limited in volume of air in contact with atmosphere and, although the odour intensity is high, the odour is not persistent and disappears after 200-300m.

- *Mud operations:*

Mud from the Superthickener is sent to the RSAs following a specific plan. The periods for mud pouring depend on the status of the mud already in the RSA and how the liquor has evaporated and drained out to achieve some conditions where a new layer of wet mud can be added to the same area.

On the odour maps for each OFA or OP, the RSA which was receiving the mud will be highlighted with a blue polygon.

- *Superthickener operations:*

As indicated in the OOA, the Superthickener receives the mud slurry from the refinery to concentrate the mud prior to being sent to some RSAs. Emissions from this source have a high odour intensity level.

IMPORTANT NOTE:

During March 2021 to June 2021, the Superthickener was offline for a major maintenance overhaul. As a result, the mud was mixed with flocculant and pumped directly to the RSAs resulting in RSAs being wetter and remaining wet longer than usual. It would represent a worst-case scenario in the summer period in Q4 2021 to Q1 2022 for odour emissions.

For each OFA and OP, a status of the mud and sand activities that occurred at the Residue Area during the period of the odour survey will be provided.

E. Odour map for field surveys with Dynamic Plume method

Each odour map represents the results of the dynamic plume OFAs including:

- A map of the area investigated with identification of the measurement position (labelled with numbers);
- A legend including:
  - The scale;
  - The wind cone;
  - The north direction;
  - The colour code for the characteristic and intensity scale of odour recognised in the field (detailed in **Table 8**).

F. Odour map for field surveys with Stationary Plume method

Each odour map presenting the results of stationary plume OFAs will include:

- A map of the area being investigated with measurement points (labelled with numbers)
- A legend including:
  - The scale;
  - The wind cone;
  - The north direction;
  - The colour code for the characteristic and intensity scale of odour recognised in the field (detailed in **Table 8**) used in a pie chart presentation. The sectors of the colour-coded pie chart indicate the percentage of time each odour type and intensity were recognised by the panellist during the 10-min single measurement.

2.4.4 OP#1 – Tuesday 5 October 2021 – 18:11 to 18:52

Odour map for OP #1 is presented in **Appendix 3**.

OP #1 was carried out under a temperature of 11-12°C, cloud cover 5/8 and calm to light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[192, 220] – [S, SW]	[1.4, 2.3]
Bancell Rd 10m	[182, 227] – [S, SW]	[0, 1.7]
DPIRD 3m	[158, 248] – [SE – WSW]	[0.3, 1.4]

Activity at the Residue Area

The sand mix was poured at the RSA3 West and the mud was poured at RSA3 (pouring was occurring since 2/10/22).

Observations

The Wet Cement odour was recognised up to 2,200m at obvious level and up to 2,600m from the activity boundary.

It can also be noticed that no odour could be recognised at some points at the boundary of the Residue Area, south of the Farmlands Area. It would mean that plumes emitted from the RSAs (5m to 10m higher level than the ground level at the Alcoa Farmlands Area) may travel several meters above the ground once beyond the Residue Area boundary under more likely 10m winds than lower level winds.

2.4.5 OP#2 – Wednesday 6 October 2021 – 6:25 to 8:47

Odour maps for OP #2 is presented in **Appendix 4**.

It is divided into two periods:

- OP#2a: 6.25 to 6:55
- OP#2b: 8:25 to 8:50

Between these two periods, OPAM Consulting performed a reconnaissance of accesses and measurement point locations within the Alcoa Farmlands area. No measurements were carried out.

Periods are presented separately as the wind regime was significantly different.

OP #2a was carried out under a temperature of 5-12°C, cloud cover 0/8 and calm to light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	No direction	-
Bancell Rd 10m	[250, 300] – [WSW, WNW]	[0, 1.2]
DPIRD 3m	[70, 95] – ENE, E]	[0.3, 1.1]

OP #2b was carried out under a temperature of 10-13°C, cloud cover 0/8 and calm to light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[340, 350] – [NNW – N]	[0, 1.5]
Bancell Rd 10m	[40, 130] – [NE, SE]	[0, 1.7]
DPIRD 3m	[270, 170] – [NW, S]	[0.3, 2]

Activity at the Residue Area

The sand mix was poured at the RSA7 West, and the mud was poured at RSA3 (pouring was occurring since 2/10/22).

Observations

The wind was light for both periods and difficult to measure and predict. OPAM Consulting's measurement at ground level showed an E wind trend for the OP #2a period and a N/NNW wind for the OP #2b period.

From the weather stations (Alcoa Bancell Rd and DPIRD), it appears that the wind:

- During OP #2a:
  - Was E close to ground level;
  - Was W at 10m high.
- During OP #2b:
  - Was S to W close to ground level;
  - NE to S at 10m high.

During OP #2a period, the plume loaded with the Residue Area emissions may have travelled towards east rather than west. Therefore, it may explain that no odour was recognised at the measurement points.

During OP #2b, Wet Cement odour was recognised at the south-east and south boundary of Alcoa Farmlands

It appears that the plume was more under the influence of wind at 10m high than ground level winds as per OP #1.

2.4.6 OFA#1 – Friday 8 October 2021 – 7:40 to 9:39

Odour maps for OFA #1 is presented in **Appendix 5**.

Six single measurements (SM) of 10 minutes each were carried out by three odour panellists.

Wind conditions during the six single measurements were the following:

SM1: 7:40 to 7:50 - temperature of 14°C, cloud cover 6/8 and calm to light winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[150, 160] – [SSE]	[0, 1.1]
Bancell Rd 10m	[120, 185] – [ESE, S]	[0.7, 1.5]
DPIRD 3m	[140, 220] – [SE, SW]	[0.3, 0.6]

SM2: 8:06 to 8:16 - temperature of 14-15°C and calm to light winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[220, 240] – [SW, WSW]	[1.5, 1.7]
Bancell Rd 10m	[210, 240] – [SSW, WSW]	[1.1, 1.4]
DPIRD 3m	[180, 225] – [S, SW]	[0.6, 1.9]

SM3: 8:27 to 8:37 - temperature of 15°C and calm to light winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[170, 195] – [S, WSW]	[2.5, 3]
Bancell Rd 10m	[195, 205] – [WSW]	[1.2, 1.7]
DPIRD 3m	[180, 225] – [S, SW]	[0.8, 1.9]

SM4: 8:47 to 8:57 - temperature of 15°C and light to gentle winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[195, 205] – [SSW]	[4.6, 4.8]
Bancell Rd 10m	[195, 225] [SSW, SW]	[1.6, 2.5]
DPIRD 3m	[175, 200] – [S, SSW]	[1.4, 2.8]

SM5: 9:07 to 9:17 - temperature of 15-16°C and light to gentle winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[185, 210] – [S, SSW]	[4.6, 4.8]
Bancell Rd 10m	[190, 225] – [SSW, SW]	[2.2, 3]
DPIRD 3m	[175, 210] – [S, SSW]	[1.4, 3.3]

SM6: 9:29 to 9:39 - temperature of 14-15°C and light winds

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[195, 215] – [SSW, SW]	[1.2, 2.3]
Bancell Rd 10m	[230, 255] – SW, WSW]	[1.2, 2.4]
DPIRD 3m	[180, 220] – [S, SW]	[1.7, 3.3]

Activity at the Residue Area

The sand mix was poured at the RSA9 West, and the mud was poured at RSA3 (pouring was occurring since 2/10/22).

Observations

Under these low wind speeds (SM1, SM2 and SM3), the Wet Cement odour was recognised between 1,000 and 3,000 m at subtle level for the three panellists and never more than 25% of the time.

Livestock odours were recognised between a few percent and 60% at some points.

SM1 and SM5 results show that the plume dispersed with distance from the Residue Area.

SM2 results show that measurements were likely carried out on the edge of the plume. It is also possible that the plume was more driven by higher winds than ground level winds as per OP#1 and OP#2.

During SM3 and with measurements more in the centreline of the plume according to the general wind direction from the different weather stations, the Wet Cement odour was recognised between 3% and 17% up to about 2000m from the activity boundary.

SM4, SM5 and SM6 were undertaken from mid-morning onwards, under higher atmospheric temperature and stronger winds which likely created more mixing and turbulences and less impacts than earlier in the morning.

2.4.1 OFA#2 Tuesday 12 October 2021 – 17:25 to 19:05

Odour map for OFA #2 is presented in **Appendix 6**.

OFA #2 was carried out under a temperature of 12-15°C, cloud cover 1/8 and light to gentle gusty winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[190, 203] – [S, SSW]	[2.6, 4.7]
Bancell Rd 10m	[180, 220] – [S, SW]	[1, 2.7]
DPIRD 3m	[175, 250] – [S, WSW]	[0.8, 3.3]

Activity at the Residue Area

The sand mix was poured at the RSA3 West, and the mud was poured at RSA3 (pouring was occurring since 2/10/22).

Observations

The Wet Cement odour was recognised up to 3,800m at subtle level and up to 3,200m at obvious level from the activity boundary.

It is interesting to observe that the plume with the Wet Cement odour was relatively narrow which may suggest that only some specific sources at the Residue Area have emissions that may reach such distances. However, it is not possible to identify which ones.

2.4.2 OFA #3 Wednesday 13 October 2021 – 6.50 to 8.40

Odour map for OFA #3 is presented in **Appendix 7**.

OFA #3 was carried out under a temperature of 9-12°C, cloud cover 4/8 and light to gentle gusty winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[130, 190] – [SE, S]	[1.8, 4.6]
Bancell Rd 10m	[125, 170] – [SE, S]	[1.4, 3]
DPIRD 3m	[110, 165] – [ESE, SSE]	[0.6, 4.7]

Activity at the Residue Area

The sand mix was poured at the RSA9 West, and the mud was poured at RSA3 (pouring was occurring since 2/10/22).

Observations

The Wet Cement odour was recognised up to 3,000m at subtle level and up to 1,100m at obvious level from the activity boundary.

The dominant odour was livestock and vegetation on this day under this meteorological conditions with limited Wet Cement odour impacts.

2.4.3 OP #3 Monday 1 November 2021 – 15.20 to 17.05

Odour map for OP #3 is presented in **Appendix 8**.

OP #3 was carried out under a temperature of 14-15°C, cloud cover 5/8 and light to moderate gusty winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[230, 250] – [SW, WSW]	[5.7, 7.6]
Bancell Rd 10m	[240, 255] – [WSW]	[3.5, 5.5]
DPIRD 3m	[185, 260] – [S, W]	[2.5, 7.8]

Activity at the Residue Area

The sand mix was poured at the RSA8N, and the mud was poured at RSA 5.

Observations

The Wet Cement odour was recognised up to 2,000m at subtle level and up to 1,230m at obvious level from the activity boundary.

Several measurements were performed beyond the furthest points where the Wet Cement odour was recognised. No odour could be detected at those points.

No odour could be recognised during a single measurement of 8 minutes on the east of the Lower Dam.

2.4.4 OP #4 Thursday 4 November 2021 – 15.50 to 17.40

Odour map for OP #4 is presented in **Appendix 9**.

OP #4 was carried out under a temperature of 17-19°C, cloud cover 0/8 and light to moderate gusty winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[220, 240] – [SW, WSW]	[4.4, 6]
Bancell Rd 10m	[220, 250] – [SW, WSW]	[2.8, 4.2]
DPIRD 3m	[200, 250] – [SSW, WSW]	[1.9, 6.1]

Activity at the Residue Area

The sand mix was poured at the RSA8N, and the mud was poured at RSA 6.

Observations

The Wet Cement odour was recognised up to 700m at subtle level and up to 500m at obvious level from the activity boundary.

Several measurements beyond the furthest point with the Wet Cement odour recognised showed that no odour could be recognised.

Despite standing on the east of the Lower Dam for 7 minutes, no odour could be recognised this day.

2.4.5 OFA #4 Thursday 11 November 2021 – 17.10 to 18.10

Odour map for OFA #4 is presented in **Appendix 10**.

OFA #4 was carried out under a temperature of 19-20°C, cloud cover 0/8 and light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[210, 250] – [SSW, WSW]	[2.6, 3.3]
Bancell Rd 10m	[220, 260] – [SW, W]	[1.4, 2.8]
DPIRD 3m	[200, 250] – [SSW, WSW]	[0.8, 2.8]

Activity at the Residue Area

The sand mix was poured at the RSA8 South, and the mud was poured at RSA 6.

Observations

The Wet Cement odour was recognised up to 2,200m at subtle level and up to 500m at obvious level from the activity boundary.

Subtle odour of Wet Cement could be recognised at the east of the Lower Dam during a single measurement and no odour during another one. It is unclear if the source was the lake or the activity behind the lake.

The panellist who patrolled the area of Hamel was within large plumes of wood smoke. The atmosphere was hazy west of the Residue Area and was likely the result of bushfires.

2.4.6 OFA #5 Friday 12 November 2021 – 6.05 to 7.30

Odour map for OFA #5 is presented in **Appendix 11**.

OFA #5 was carried out under a temperature of 13-15°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[80, 120] – [E, ESE]	[2, 5]
Bancell Rd 10m	[90, 125] – [E, SE]	[2.6, 5.1]
DPIRD 3m	[75, 120] – [ENE, ESE]	[2.8, 5.8]

Activity at the Residue Area

The sand mix was poured at the RSA2 East, and the mud was poured at RSA 6.

Observations

The Wet Cement odour was recognised several times at 1,300m and twice up to 2,200m at subtle level.

Under this NE-SE wind, a panellist patrolled downwind of the refinery but upwind of the Residue Area. Obvious Wet Cement odour type was recognised at points 44b, 45 and 46 at a distance of 1,200-1,400m from the refinery boundary.

Wet Cement odour recognised at points 34, 35 and 36 are more likely coming from sources within the Residue Area rather than the refinery.

2.4.7 OFA #6 Thursday 18 November 2021 – 15.10 to 16.45

Odour map for OFA #6 is presented in **Appendix 12**.

OFA #6 was carried out under a temperature of 16-18°C, cloud cover 7/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[140, 175] – [SE, S]	[4.1, 7.3]
Bancell Rd 10m	[135, 190] – [SE, SSW]	[1.2, 4.3]
DPIRD 3m	[125, 190] – [ESE, S]	[1.9, 5.3]

Activity at the Residue Area

The sand mix was poured at the RSA8 South then RSA8 north and the mud was poured at RSA 6.

Observations

The Wet Cement odour was only recognised at subtle and obvious intensity within the Farmlands Area and at its boundary (point 27).

It is possible that the limited number of Wet Cement odour impacts is due to the survey being carried out in the middle of the afternoon.

2.4.8 OFA #7 Monday 29 November 2021 – 16.05 to 17.30

Odour map for OFA #7 is presented in **Appendix 13**.

OFA #7 was carried out under a temperature of 21-23°C, cloud cover 2/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[230, 250] – [SW, WSW]	[4.4, 6.3]
Bancell Rd 10m	[230, 250] – [SW, WSW]	[2.4, 4.2]
DPIRD 3m	[200, 260] – [SSW, WSW]	[1.7, 5.6]

Activity at the Residue Area

The sand mix was poured at the RSA8 North then RSA2 North and the mud was poured at RSA 8.

Observations

The Wet Cement odour was only recognised at obvious intensity within the Farmlands Area and at a maximum distance of 700m.

As for OFA #6, the limited number of Wet Cement odour impacts may be due to the survey being carried in the second half of the afternoon.

2.4.9 OP #5 Thursday 2 December 2021 – 17.10 to 18.30

Odour map for OP #5 is presented in **Appendix 14**.

OP #5 was carried out under a temperature of 21-23°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[205, 230] – [SSW, SW]	[3.8, 6.3]
Bancell Rd 10m	[200, 235] – [SSW, SW]	[1.5, 3.8]
DPIRD 3m	[185, 250] – [S, WSW]	[1.4, 4.2]

Activity at the Residue Area

The sand mix was poured at the RSA8 North, and the mud was poured at RSA 8.

Observations

The Wet Cement odour was recognised up to 2,000m at subtle level and up to 500m at obvious level from the activity boundary.

2.4.10 OFA #8 Thursday 9 December 2021 – 9.55 to 11.40

Odour map for OFA #8 is presented in **Appendix 15**.

OFA #8 was carried out under a temperature of 33-35°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[340, 40] – [NNW, NE]	[5.3, 7.6]
Bancell Rd 10m	[330, 60] – [NNW, ENE]	[1.4, 4.1]
DPIRD 3m	[320, 60] – [NW, ENE]	[2.8, 6.1]

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 8.

Observations

The Wet Cement odour was recognised up to 1,100m at subtle and obvious levels from the activity boundary.

The limited number of Wet Cement odour impacts at further distances may be partly due to the survey carried out in mid-morning and the hot conditions of the day which may generate convective effects to the air and vertical dispersion.

2.4.11 OFA #9 Monday 13 December 2021 – 15.30 to 16.45

Odour map for OFA #9 is presented in **Appendix 16**.

OFA #9 was carried out under a temperature of 21-23°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[230, 245] – [SW, WSW]	[4.8, 6.1]
Bancell Rd 10m	[220, 255] – [SW, WSW]	[2.8, 4.3]
DPIRD 3m	[195, 255] – [SSW, WSW]	[2.2, 5.3]

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 7/8.

Observations

The Wet Cement odour was recognised at obvious and subtle levels up to 2,400m from the activity boundary (4,100m from the RSA north boundary).

It was the first time that obvious Wet Cement odour was recognised at such distance in Hamel. It can be noted that wind conditions and periods of the day were similar to previous surveys with obvious odour recognised at shorter distances. The meteorological data provided by Alcoa does not show any likelihood of a thermal inversion occurring for this period and that would have partly explained the numerous impacts at Hamel.

An odour described as “sweet” was recognised at points 9, 19 and 23. However, it was not possible to identify a source.

2.4.12 OFA #10 Monday 20 December 2021 – 17.10 to 18.45

Odour map for OFA #10 is presented in **Appendix 17**.

OFA #10 was carried out under a temperature of 24-26°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[210, 240] – [SSW, WSW]	[2, 4.3]
Bancell Rd 10m	[225, 245] – [SW, WSW]	[1.5, 3.2]
DPIRD 3m	[190, 255] – [S, WSW]	[1.5, 3.2]

Meteorological data provided by Alcoa shows that air was hotter (+0.2 to +1.8°C) at 30m compared to 10m high and about +2.5°C between 30m and 2m high. A thermal inversion phenomenon may have occurred which may partly explain the larger than usual number of impacts at Hamel.

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 7/8.

Observations

The Wet Cement odour was recognised at obvious and subtle levels up to 2,700m from the activity boundary (3,800m from the RSA north boundary).

2.4.13 OFA #11 Tuesday 21 December 2021 – 7.20 to 8.55

Odour map for OFA #11 is presented in **Appendix 18**.

OFA #11 was carried out under a temperature of 18-22°C, cloud cover 3/8 and light to gentle winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[135, 170] – [SE, S]	[3, 4.5]
Bancell Rd 10m	[125, 220] – [SE, SW]	[1.3, 3.4]
DPIRD 3m	[70, 270] – [ENE, W]	[0.3, 3.9]

It appears that the plume of the Residue Area is driven by wind at 10m high rather than ground level winds as per observations made from OP #1 and OP #2 results.

Activity at the Residue Area

The sand mix was poured into the Sand Lake and the mud was poured at RSA 7/8.

Observations

The Wet Cement odour was recognised at obvious level up to 2,400m from the northern activity boundary.

It was the first time that the Wet Cement odour was recognised at subtle level at point 7 (3,700m from the northern activity boundary).

2.4.14 OFA #12 Tuesday 11 January 2022 – 16.45 to 18.20

Odour map for OFA #12 is presented in **Appendix 19**.

OFA #12 was carried out under a temperature of 28-32°C, cloud cover 0/8 and calm to gentle winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[200, 255] – [SSW, WSW]	[0, 5.2]
Bancell Rd 10m	[170, 240] – [S, WSW]	[1.5, 3]
DPIRD 3m	[160, 255] – [SSE, WSW]	[1.4, 3.6]

Activity at the Residue Area

The sand mix was poured at the RSA8 South and the mud was poured at RSA 3.

Observations

The Wet Cement odour was recognised up to 2,200m at subtle level and up to 1,600m at obvious level from the activity boundary (4,100m at subtle and 3,200m at obvious level from the northern boundary of the RSAs).

A sweet odour was also recognised without being able to identify a specific source.

2.4.15 OFA #13 Tuesday 18 January 2022 – 10.25 to 11.40

Odour map for OFA #13 is presented in **Appendix 20**.

OFA #13 was carried out under a temperature of 33-36°C, cloud cover 0/8 and calm to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[5, 55] – [N, NE]	[3.7, 6.3]
Bancell Rd 10m	[325, 60] – [NW, ENE]	[2,3.2]
DPIRD 3m	[330, 95] – [NNW, E]	[0.6, 5]

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 6.

Observations

The Wet Cement odour was recognised up to 2,800m at subtle level and up to 1,100m at obvious level from the activity boundary (southern side).

2.4.16 OFA #14 Monday 24 January 2022 – 16.30 to 17.50

Odour map for OFA #14 is presented in **Appendix 21**.

OFA #14 was carried out under a temperature of 26-28°C, cloud cover 0/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[135, 170] – [SE, S]	[5.9, 8.6]
Bancell Rd 10m	[130, 155] – [SE, SSE]	[3.7, 5]
DPIRD 3m	[110, 170] – [ESE, S]	[2.8, 6.7]

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 6.

Observations

The Wet Cement odour was only recognised within the Alcoa Farmlands Area and at its boundary at subtle and obvious levels.

2.4.17 OFA #15 Tuesday 8 February 2022 – 16.20 to 17.40

Odour map for OFA #15 is presented in **Appendix 22**.

OFA #15 was carried out under a temperature of 21-23°C, cloud cover 6/8 and light to gentle winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[210, 250] – [SSW, WSW]	[3.4, 5]
Bancell Rd 10m	[220, 255] – [SW, WSW]	[1.4, 3.8]
DPIRD 3m	[180, 250] – [S, WSW]	[1.7, 4.2]

Activity at the Residue Area

The sand mix was poured at the RSA5 North, and the mud was poured at RSA 5.

Observations

The Wet Cement odour was recognised up to 2,200m at subtle and obvious levels from the activity boundary (4,100m from the northern boundary of the RSAs).

2.4.18 OFA #16 Tuesday 22 February 2022 – 19.05 to 20.35

Odour map for OFA #16 is presented in **Appendix 23**.

OFA #16 was carried out under a temperature of 24-26°C, cloud cover 2/8 and light to gentle winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	No data	No data
Bancell Rd 10m	[190, 220] – [S, SW]	[3, 5.6]
DPIRD 3m	[175, 230] – [S, SW]	[1.1, 4.7]

Activity at the Residue Area

The sand mix was poured at the RSA6 North then RSA8 North and the mud was poured at RSA 4.

Observations

The Wet Cement odour was recognised up to 2,900m at subtle level and up to 2,500m at obvious level from the activity boundary (3,600m for both levels from the northern boundary of the RSAs).

There was a higher frequency of impacts than usual at points 18, 19 and 22 with the Wet Cement odour recognised at obvious level. An earlier evening survey may have provided a more stable atmosphere and lower dispersion which may have explained the higher obvious odour impacts.

2.4.19 OP #6 Thursday 3 March 2022 – 14.45 to 16.20

This assessment was specifically dedicated to the Residue Area. The purpose was to identify the strength of the odour emissions from the main sources from an odour point of view.

The outcome of this assessment has been used in the OOA to rank the sources from their odour emission potential based on odour intensity measured on their edges.

Odour map for OP #6 is presented in **Appendix 24**.

OP #6 was carried out under a temperature of 23-25°C, cloud cover 2/8 and light to moderate winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[155, 245] – [SSE, WSW]	[3.1, 6]
Bancell Rd 10m	[110, 250] – [ESE, WSW]	[1.1, 4]
DPIRD 3m	[135, 250] – [SE, WSW]	[1.7, 5.8]

Presentation of the results

Due to the close proximity of the measurement points downwind of all sources (RSAs, Lakes and Ponds), the presentation of the results was slightly modified to provide a ranking of the odour source based on the odour intensity levels experienced on their edges at the measurement point.

Every single measurement at one point lasted between 1 and 6 minutes. For each point and for the duration of the measurement at the point, the code presented in **Table 8** has been used on the odour map presented in **Appendix 24**.

Table 8: Coloured code used for OP #6 odour map

○	No odour recognised or no possible clear characterisation of the odour
◑	Part of the time with no odour and with odour at subtle intensity
●	Odour at subtle intensity for the duration of the assessment
●	Odour at obvious intensity for the duration of the assessment
★	Odour at obvious intensity and stronger than other obvious odour at other sources

Also, with the proximity of the source during the measurement, it is important to indicate the exact wind direction during the assessment period that shows that the measurement was performed downwind of the source. The wind shifted from 160° (SSE) to 250° (WSW) between the beginning and the end of the assessment.

On the side of each colour code presented at a measurement point will be three arrows representing the average wind direction for the duration of the measurement from the Bancell Rd West, Bancell Rd and DPRID weather stations.

Activity at the Residue Area

The sand mix was poured at the RSA5 North.

For the mud, **operating conditions were abnormal** with maintenance required at the superthickener. To do so, the superthickener needed to be emptied. The pumping from the superthickener started on Sunday 27/02 to Monday 28/02 with the liquor directed to RSA4. Then, during the maintenance at the Superthickener, the mud was bypassed from the refinery to RSA3 between Sunday 27/02 to Wednesday 2/03 (up to about 10.30pm). The superthickener was then refilled with mud over two days (Thursday 03/03 and Friday 04/03) following the maintenance. No mud was directed into any RSA during the refill operation of the Superthickener.

During the survey on the 3rd of March, the liquor was still draining out from RSA4 (observed during the survey, see photo on odour map in **Appendix 24**). The content of the superthickener sent to RSA4 had more liquor than usual. This additional volume of liquor, discharged over a large surface area took more time to drain and evaporate, creating longer but also slightly higher emissions (due to the large surface area) than usual.

The mud bypassed for four days was applied to a ¼ only of RSA3. Although the flocculant line was connected to the bypass, the slurry arriving at RSA3 had, similarly to RSA4, a higher volume of liquor in it. Therefore, during these days and for several days later, the odour emissions from this ¼ of the surface area of RSA3 would have lasted longer than usual.

Observations

From the measurements carried out at the Residue Area, downwind of the major possible odour sources of the site, it was possible to provide a ranking of their potential for odour emissions. This assessment was undertaken under considered similar wind conditions and therefore dilution. It should be considered that this ranking does not provide an absolute strength of a source but a relative one to other source's strengths. The intensity rank needs then to be associated to the surface area of the source(s) to understand their role regarding the odour emission potential for the Residue Area, and the risk associated with them if abnormal operating conditions occur with likely higher odour emissions than usual (see OOA section 3.1).

The relative ranking of the sources from their odour emissions potential is as follows:

- HIGH emissions: ROCPs, Cooling Pond and superthickener;
- MEDIUM to HIGH emissions: Partly wet sections of the RSAs, Sand Lake;
- MEDIUM emissions: Partly dry sections of the RSAs;
- LOW to MEDIUM emissions: Oxalate 1 & 2, Spent Liquor Pond, ROWS Pond, Detention Ponds 1 & 2, fresh water duck pond and the Lower Dam(1)

(1) The lower dam was not assessed during OP #6 but during several surveys prior to this one

2.4.20 OFA #17 Wednesday 9 March 2022 – 18.45 to 20.30

Odour map for OFA #17 is presented in **Appendix 25**.

OFA #17 was carried out under a temperature of 26-28°C, cloud cover 8/8 (overcast) and calm to light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[185, 215] – [S, SW]	[1.5, 2.4]
Bancell Rd 10m	[200, 245] – [SSW, WSW]	[0, 1.7]
DPIRD 3m	[165, 230] – [SSE, SW]	[0.3, 2.2]

Activity at the Residue Area

The sand mix was poured into the Sand Lake and the mud was poured at RSA 8.

The Residue Area was under abnormal operating conditions.

There were planned works implemented on this day with a reduced production at the refinery. However, the forecasted sand plan matched the actuals. Flows for sand mixture under this reduced capacity are normally 50-60% of normal flow days. Low flows dilute the sand being deposited at residue at the sand pour (high water to sand

ratio). The mud has a less effect on the flows to the dry beds as the super thickener is normally pumped down during this low flow days to maintain normal consistency.

Therefore, despite a reduction in production at the refinery, it is not expected that it significantly impacted the levels of odour emissions at the Residue Area.

Observations

The Wet Cement odour was recognised up to 3,600m to 3,900m at subtle and obvious levels from the northern side of the activity boundary. The Wet Cement odour was impacting the area for the whole duration of the survey. The odour map in **Appendix 25** shows that the plume was constantly following a similar path of about 1,800m wide.

As per OFA #16, there was a slightly higher frequency of impacts than usual at points 7, 8, 9, 10 and 21 with the Wet Cement odour recognised at subtle and obvious level. An earlier evening survey may have provided a more stable atmosphere and lower dispersion which may have explained the higher obvious odour impacts.

2.4.21 OP #7 Saturday 19 March 2022 – 5.25 to 6.40

Odour map for OP #7 is presented in **Appendix 26**.

OP #7 was carried out under a temperature of 19-20°C, cloud cover 6/8 and calm to light winds:

	Wind direction range (deg & azimuths)	**Wind speed range (m/s)**
Bancell Rd West 10m	[145, 195] – [SE, SSW]	[0, 5]
Bancell Rd 10m	[130, 225] – [SE, SW]	[0, 3.1]
DPIRD 3m	[130, 200] – [SE, SSW]	[0.8, 4.2]

Activity at the Residue Area

The sand mix was poured into RSA6 North, and the mud was poured into RSA 7.

Observations

During this early morning survey with cooler conditions than during summer and low wind speed, Wet Cement subtle odour could be recognised up to 5,200m from the northern activity boundary of the Residue Area.

As per OFA#16 and OFA #17, a more stable atmosphere and lower dispersion may be more likely the conditions at this period of the day and period of the year with cooler conditions. It may explain the further distances (points 6A and 6B) at which subtle Wet Cement odour was recognised. It should also be noted that the Wet Cement odour was recognised only once despite several assessments at these points during this OP.

2.4.22 OP #8 Monday 21 March 2022 – 5.25 to 7.10

Odour map for OP #8 is presented in **Appendix 27**.

OP #8 was carried out under a temperature of 17-18°C, cloud cover 0/8 and light to gentle winds:

	Wind direction range (deg & azimuths)	Wind speed range (m/s)
Bancell Rd West 10m	[160, 190] – [SSE, S]	[3.7, 5.7]
Bancell Rd 10m	[160, 200] – [SSE, SSW]	[1.1, 3]
DPIRD 3m	[140, 200] – [SE, SSW]	[1.9, 5.3]

Activity at the Residue Area

The sand mix was poured at the RSA6 North, and the mud was poured at RSA 7.

Observations

During this early morning survey and cooler period than during summer, Wet Cement odour could not be recognised further than the boundary of the Alcoa Farmlands Area.

This is significantly different from two days earlier during OP #7. The reason may be partly related to the possibility of more stable atmospheric conditions during OP #7 with an overcast sky, lower wind speeds and cool temperatures.

2.4.23 OFA and OP results and interpretations

Results that have emerged from these surveys are:

- 10m high winds appear to more likely drive the odour plumes emitted from the Residue Area and not ground level odour wind;
- Under a quasi-constant light-gentle wind, some plumes remain narrow compared to the length of the Residue Area section (3,000m E-W section, 3500m NW-SE section) with some widths of about 1,500 to 1,800m.
- There are no significant other odours in the 3km to 5km area around the Residue Area except some odours of livestock or manure.

Figure 5 presents the consolidated results of the 17 OFAs and 8 OPs between the 5th of October 2021 and the 21st of March 2022.

Representations show when a Wet Cement odour was recognised at this point. It depicts the highest odour intensity possible at least during one OFA or one OP.

All points have been patrolled numerous times downwind of the Residue Area and under conducive conditions for Wet Cement odour impacts should they reach this point.

Table 9 presents the colour code used to represent the summary of all Wet Cement odour impacts during this project between October 2021 and March 2022 over the entire 6-month period.

Table 9: Colour code used to summarise results of odour surveys

	**ONE** recognition at OBVIOUS level ONLY – no other recognition
	ONE recognition at SUBTLE level ONLY – no other recognition
	Odour recognised at OBVIOUS and SUBTLE levels **AND** more than **twice** at OBVIOUS level
	Odour recognised at SUBTLE level ONLY **AND** more than twice
	**ONE** recognition at OBVIOUS level **AND ONE** recognition at SUBTLE level
	ONE recognition at OBVIOUS level **AND** more than one recognition at SUBTLE level

The low number of impacts south of the Residue Area is due to limited surveys carried out under N winds (not prevailing winds during summer period). In addition, the few surveys carried out south of the Residue Area were carried out during mid-morning or mid-afternoon on some warm days with convective vertical dispersion and lower ground levels impacts.

The topography and terrain south of the Residue Area is similar to the north side. Therefore, it is highly likely that the distance between the southern boundary of the RSA and the likely odour impacts south of the Residue Area would be similar to the distances found north of this area.

From the 25 odour survey results, approximative odour footprints for obvious and subtle odour levels were estimated. The southern limits of these footprints have considered the assumption of a "mirrored" distance from the northern zone discussed in the previous paragraph (thin yellow and red lines in **Figure 5**).

The two measurements north of Buller Road have not been accounted for the design of the subtle level odour footprint. It is more robust to consider the estimated footprint based on measurement point locations with more than twice the Wet Cement odour recognised at the point.

It shows that the current maximum distance of the odour footprint for obvious odour would be about 3,200m and 3,700m for subtle level from the northern and assumed from the southern boundary of the RSAs.

IMPORTANT NOTE:

It must be considered that these distances are not strict but an approximative guide and should be read as being in the vicinity of the proposed distance.

With consideration of the note in section 3.3, it is likely that the odour footprint during winter conditions would be slightly larger than the estimated odour footprint obtained under summer period conditions.

It is difficult to estimate the additional distance of winter impacts compared to summer events. However, OPAM Consulting would use its experience in performing odour surveys around large surface area odour sources in summer and in winter periods to provide an estimate of 10-15% possible distance increase.

By applying 15% on the summer odour footprint, the approximative but more likely conservative odour footprint for the Residue Area presented in **Figure 5** would be **3,650m for obvious** levels and **4,250m for subtle** levels (thick yellow and red lines).

It can be noted that the major odour complainant located at 3,800m from the northern boundary of the RSAs is within the limit of the odour footprint.

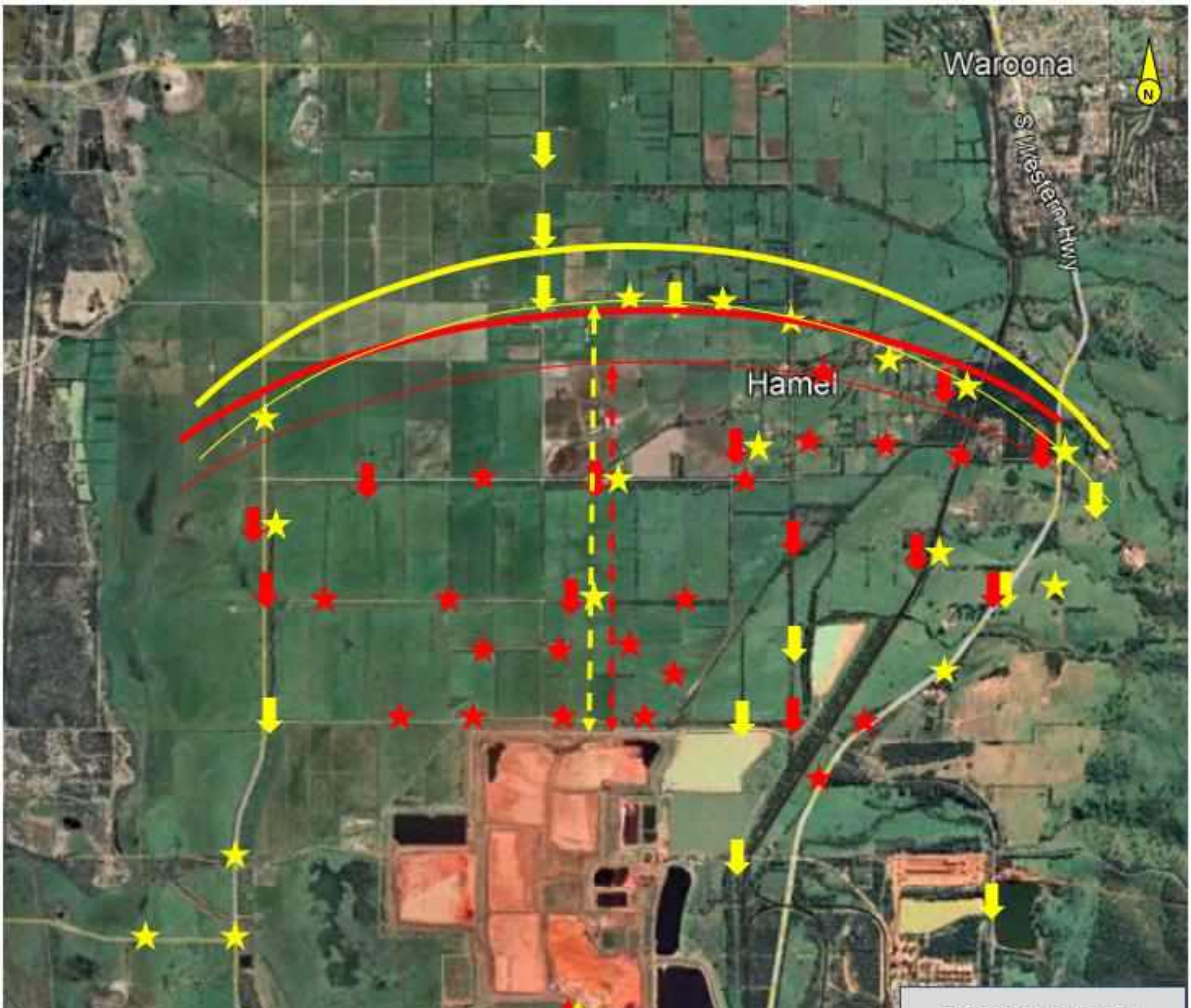


Figure 5: Consolidated offsite odour findings and estimated odour footprints

3. Comparative odour impact footprint

The information presented in this section is based on reasoning similar to the comparative dispersion modelling. Although no odour modelling was performed, simple power function ratios derived from steady-state Gaussian plume modelling were used.

The power function used to derive the expected new offsite odour footprint distance D_1 from the existing offsite odour footprint distance D_0 is:

$$\left(\frac{D_1}{D_0}\right) = \left(\frac{OER_1}{OER_0}\right)^{0.7}$$

With: **OER_0**: Existing odour emission rate for the existing surface area sources at the Residue Area

OER_1: Future odour emission rate from the existing surface area sources and the new proposed RSA10

For a surface area, the OER is the product of the surface area of the source by the specific odour emission rate (SOER) expressed per unit of surface area.

The Refinery Water Areas and material received will remain unchanged after the commissioning of RSA10. RSA10 will receive similar material as other RSAs. Therefore, the component that may have the most significant role regarding odour emissions and impacts is the variation of the surface area of the current RSAs and the addition of the surface area of RSA 10. RSA10 will have similar behaviour regarding odour emissions to the other RSAs.

Figure 6 shows all possible odour sources of the Wagerup Alcoa Residue Area (existing and with the new RSA10). It should be noted that the Lower Dam was excluded as a source for this project (see OOA section 3.1 and section 2.4.25).

According to the assessment carried out during this project (section 3.4.26) and the findings per source type at the Residue Area regarding the significance of their odour emissions, **Figure 6** shows the sources that are considered major for odour emissions (with a white contour).

According to the information provided by Alcoa, the total operational Active Mud Drying area for RSAs 3 to 9 (January 2022) was 195.8 Ha. Wagerup residue loses drying surface area every year due to residue drying area embankment wall lifts. By 2027 the residue area drying area is forecast to be approximately 178.4 Ha with an additional 42.4 Ha from RSA 10.

It is assumed that the total OER for the Residue Area is from the **major odour sources only** (white contour in **Figure 6**) and not from the sources identified as being with lower emissions (see OOA section 3.1 and section 3.4.25). Every major source has the same average $\overline{SOER_{Maj}}$ which multiplied by the surface area of all major sources equal to the total OER of the Residue Area.

Figure 6: Major odour sources (white contour) and RSA surface areas (Jan. 2022)

It is assumed that the RSA10 will have the same $\overline{SOER_{Maj}}$.

In this case the ratio of the OERs post and prior to RSA10 with all the same average $\overline{SOER_{Maj}}$ will be equal to the ratio of the surface area of all major sources A_{Maj} post and prior to the new RSA10.

$$\left(\frac{OER_1}{OER_0}\right) = \frac{SOER_1.A_1}{SOER_0.A_0} = \frac{\overline{SOER_{Maj}}.A_1}{\overline{SOER_{Maj}}.A_0} = \frac{A_{Maj} + A_{RSA10}}{A_{Maj}}$$

With:

A_0: current surface area of the operational Active Mud Drying area for RSAs 3 to 9 (194.5 Ha) and other sources, i.e. ROCP 2 & 3, Superthickener, Sand Lake, Cooling Pond (42.5 Ha)

$$A_0 = 195.8 + 42.5 = 238.2 \text{ Ha}$$

A_1: future surface area of the operational Active Mud Drying area considering the drying surface area deficit for RSAs 3 to 9 (178.4 Ha), the surface area of RSA 10 (42.5 Ha) and other sources, i.e. ROCP 2 & 3, Superthickener, Sand Lake, Cooling Pond (42.5 Ha)

$$A_1 = 178.4 + 42.5 + 42.5 = 263.4 \text{ Ha}$$

The ratio of the sum of the current major source surface area and the surface area of RSA10 to the current major source surface area at the Residue Area is equal to 1.1.

The current odour footprint distance of the Residue Area emissions is about 3,650m for obvious level and 4,250m for subtle levels (see section 3.4.29). It is also aligned with the unique odour complainant for the last year or so.

By applying the power function, **the expected odour footprint distance would be:**

- **about 3,900m for obvious levels**
- **about 4,550m for subtle levels**

which represents an increase of about 7% of the current estimated odour footprint (see **Figure 7**).

Although RSA 10 will be located in the southern section of the Residue Area, it is not expected that the southern odour footprint limit would be significantly further away from the northern odour footprint because of:

- the cumulative emission with other sources;
- the uncertainties attached to the distance of the odour footprint.

In conclusion, following the commissioning of RSA10, the odour footprint may potentially increase by approximately 7% from the current odour footprint. This prediction considers the cumulative emissions from the overall Residue Area (with RSA mud drying surface area decreasing over time as the height of the RSAs increases) as well as the addition of the new RSA10 surface area (refer to the 2017 Alcoa Wagerup Alumina Refinery LTRMS). During the operational life of RSA10, the mud drying area will reduce back to the current area of 195.8Ha, and the corresponding emissions footprint is also predicted to reduce back to the May 2022 footprint. For comparative reference, in 2017 when Wagerup RSA9 was commissioned, the mud drying area peaked at 230 Ha and has reduced to 194.5 Ha at the time the odour field assessments were completed for this report.

This limited increase and then decrease of the odour footprint should not increase the current odour risk level.

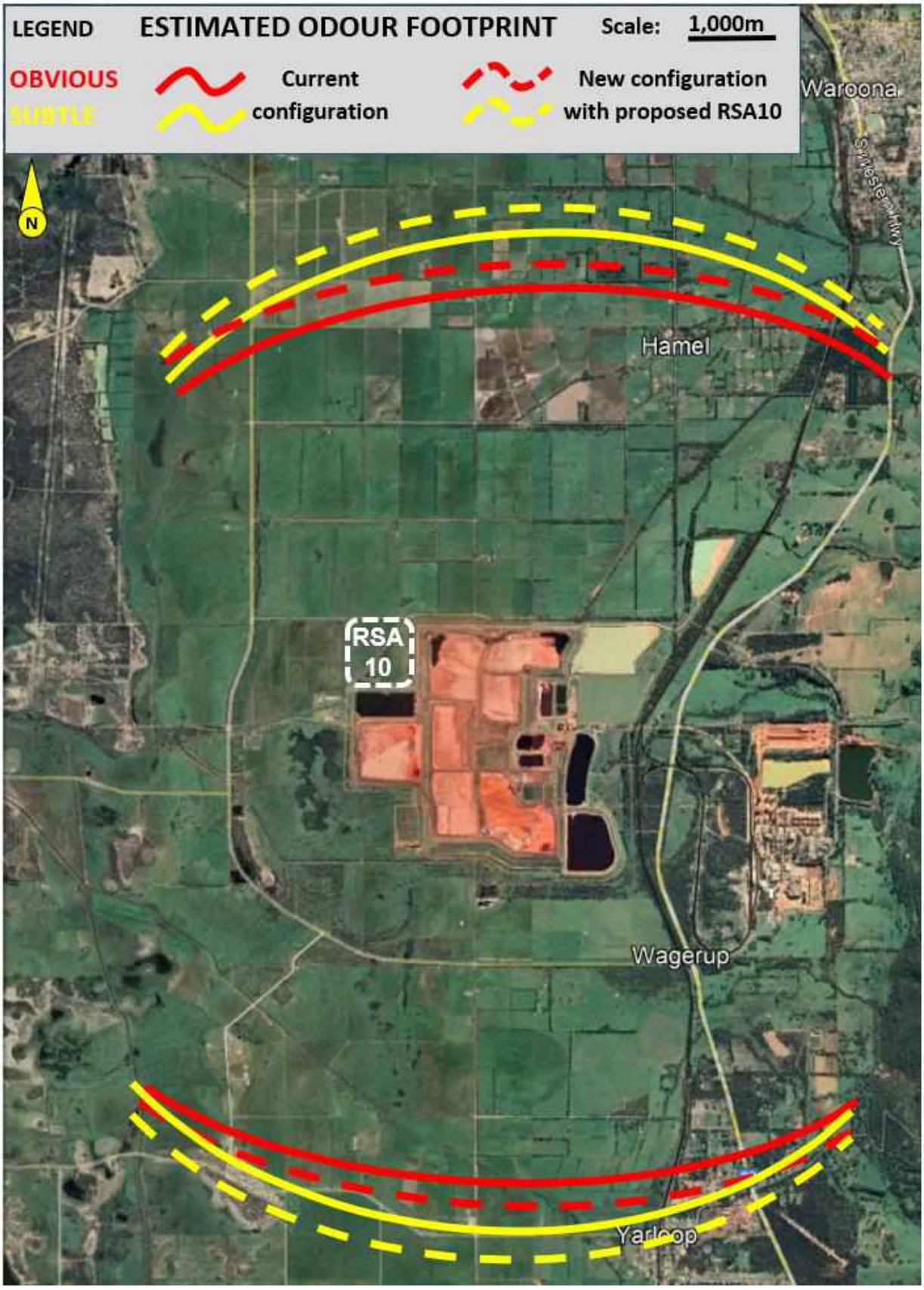


Figure 7: Current and future projected odour footprint (Residue Area emissions)

4. Conclusion

The Alcoa refinery at Wagerup extracts alumina from bauxite and stores wastes and residues in Residue Storage Area (RSA) or Residue Area in a controlled environment.

Alcoa will submit a works approval application to DWER to build and operate a new dry storage area RSA10. The works approval application for this project requires the inclusion of an odour assessment that meets the requirements of the *DWER Odour Emissions Guideline* (**DWER, 2019**).

A screening and detailed analysis were undertaken according to the *DWER Odour Emissions Guideline*. The following conclusions can be made from consideration of the findings and outcomes of these analyses:

- The Residue Area represents a substantial surface area exposed to atmosphere and odour mitigation is difficult. However, some management actions are in place at the Residue Area to minimise odour emissions as much as possible;
- Although few dwellings are closer than 1,000m, most of the sensitive receptors are located beyond 1,400m from the activity boundary of the Residue Area;
- Prevailing winds are SW/S and E/SE winds according to the 7-year wind roses of the two Alcoa-owned weather stations. Topographic features with the presence of the scarp on the east of the refinery and Residue Area may generate specific wind conditions.
- Odour complaints have significantly decreased over the last six years to reach a level where a unique resident has been complaining regarding odour likely from the Residue Area for the last year or so.
- Odour surveys were carried out in the vicinity of the Residue Area under different atmospheric and operating conditions. Odour footprints from the Residue Area odorous emissions were estimated for the survey period and then extrapolated to a yearly period with consideration of possibly more conducive atmospheric conditions during the winter period. Finally, a projected odour footprint with the new RSA10 was also provided. An odour footprint for obvious and for subtle odour intensity levels were provided for each estimation, extrapolation, and projection. **Table 10** summarises these odour footprint maximum distances.

Table 10: Odour footprint maximum distances

	Estimated odour footprint from 6-month surveys	**Extrapolated odour footprint with winter period**	**Projected future odour footprint with the new RSA10**
Obvious level	≈ 3,200m	≈ 3,650m	≈ 3,900m
Subtle level	≈ 3,700m	≈ 4,250m	≈ 4,550m

With the existing operating conditions and management in place at the Residue Area and consideration of its location and the meteorological conditions of the area, odour emissions from this activity can impact at distances within which sensitive receptors live.

However, odour complaint data shows that the number of odour complainants has reduced to a single resident north of the activity.

The projected maximum odour footprint with the new RSA10 within an area with a limited number of sensitive receptors should not increase the odour impact risk of the Residue Area which should remain low.

REFERENCES

Alcoa 2017

Wagerup Alumina Refinery Long Term Residue Management Strategy (LTRMS)

Alcoa 2021

Works Approval Application for L6217/1983/15 VOC/Odour Emission Reduction Project – Supporting Information: Detailed Odour Assessment, August 2021

AS/NZS 4323.3:2001

Stationary Source Emissions Part 3: Determination of Odour Concentration by Dynamic Olfactometry, Standards Australia, Sydney

DWER, 2019

Guideline: Odour Emissions, DWER WA, Department of Water and Environmental Regulation, June 2019

EN 16841-2:2016

Ambient Air – Determination of Odour in Ambient Air by Using Field Inspection – Part 2: Plume Method, CEN (European Committee for Standardisation)

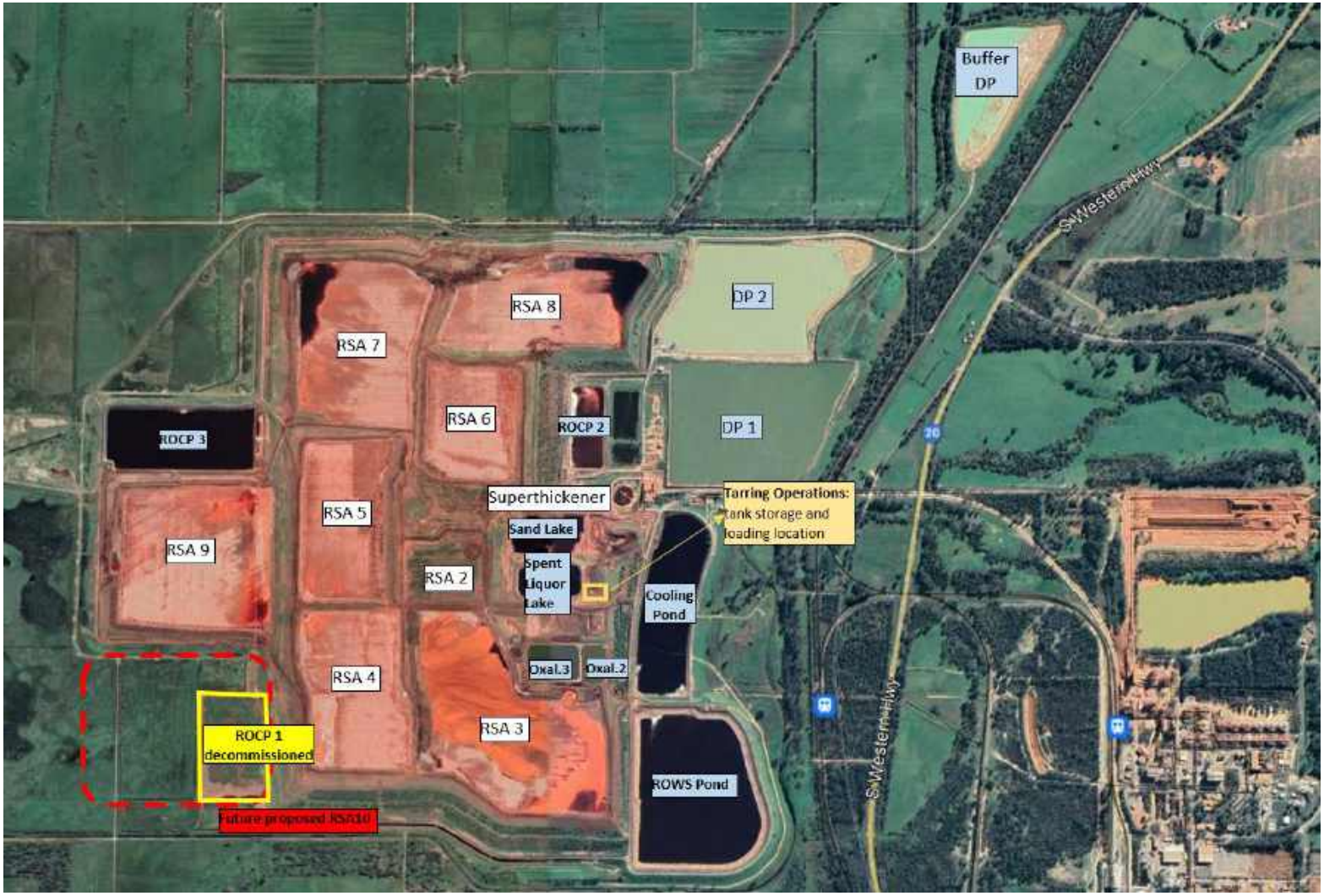
VEPA 2019

Odour Surveillance Guidance: Draft – December 2019. Environment Protection Authority Victoria

APPENDICES

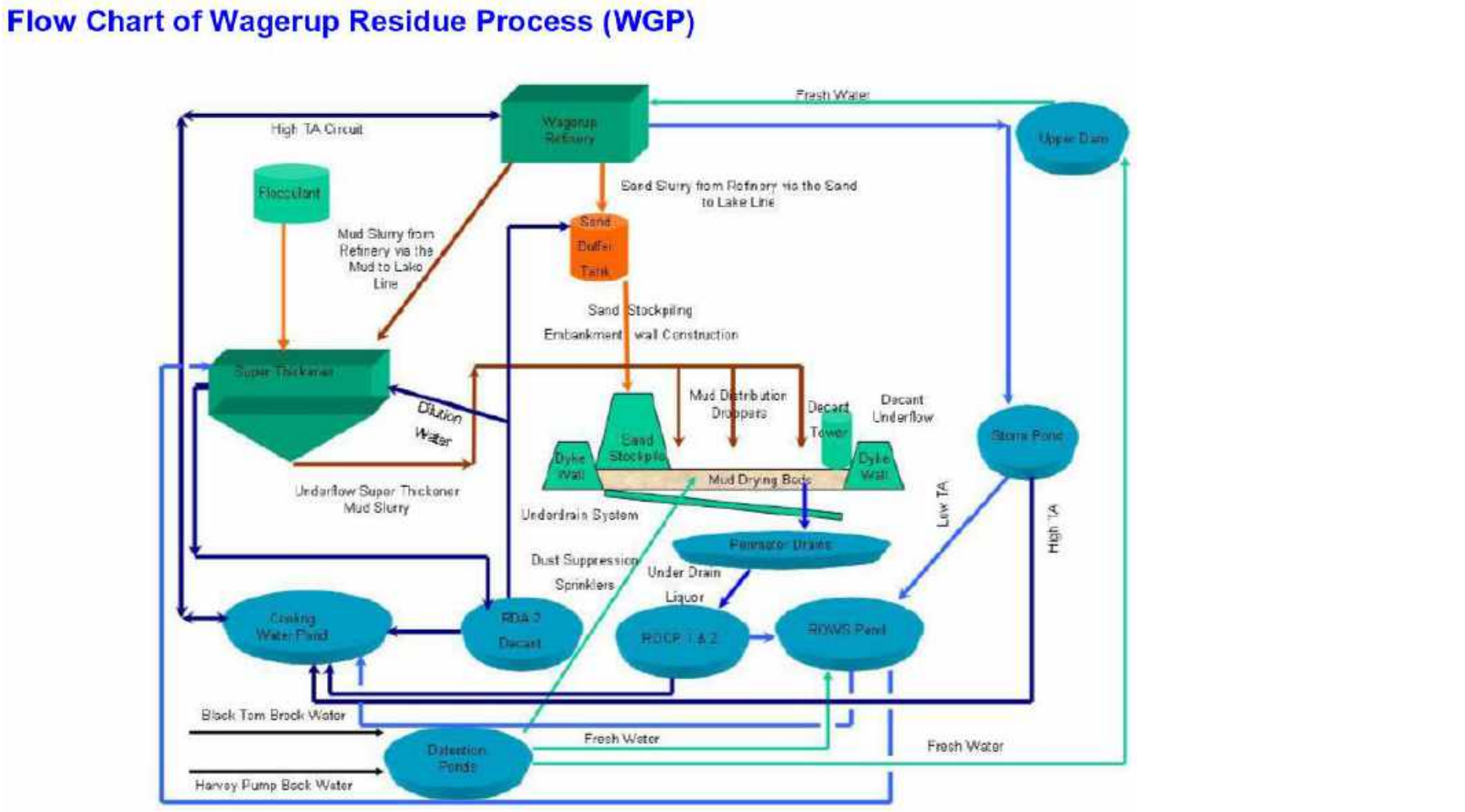
Appendix 1 - Aerial photo of the Residue Area (April 2020)

Appendix 1: Aerial photo of the Residue Area and zones identification



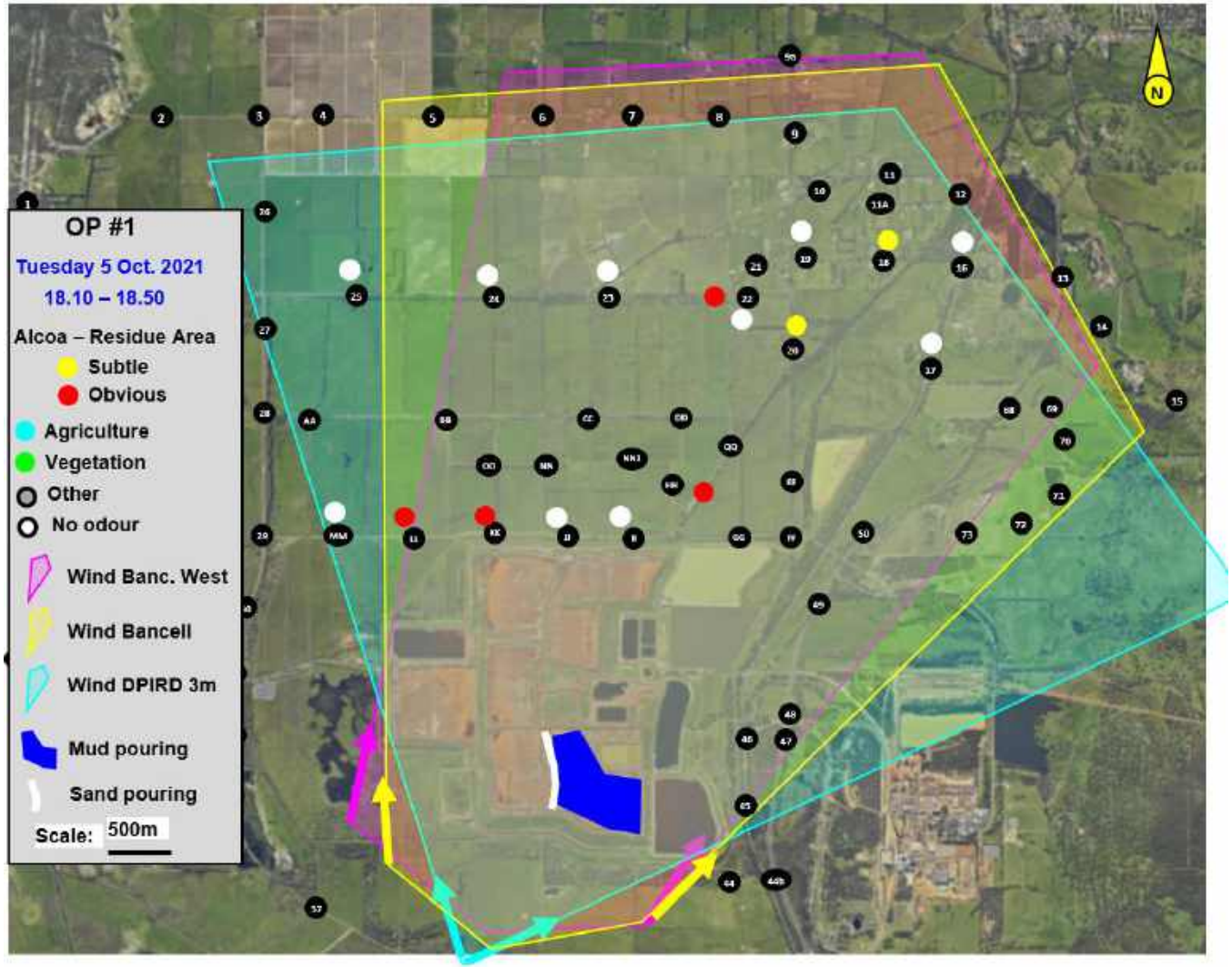
Appendix 2 - Flow Chart of the Wagerup Residue Area

Appendix 2: Flow chart of the Wagerup Residue Area (Sce: Alcoa – Doc No AUACDS-2048-1230)



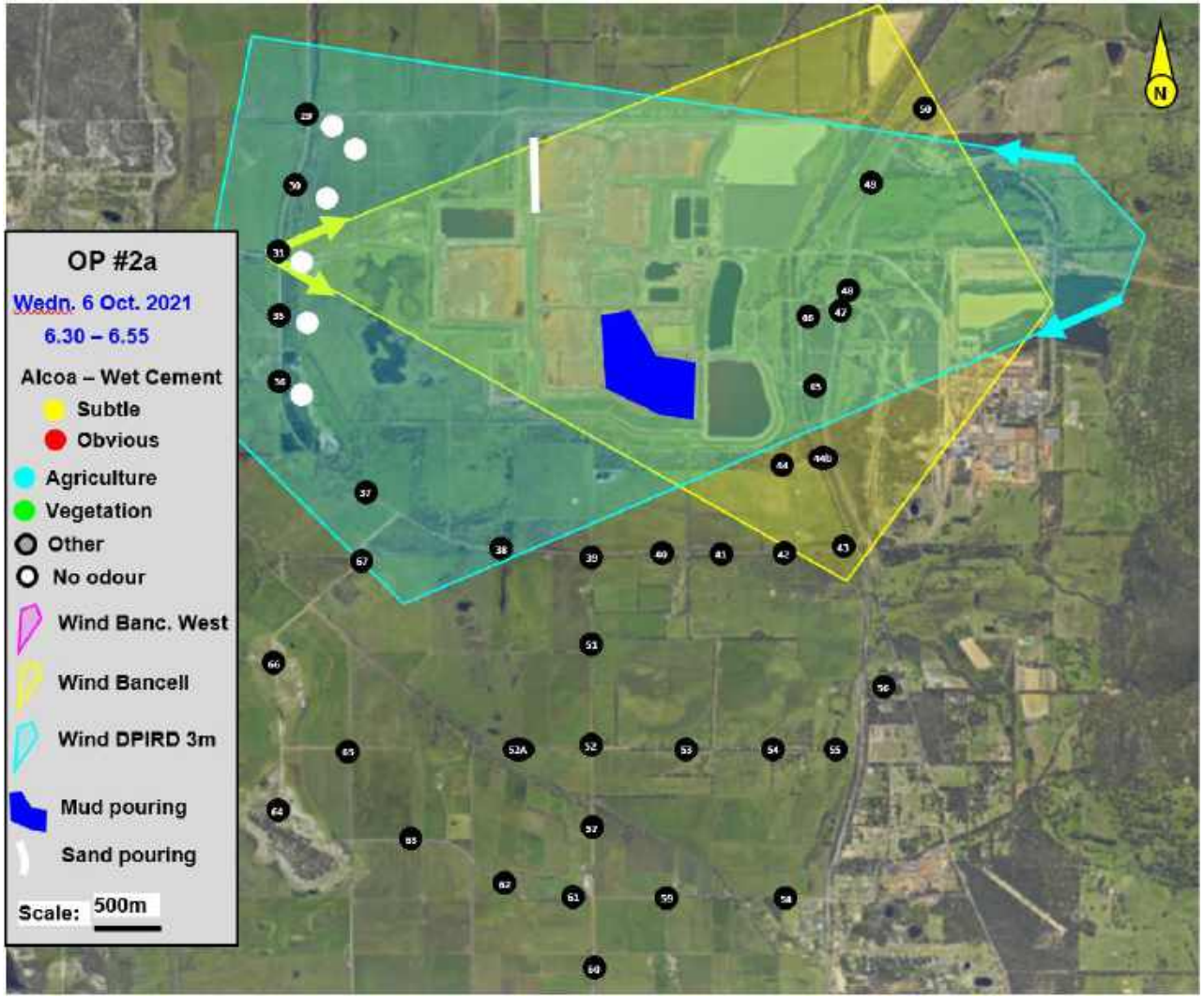
Appendix 3 – OP #1 results
Tuesday 5 October 2021
18.10 – 18.52

Appendix 3: Odour Map OP #1 – Tuesday 5 October 2021 – 18:10 to 18:52

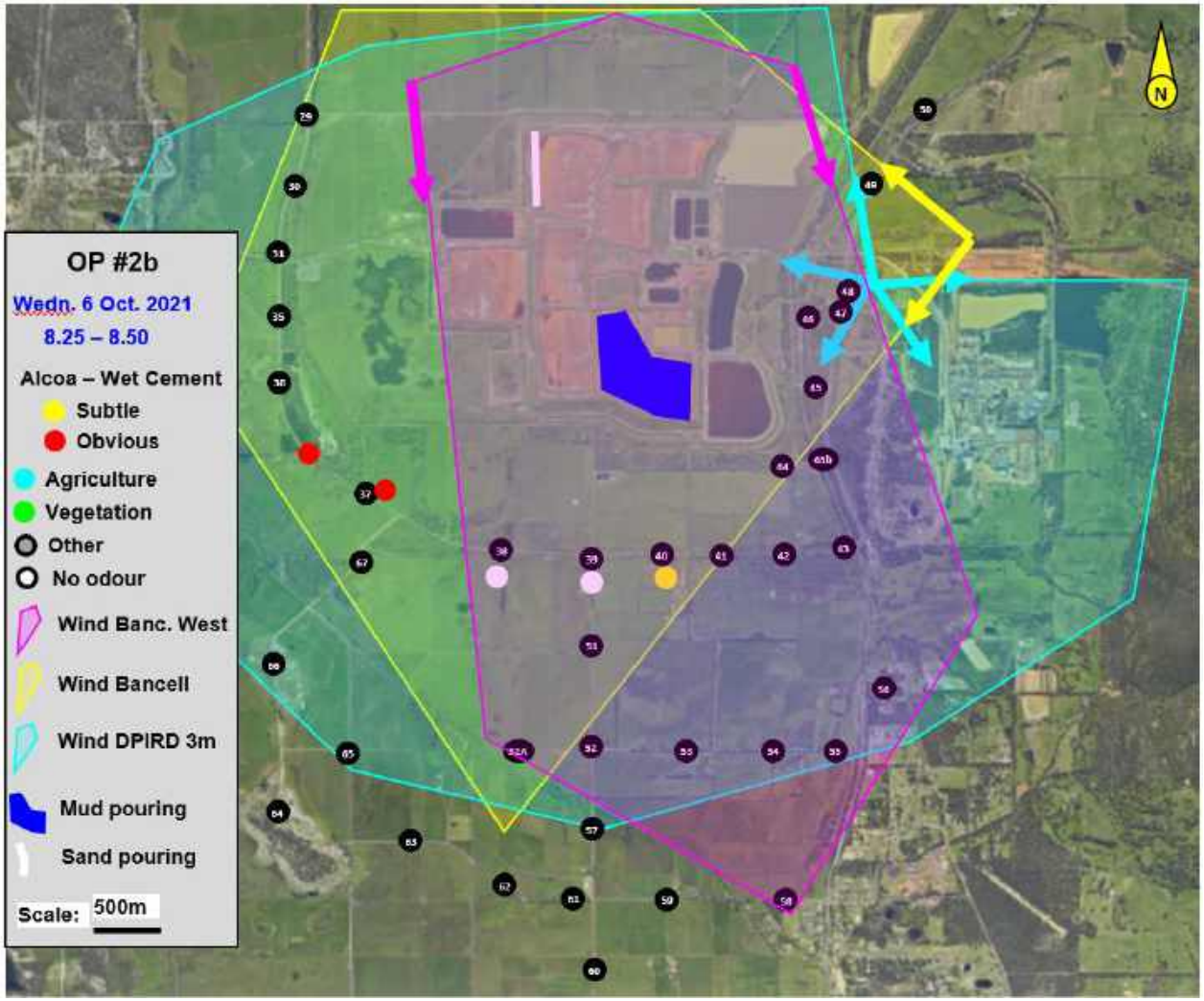


Appendix 4 – OP #2 results
Wednesday 6 October 2021
6.25 – 8.50

Appendix 4: Odour Map OP #2a – 6 October 2021 – 6:25 to 6:55

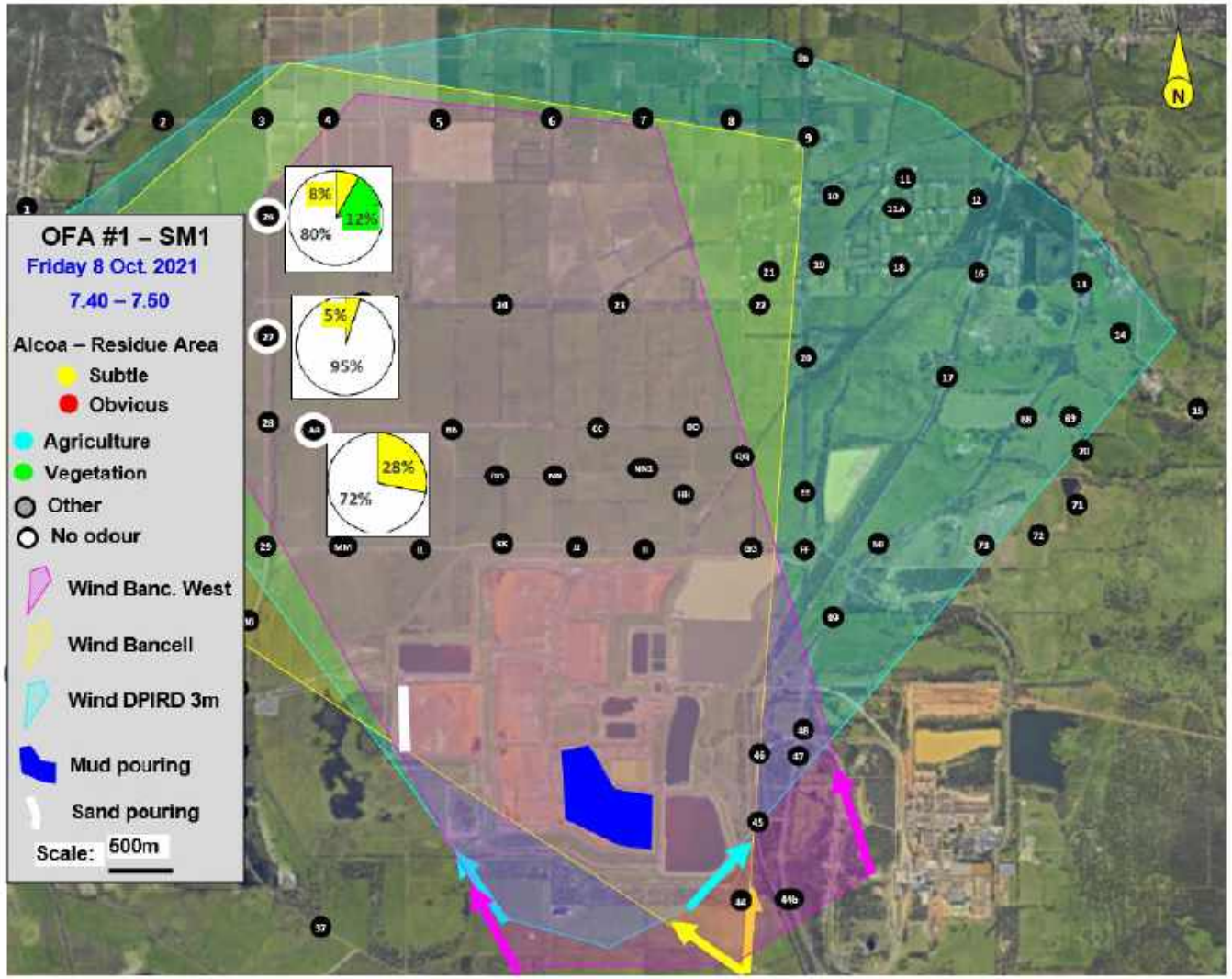


Appendix 4: Odour Map OP #2b – 6 October 2021 – 8:25 to 8:50

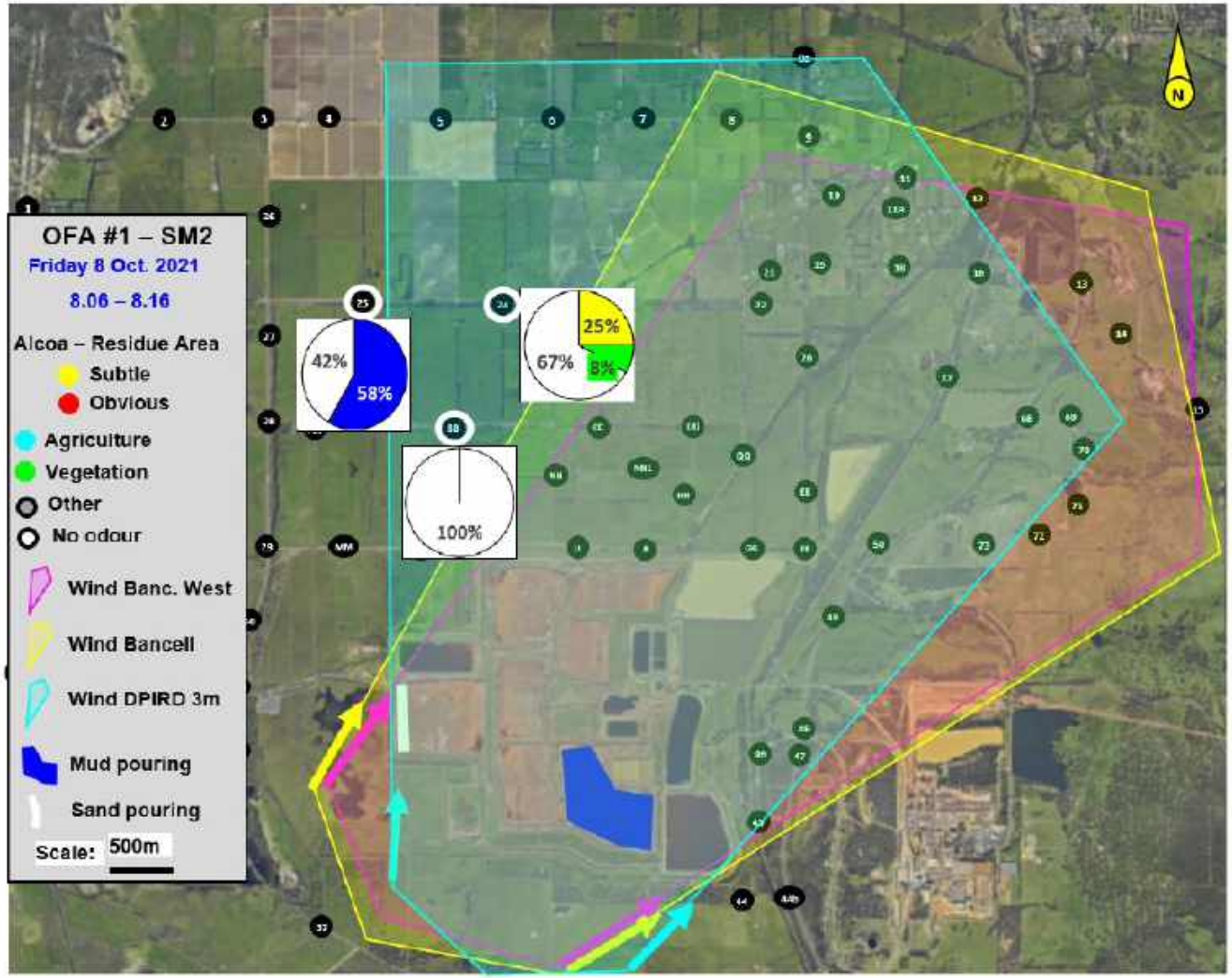


Appendix 5 – OFA #1 results
Friday 8 October 2021
7.40 – 9.39

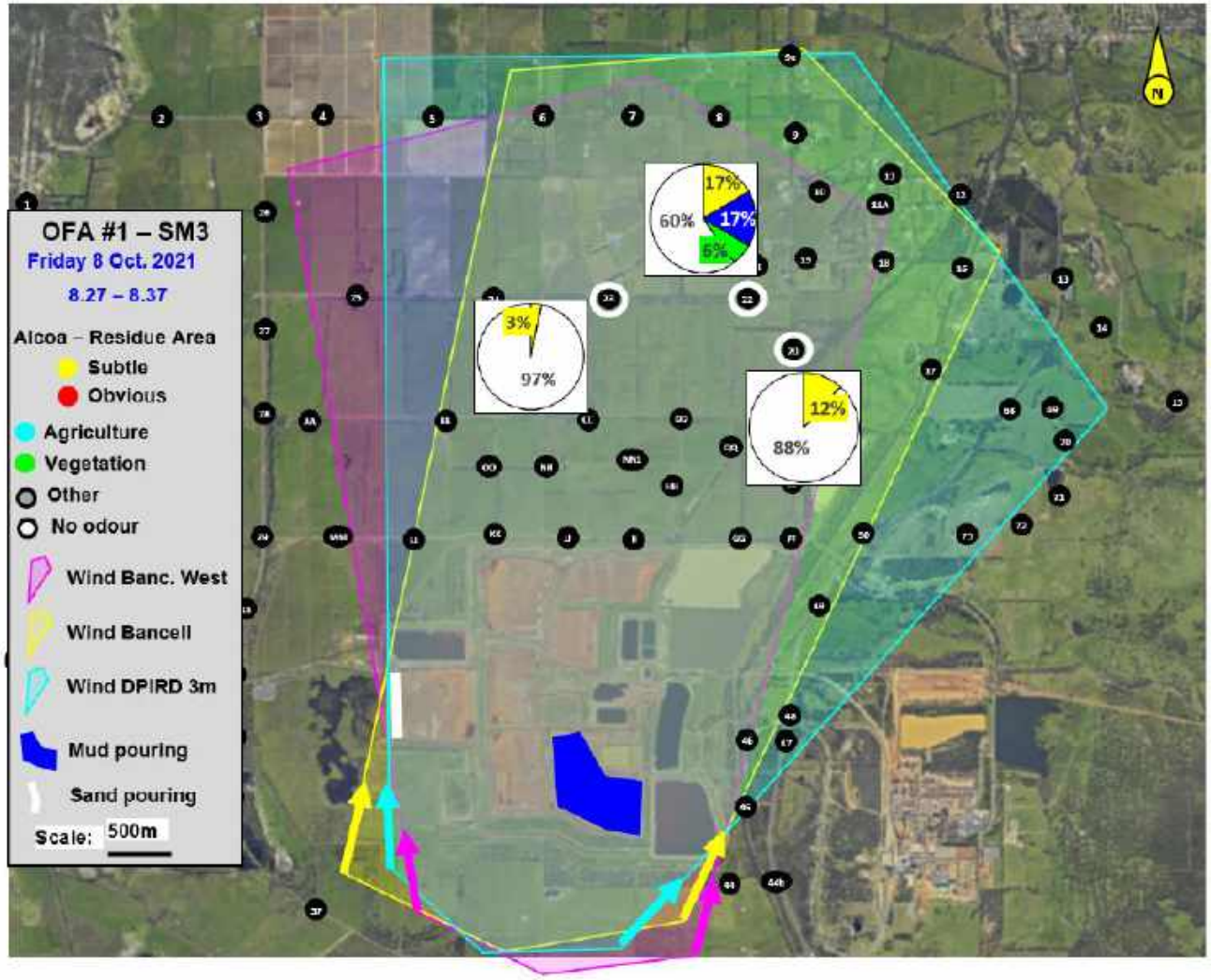
Appendix 5: Odour Map OFA #1 / SM 1 – Friday 8 October 2021 – 7.40 to 7.50



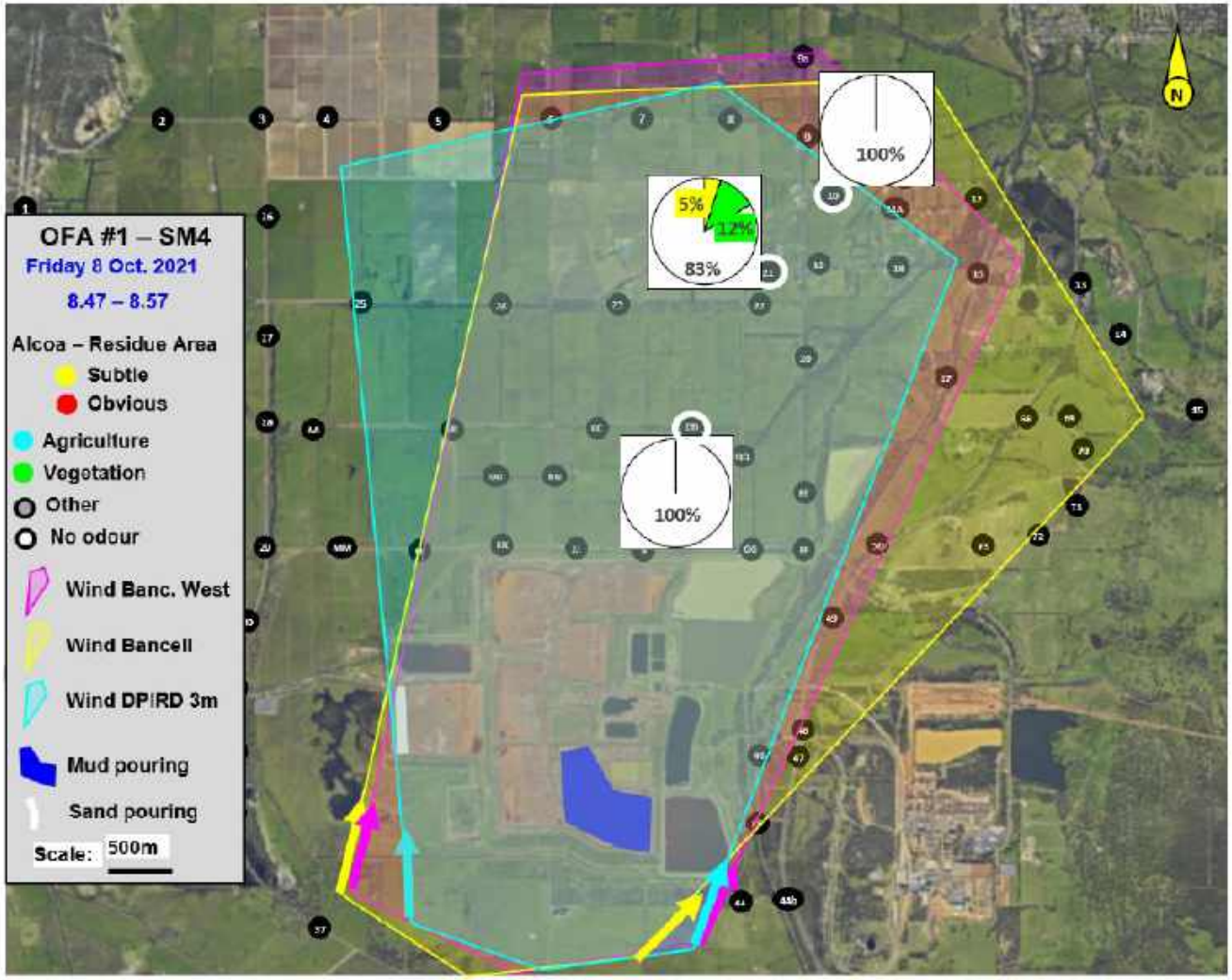
Appendix 5: Odour Map OFA #1 / SM 2 – Friday 8 October 2021 – 8.06 to 8.16



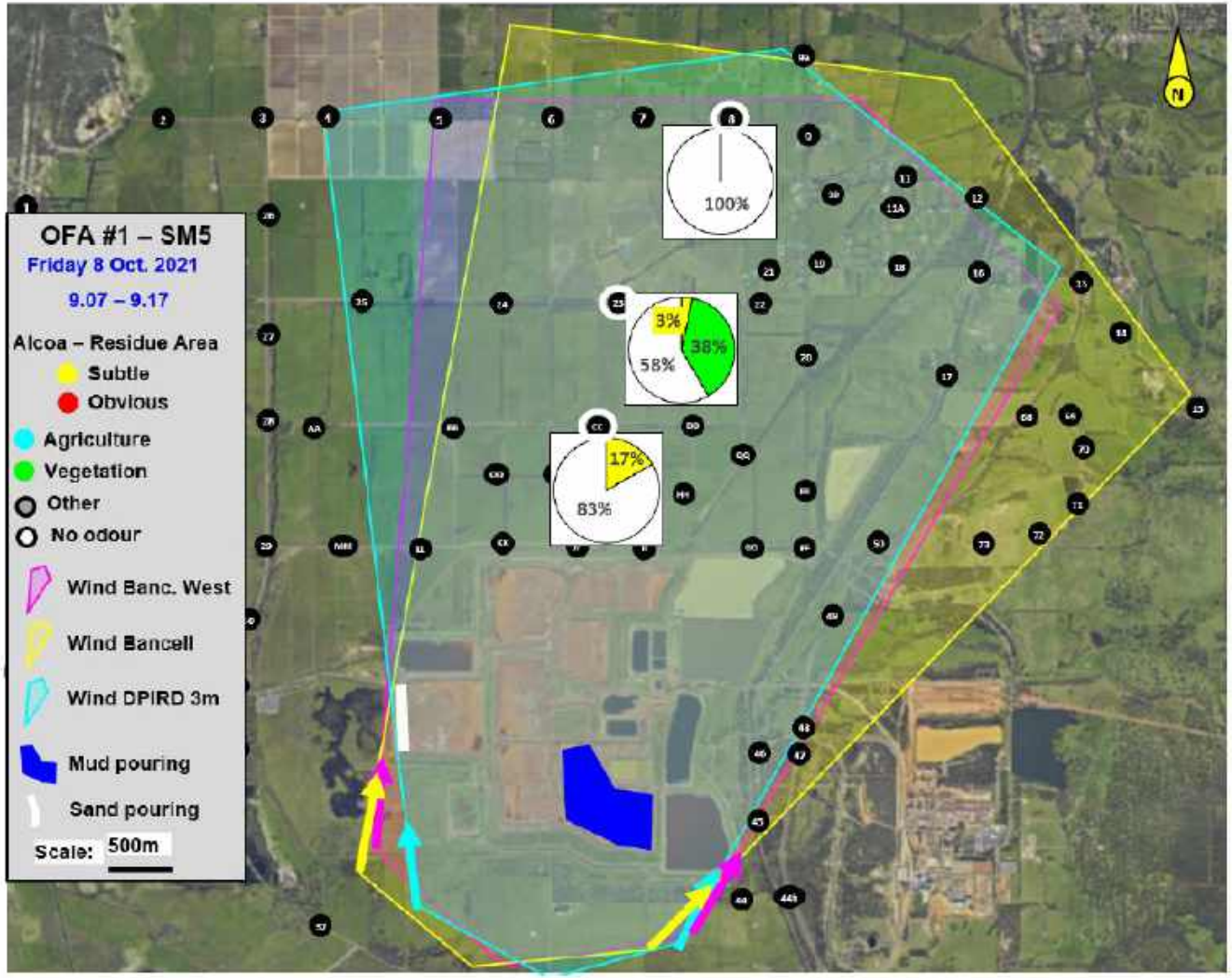
Appendix 5: Odour Map OFA #1 / SM 3 – Friday 8 October 2021 – 8.27 to 8.37



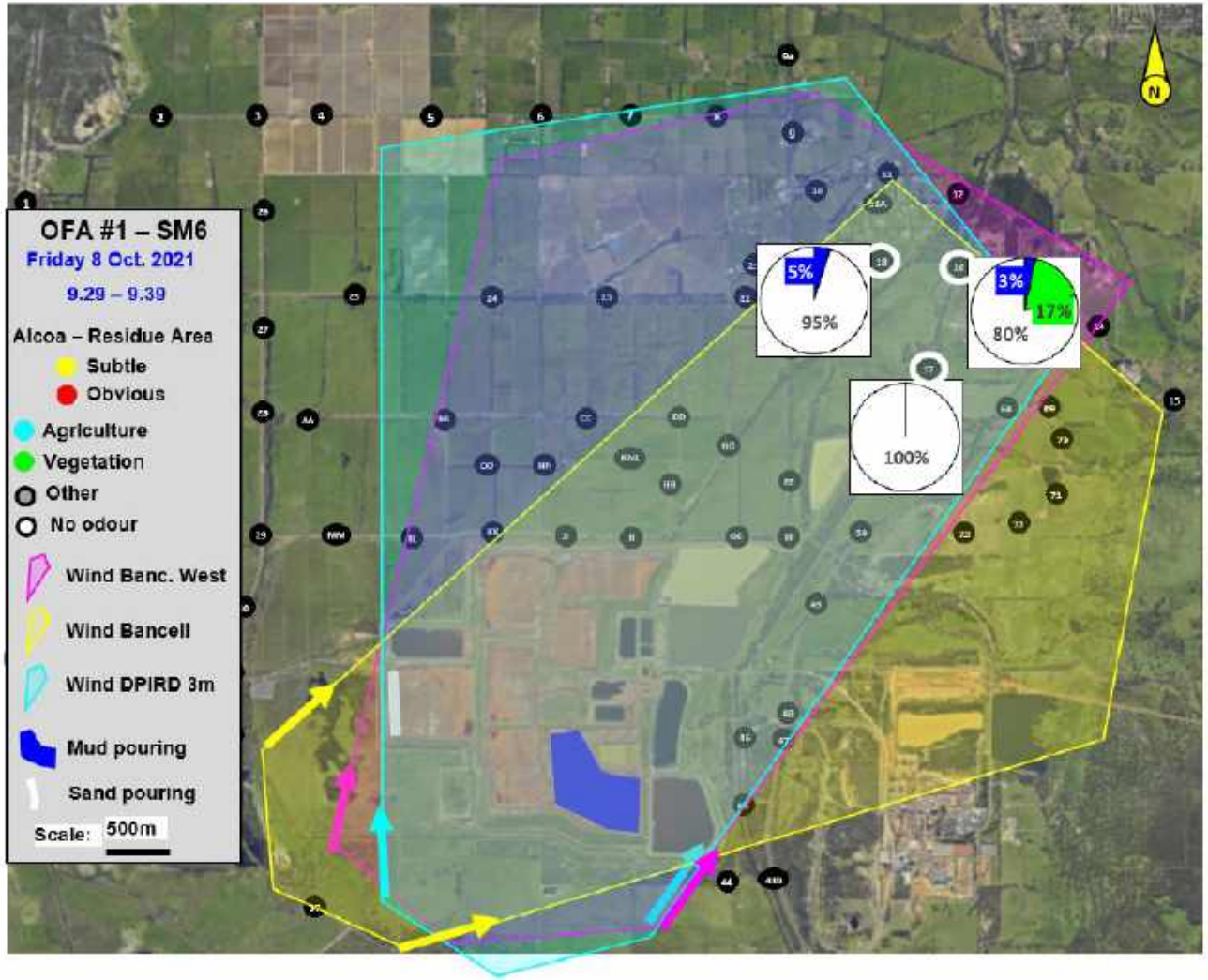
Appendix 5: Odour Map OFA #1 / SM 4 – Friday 8 October 2021 – 8.47 to 8.57



Appendix 5: Odour Map OFA #1 / SM 5 – Friday 8 October 2021 – 9.07 to 9.17

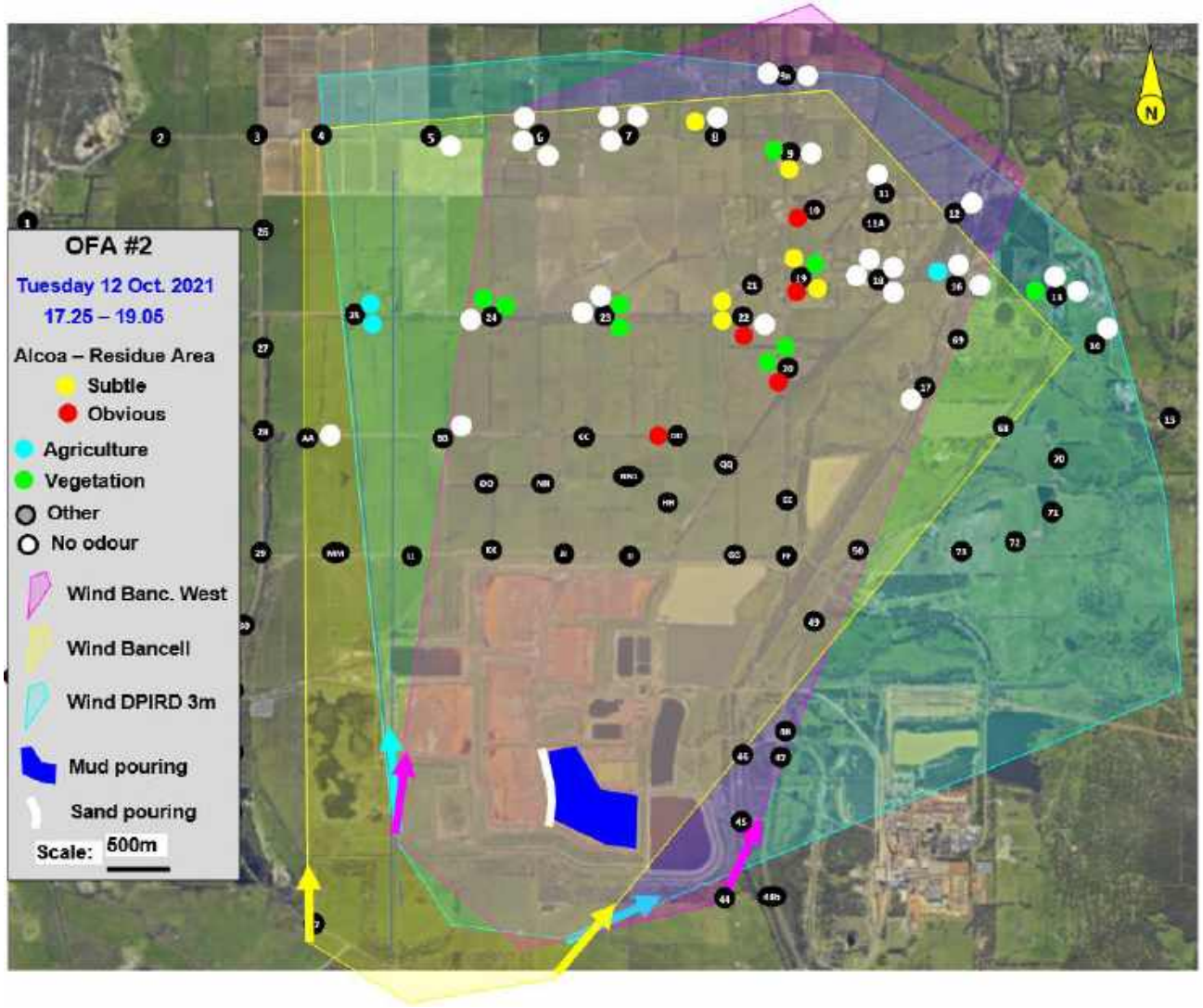


Appendix 5: Odour Map OFA #1 / SM 6 – Friday 8 October 2021 – 9.29 to 9.39



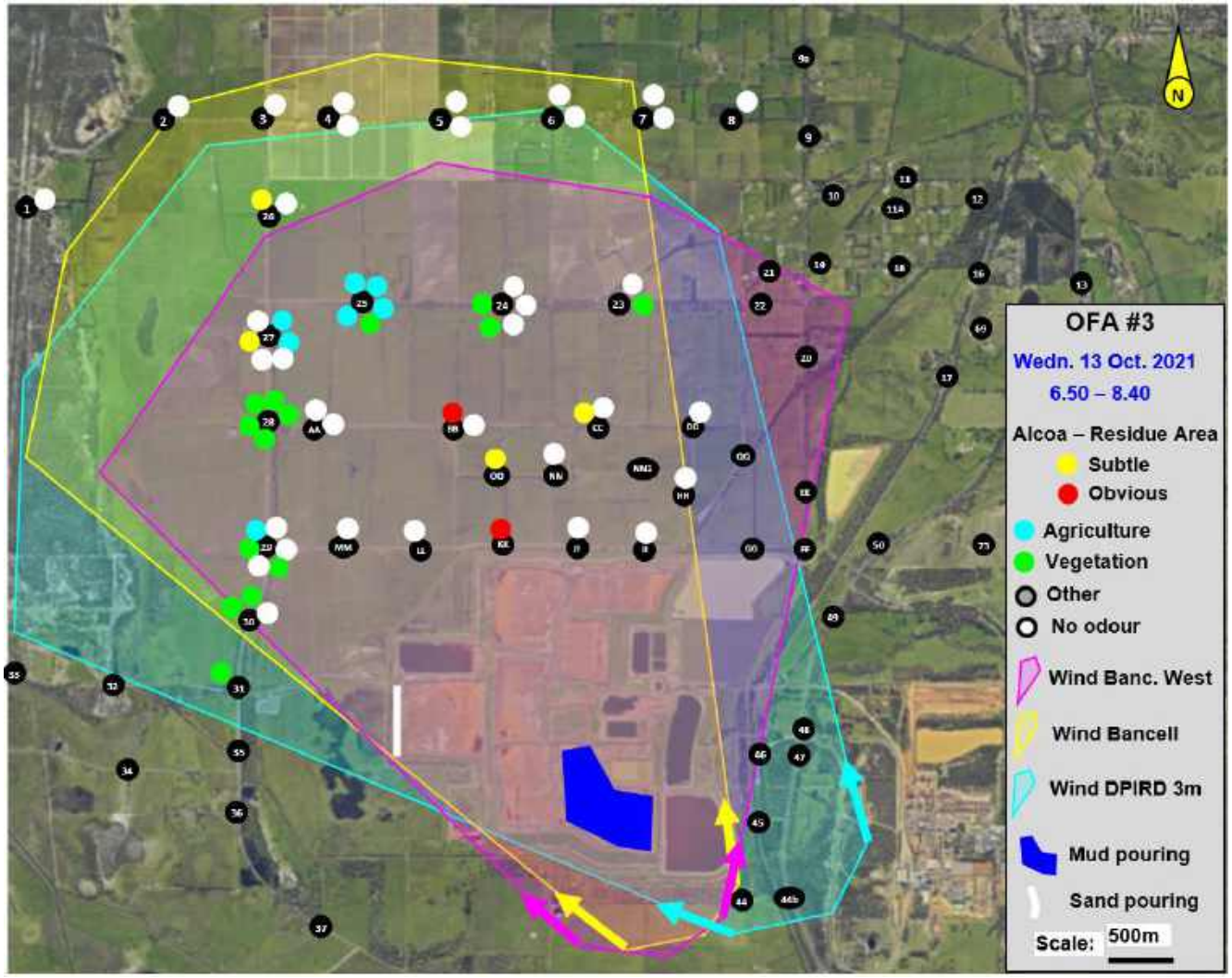
Appendix 6 - OFA #2 results
Tuesday 12 October 2021
17.25 – 19.05

Appendix 6: Odour Map OFA #2 – Tuesday 12 October 2021 – 17.25 – 19.05



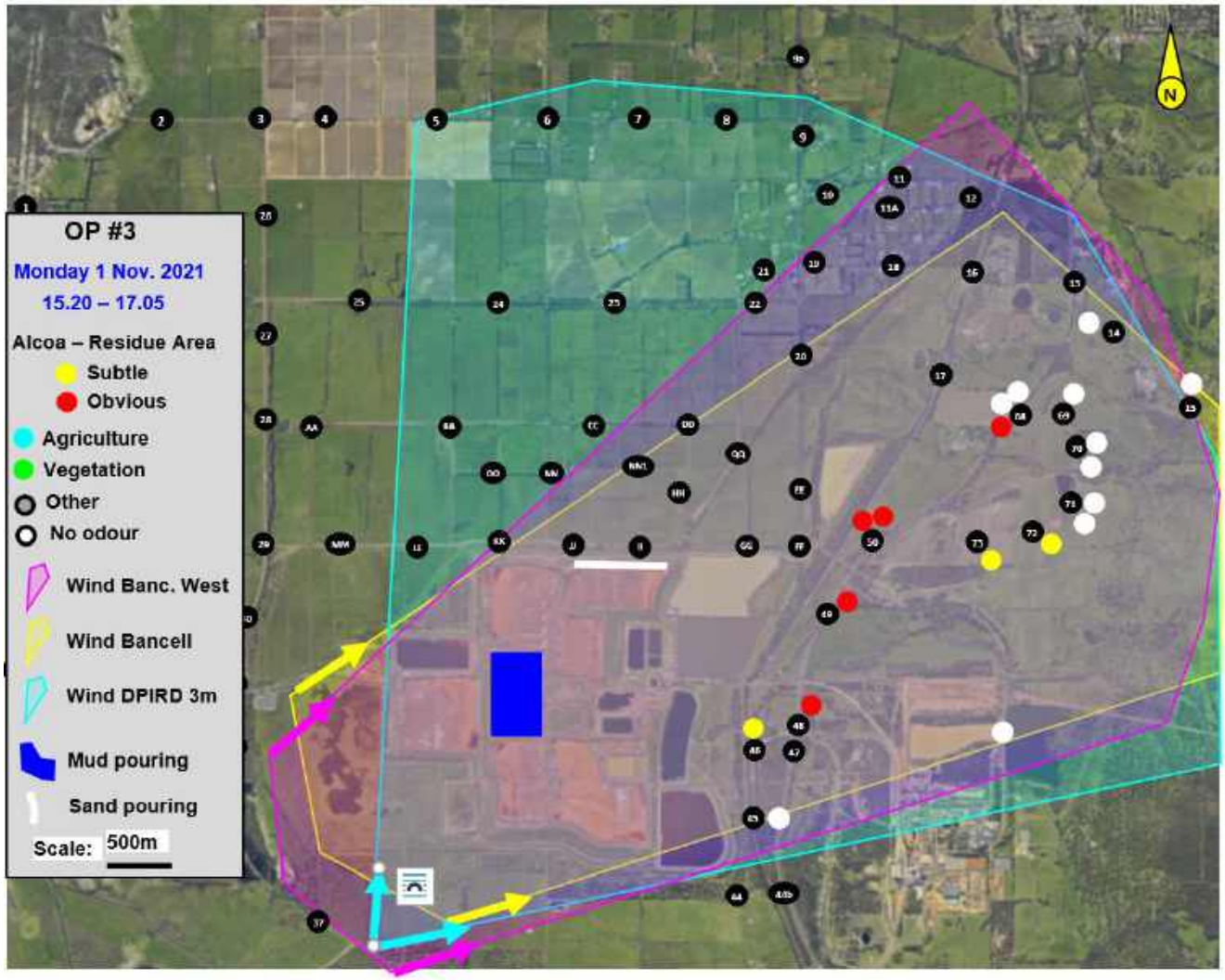
Appendix 7 - OFA #3 results
Wednesday 13 October 2021
6.50 – 8.40

Appendix 7: Odour Map OFA #3 – Wednesday 13 October 2021 – 6.50 to 8.40



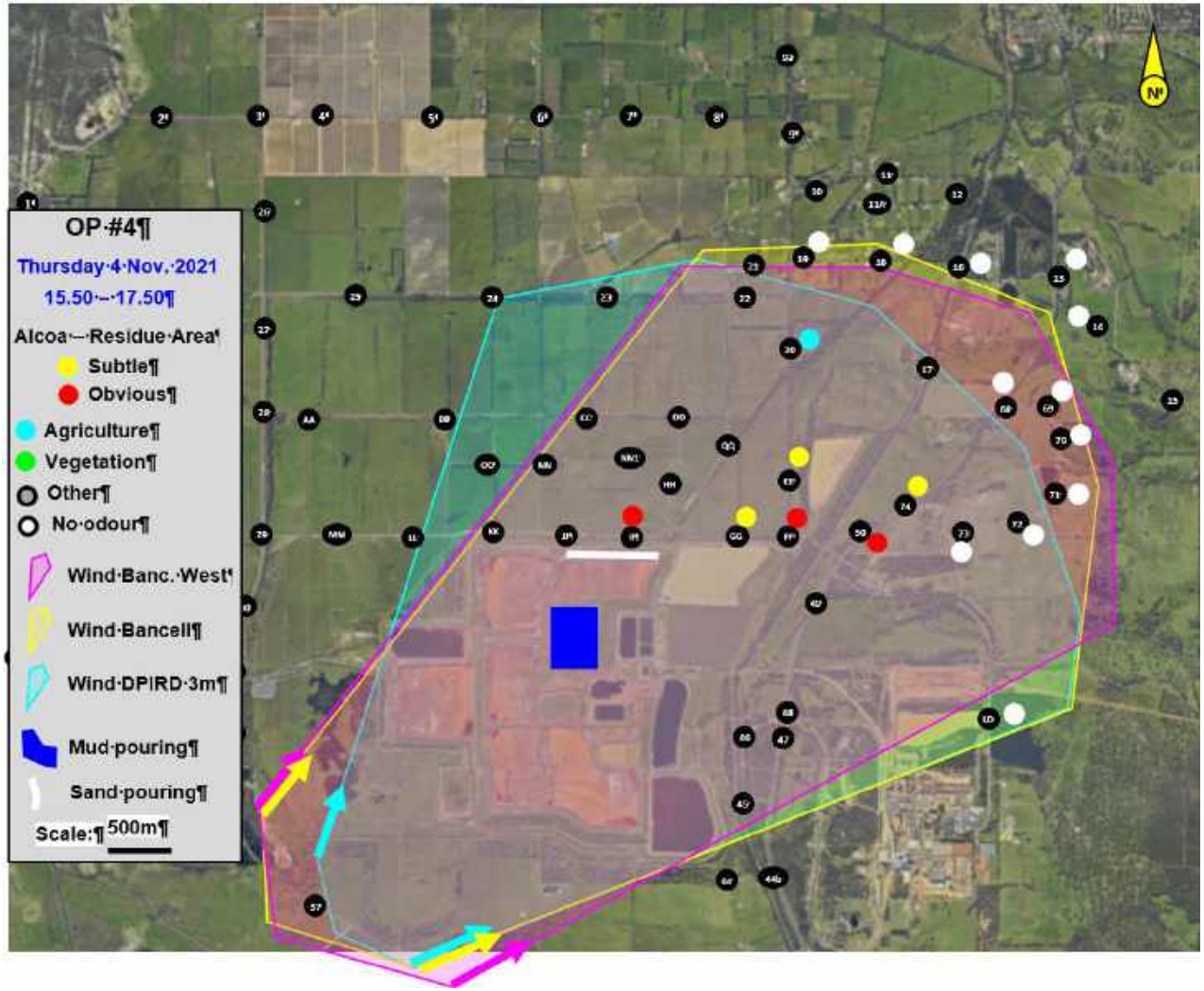
Appendix 8 - OP #3 results
Monday 1 November 2021
15.20 – 17.05

Appendix 8: Odour Map OP #3 – Monday 1 November 2021 – 15.20 to 17.05



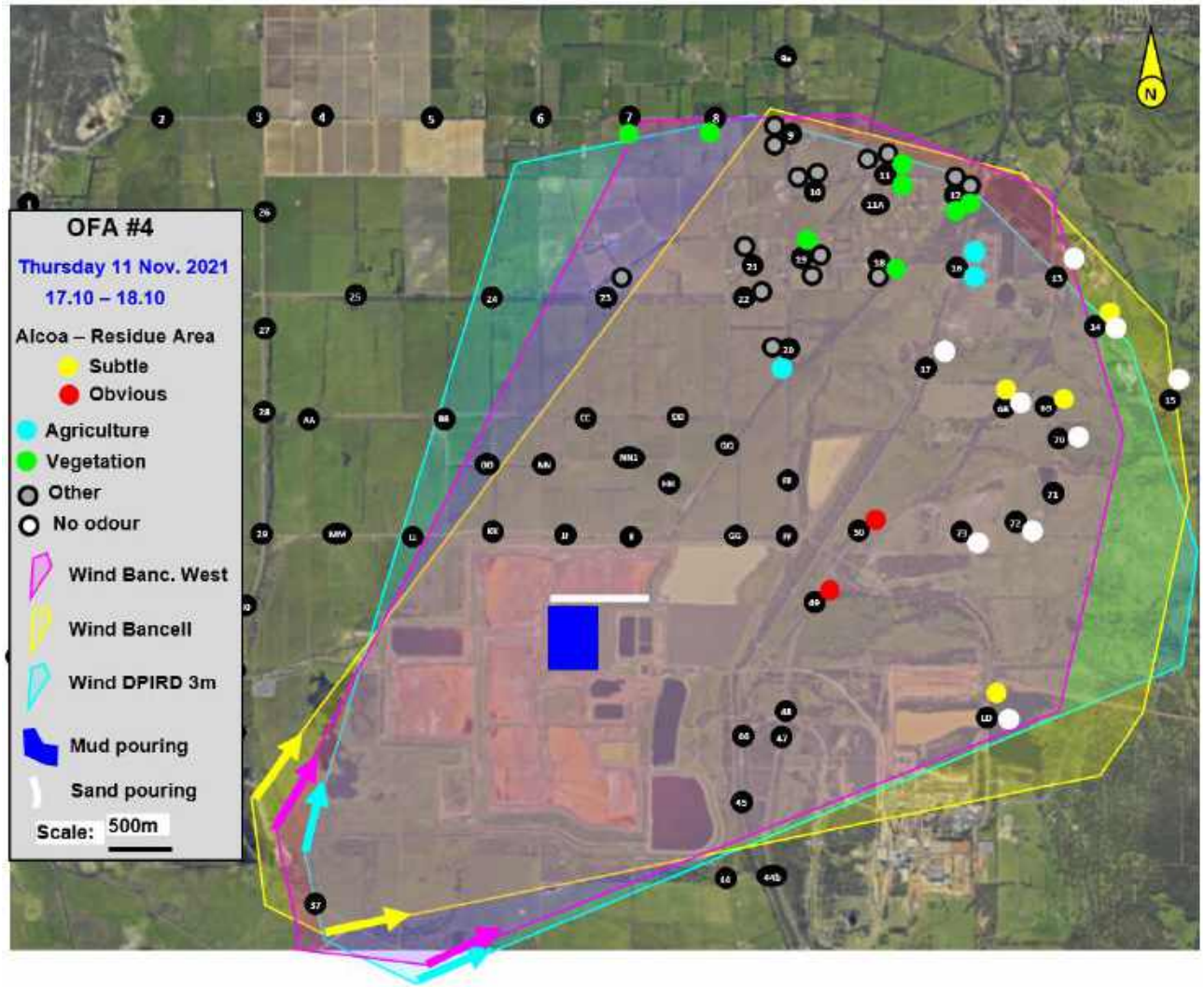
Appendix 9 - OP #4 results
Thursday 4 November 2021
15.50 – 17.50

Appendix 9: Odour Map OP #4 – Thursday 4 November 2021 – 15.50 to 17.50



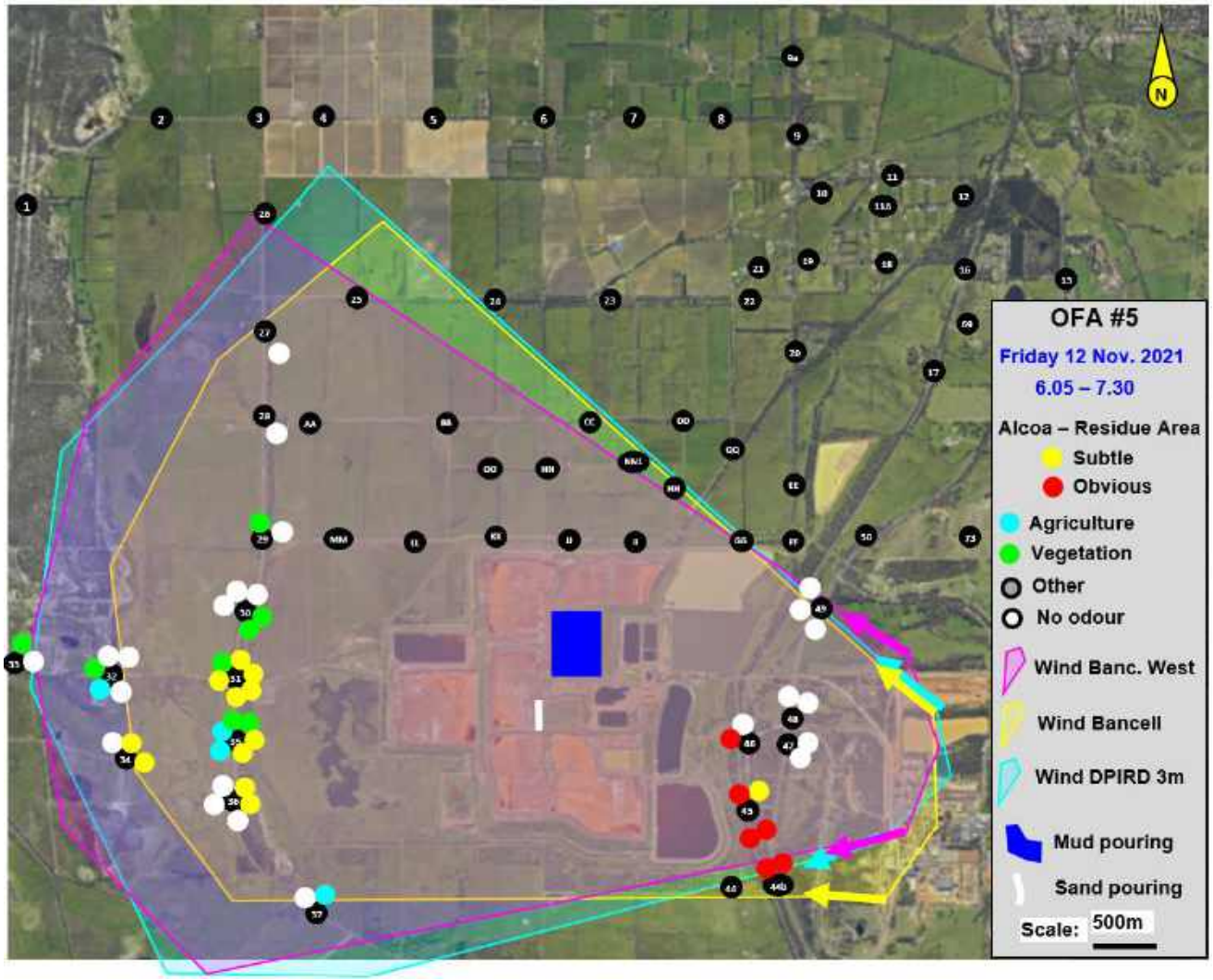
Appendix 10 - OFA #4 results
Thursday 11 November 2021
17.10 – 18.10

Appendix 10: Odour Map OFA #4 – Thursday 11 November 2021 – 17.10 to 18.10



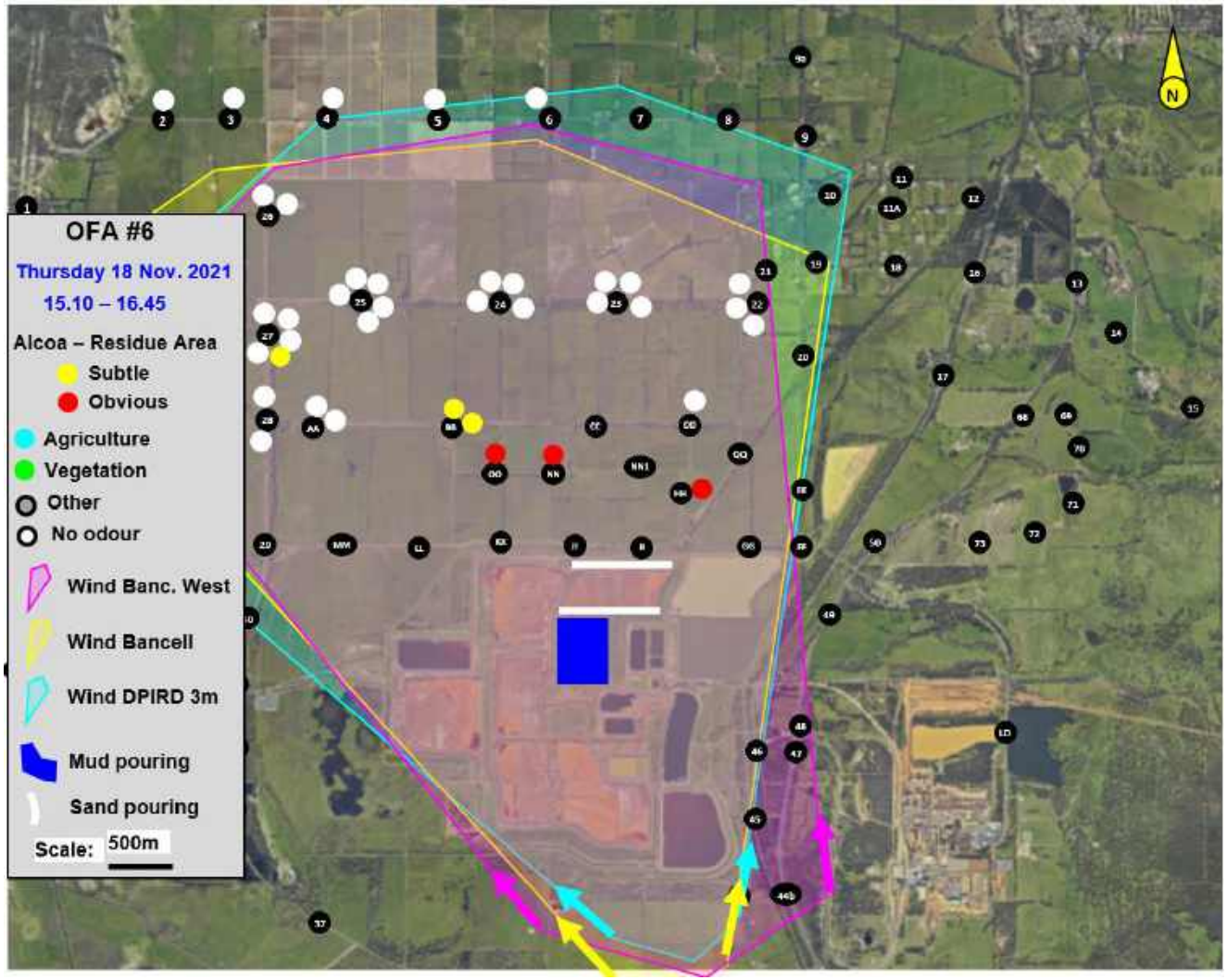
Appendix 11 - OFA #5 results
Friday 12 November 2021
6.05 – 7.30

Appendix 11: Odour Map OFA #5 – Friday 12 November 2021 – 6.05 – 7.30



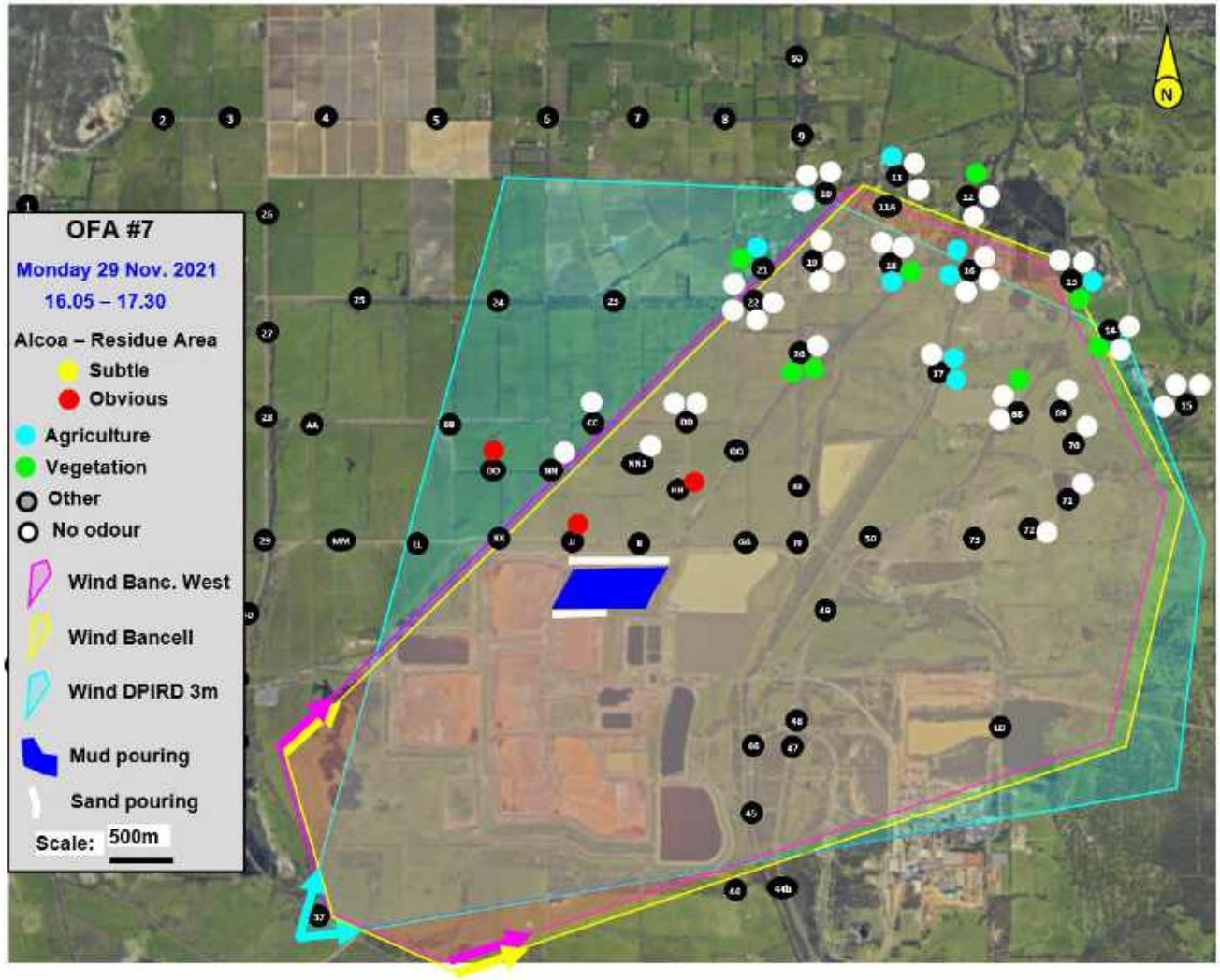
Appendix 12 - OFA #6 results
Thursday 18 November 2021
15.10 – 16.45

Appendix 12: Odour Map OFA #6 – Thursday 18 November 2021 – 15.10 to 16.45



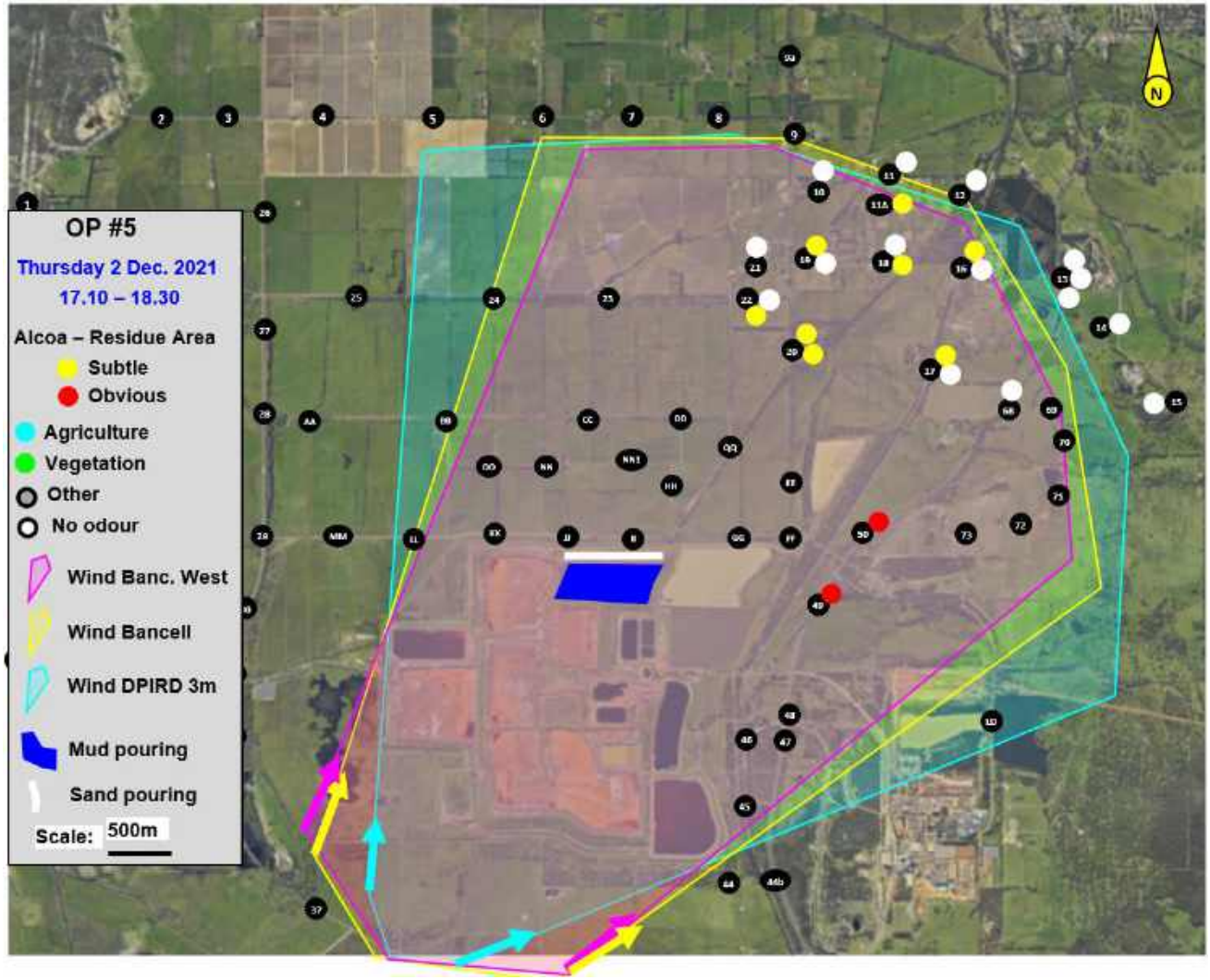
Appendix 13 - OFA #7 results
Monday 29 November 2021
16.05 – 17.30

Appendix 13: Odour Map OFA #7 – Monday 29 November 2021 – 16.05 to 17.30



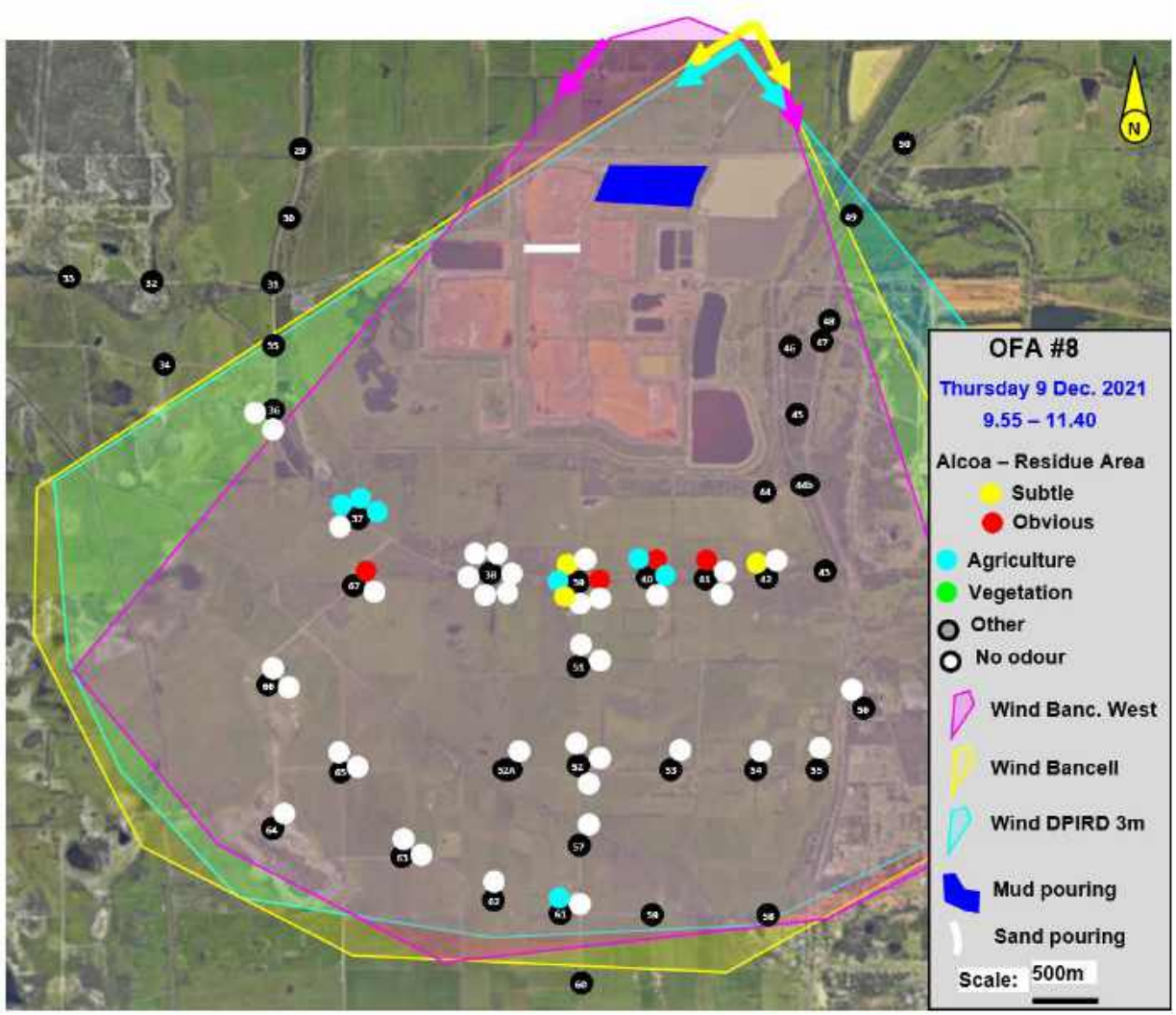
Appendix 14 - OP #5 results
Thursday 2 December 2021
17.10 – 18.30

Appendix 14: Odour Map OP #5 – Thursday 2 December 2021 – 17.10 – 18.30



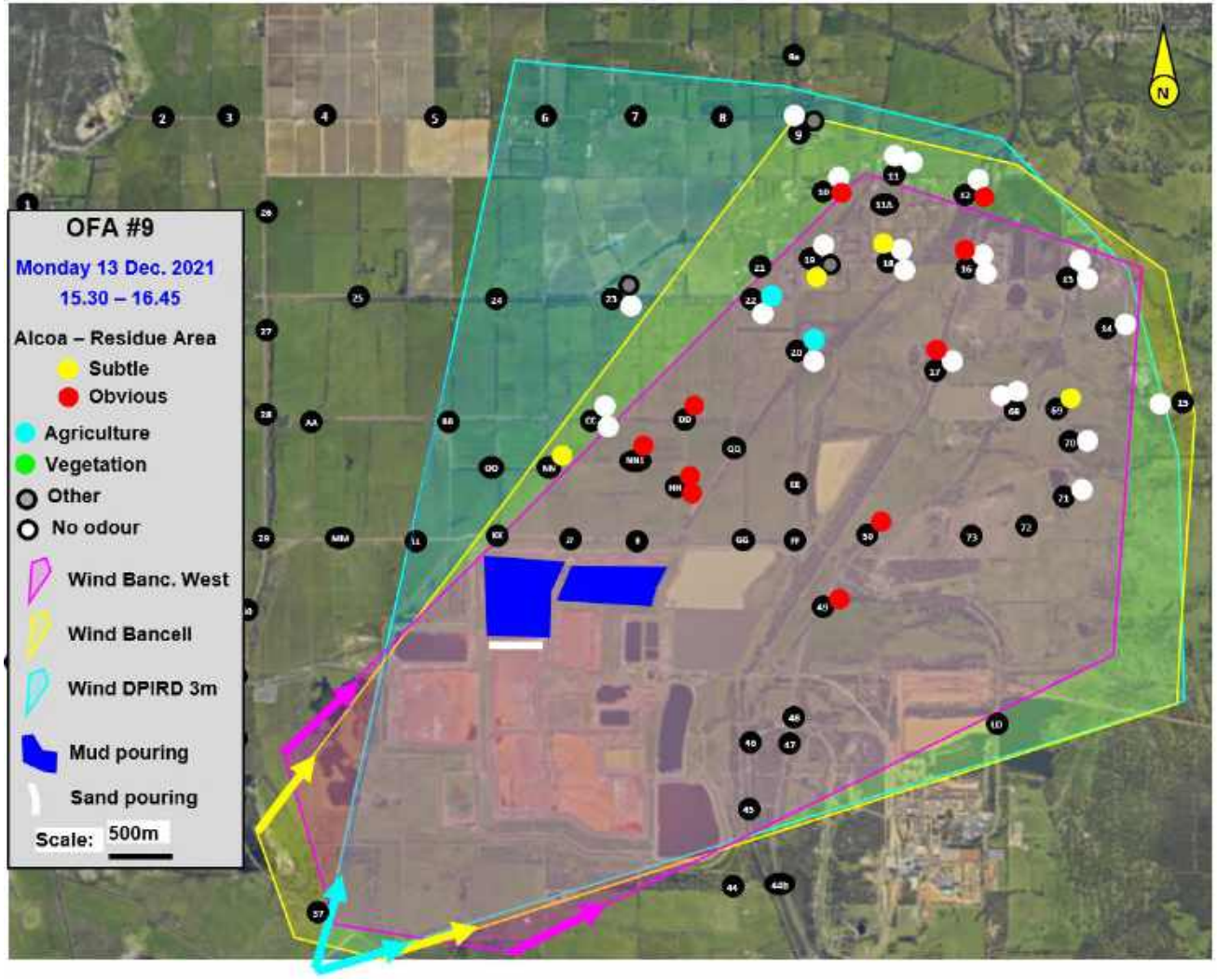
Appendix 15 - OFA #8 results
Thursday 9 December 2021
9.55 – 11.40

Appendix 15: Odour Map OFA #8 – Thursday 9 December 2021 – 9.55 to 11.40



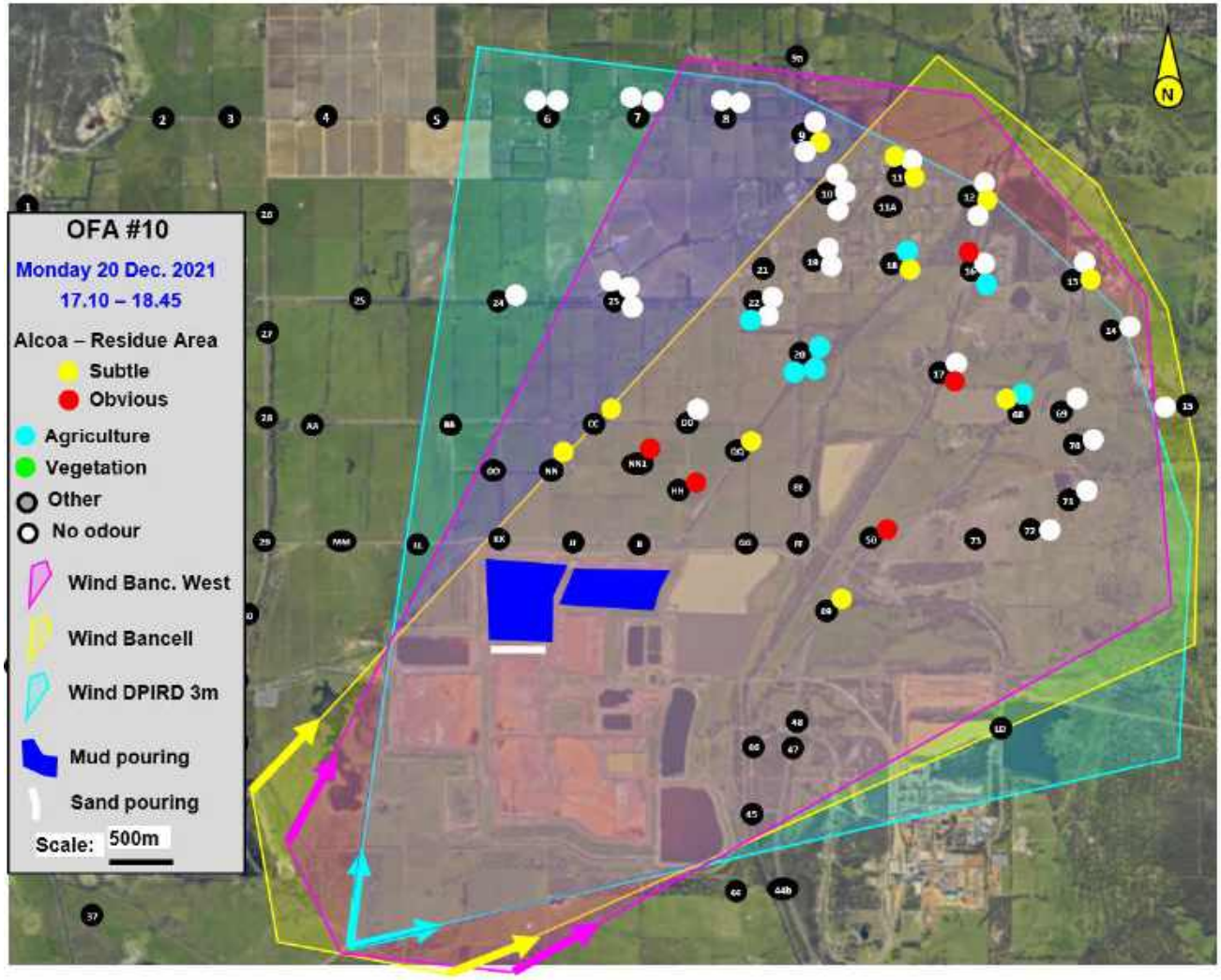
Appendix 16 - OFA #9 results
Monday 13 December 2021
15.30 – 16.45

Appendix 16: Odour Map OFA #9 – Monday 13 December 2021 – 15.30 to 16.45



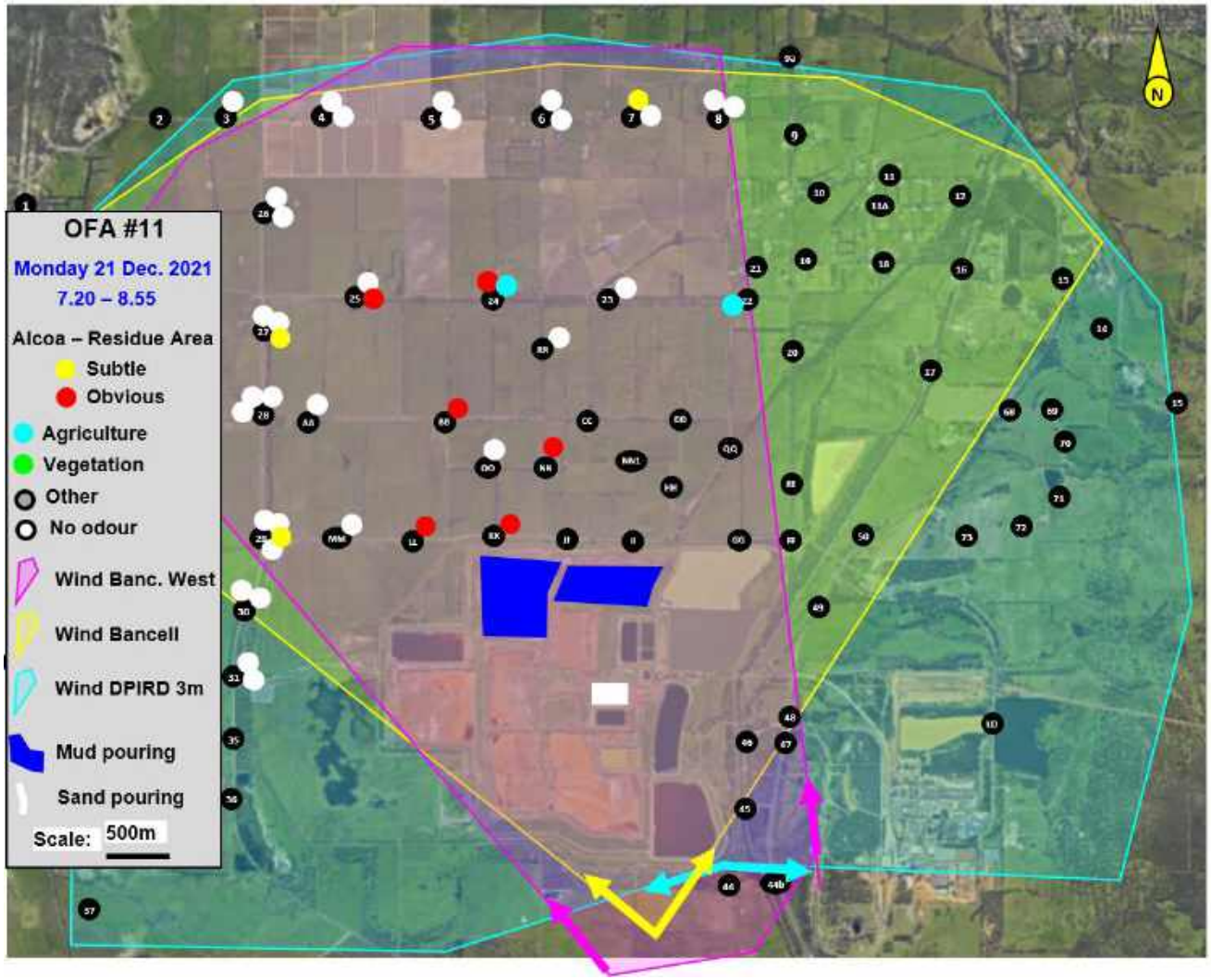
Appendix 17 - OFA #10 results
Monday 20 December 2021
17.10 – 18.45

Appendix 17: Odour Map OFA #10 – Monday 20 December 2021 – 17.10 – 18.45



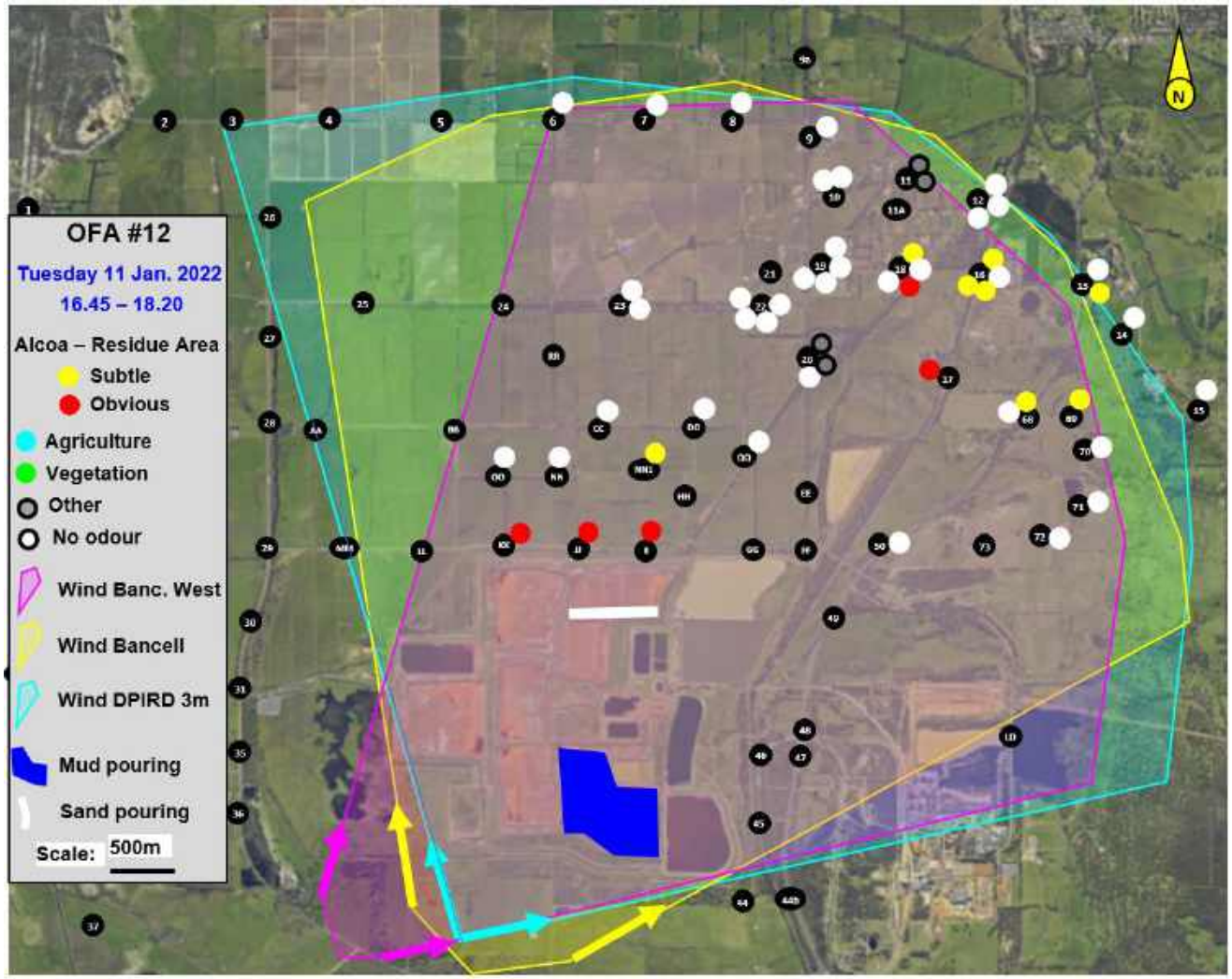
Appendix 18 - OFA #11 results
Tuesday 21 December 2021
7.20 – 8.55

Appendix 18: Odour Map OFA #11 – Tuesday 21 December 2021 – 7.20 to 8.55



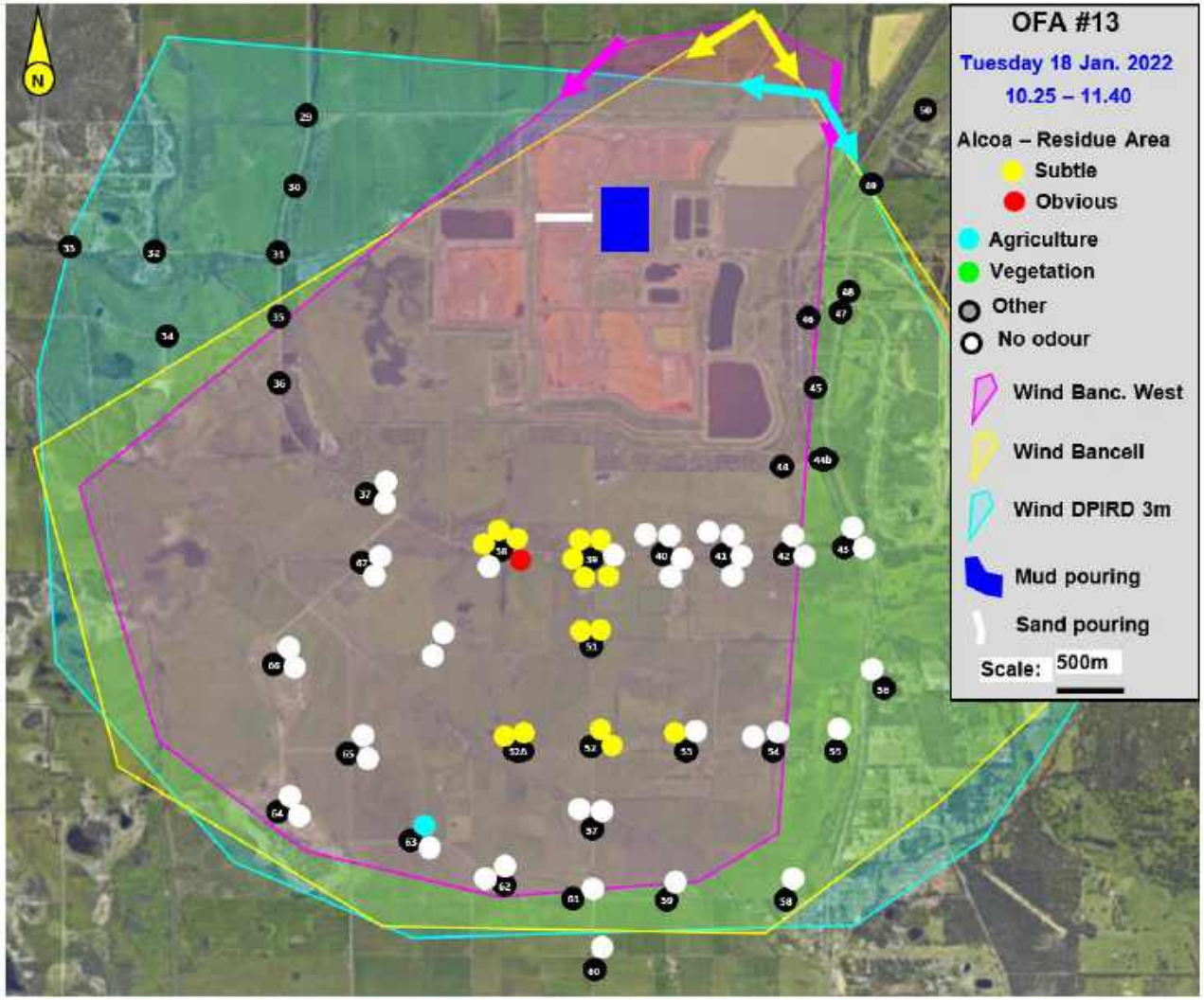
Appendix 19 - OFA #12 results
Tuesday 11 January 2022
16.45 – 18.20

Appendix 19: Odour Map OFA #12 – Tuesday 11 January 2022 – 16.45 to 18.20



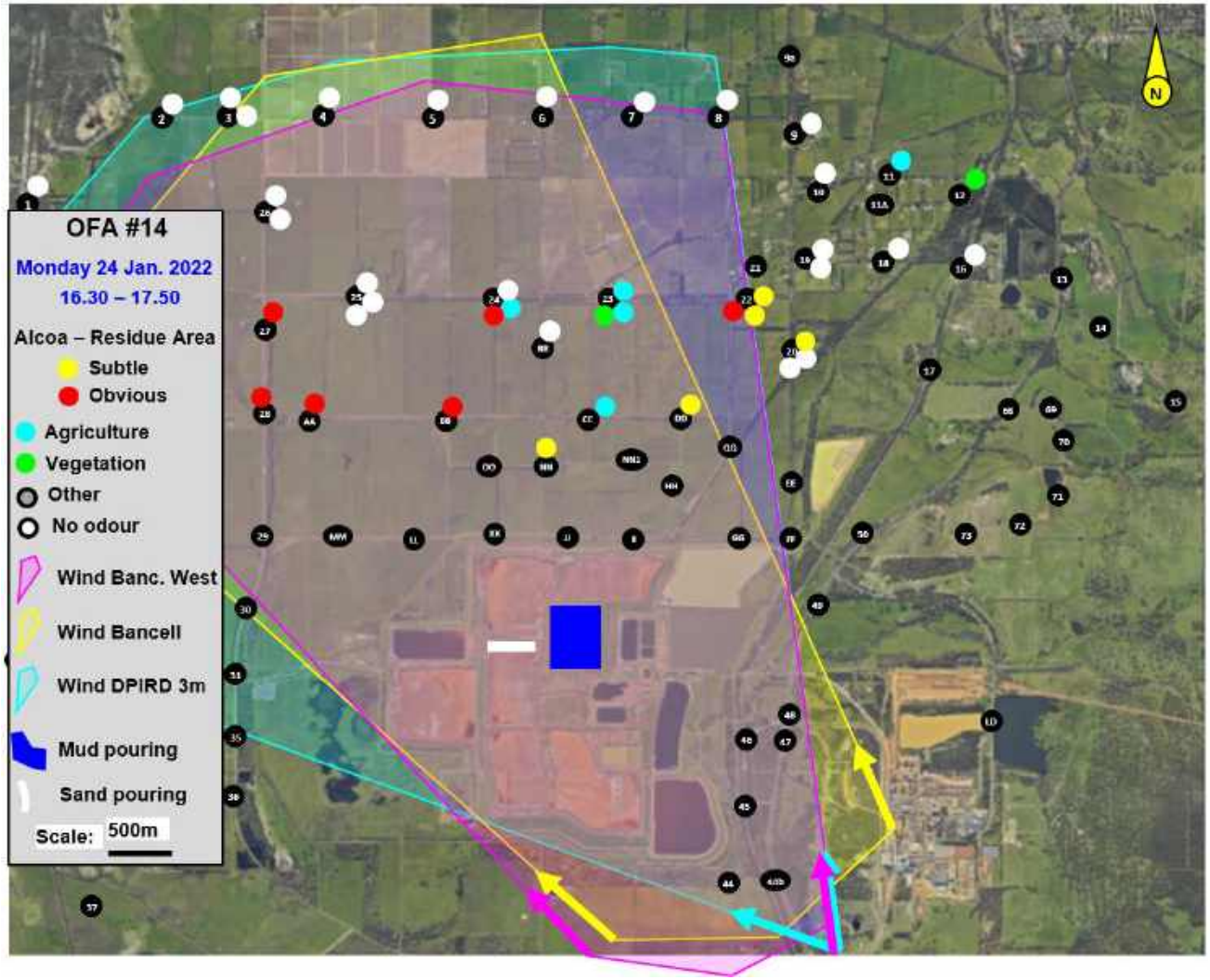
Appendix 20 - OFA #13 results
Tuesday 18 January 2022
10.25 – 11.40

Appendix 20: Odour Map OFA #13 – Tuesday 18 January 2022 – 10.25 to 11.40



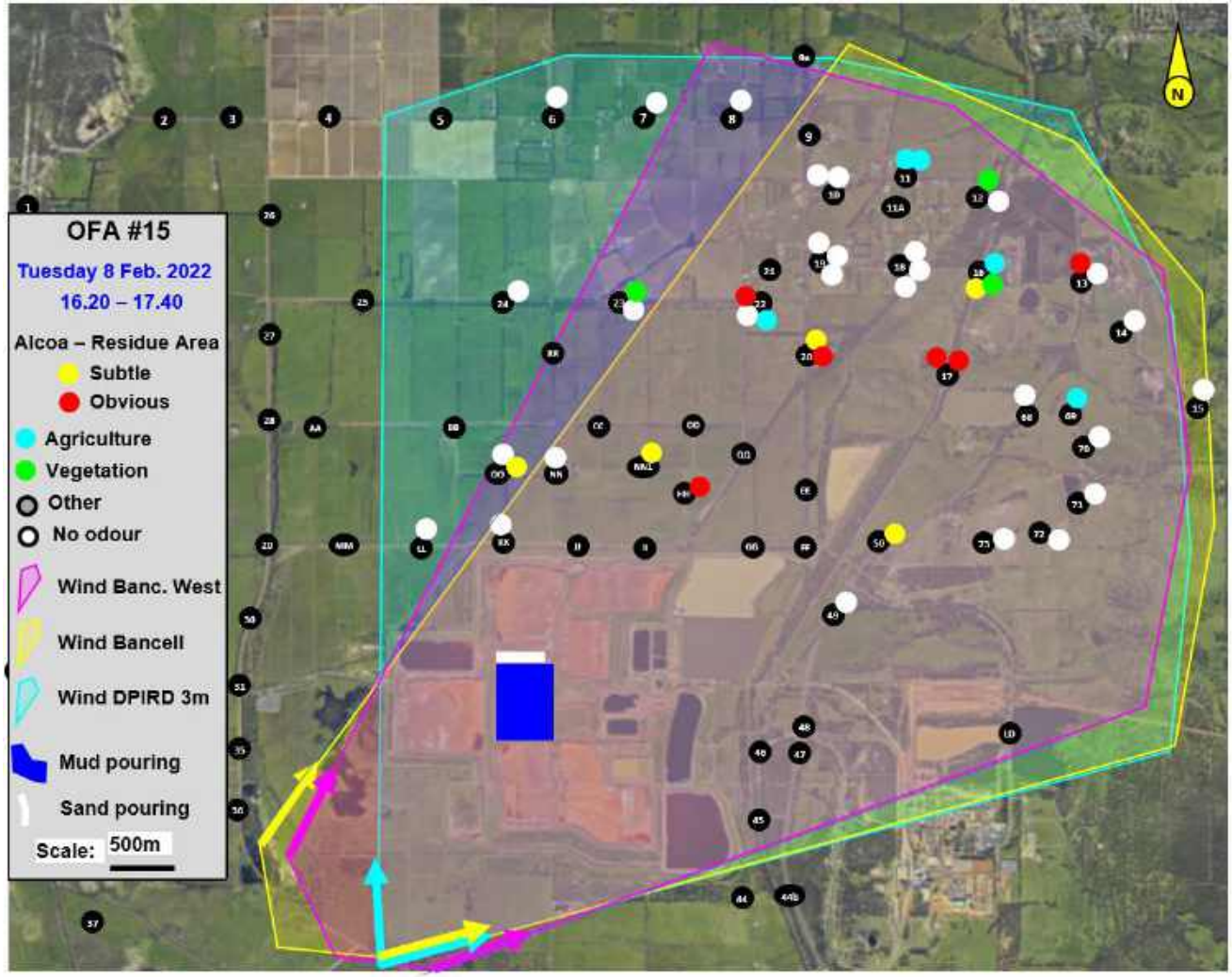
Appendix 21 - OFA #14 results
Monday 24 January 2022
16.30 – 17.50

Appendix 21: Odour Map OFA #14 – Monday 24 January 2022 – 16.30 to 17.50



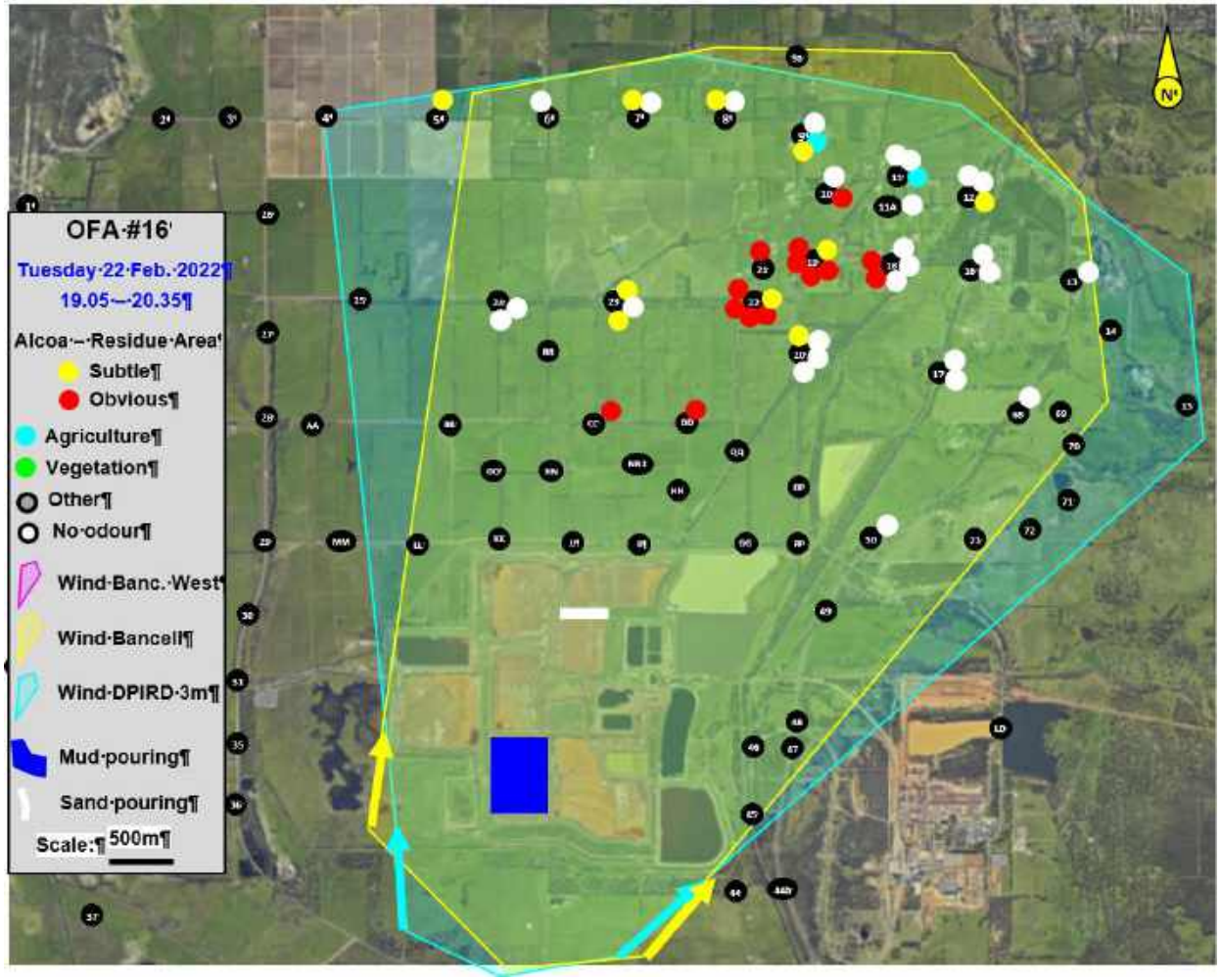
Appendix 22 - OFA #15 results
Tuesday 8 February 2022
16.20 -17.40

Appendix 22: Odour Map OFA #15 – Tuesday 8 February 2022 – 16.20 to 17.40



Appendix 23 - OFA #16 results
Tuesday 22 February 2022
19.05 – 20.35

Appendix 23: Odour Map OFA #16 – Tuesday 22 February 2022 – 19.05 to 20.35

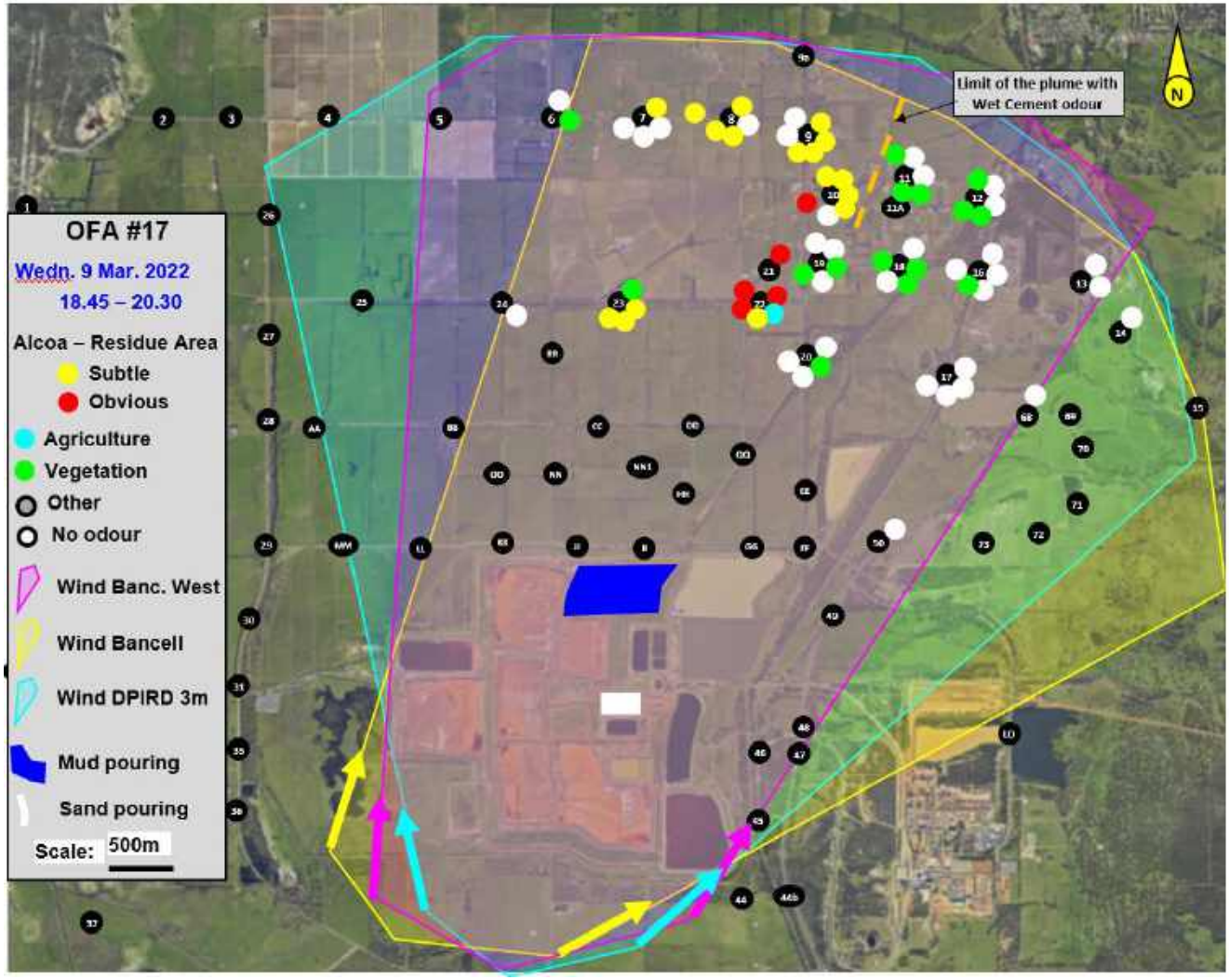


Appendix 24 - OP #6 results
Thursday 3 March 2022
14.45 – 16.20

Appendix 24: Odour Map OP #6 – Thursday 3 March 2022 – 14.45 to 16.20

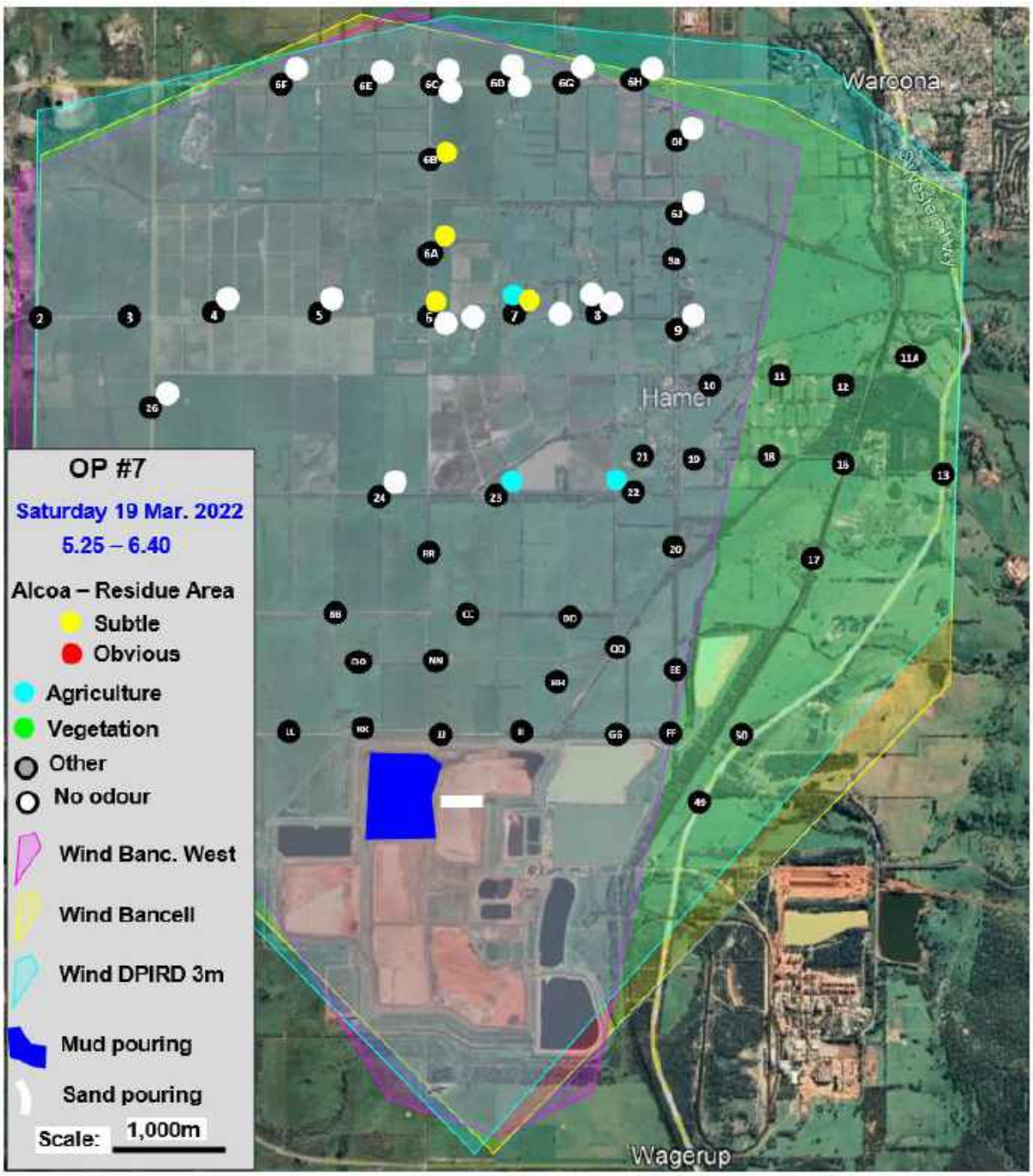
Appendix 25 - OFA #17 results
Wednesday 9 March 2022
18.45 – 20.30

Appendix 25: Odour Map OFA #17 – Wednesday 9 March 2022 – 18.45 to 20.30



Appendix 26 - OP #7 results
Saturday 19 March 2022
5.25 – 6.40

Appendix 26: Odour Map OP #7 – Saturday 19 March 2022 – 5.25 to 6.40



Appendix 27 - OP #8 results
Monday 21 March 2022
5.25 – 7.10

Appendix 27: Odour Map OP #8 – Monday 21 March 2022 – 5.20 to 7.10