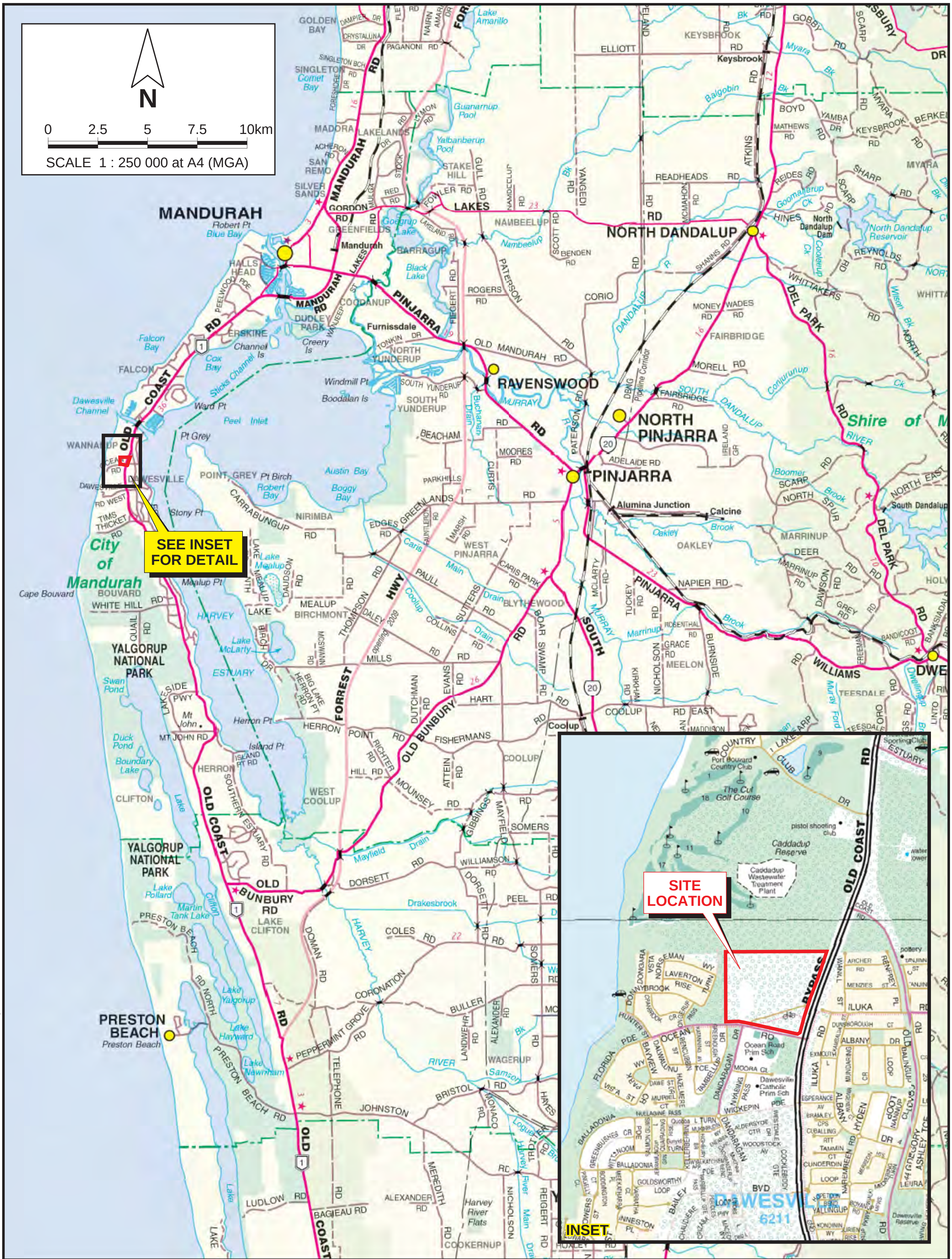
ATTACHMENT 10

BLACK COCKATOO REGIONAL HABITAT
(ATA Environmental Pty Ltd., 2006)



PINPOINT CARTOGRAPHICS (08) 9562 7136 HNP295_05-f01.dgn

EndPlan Environmental

Florida Partnership
S.38 REFERRAL
FLORIDA NORTH, LOT 9008 OCEAN ROAD, DAWESVILLE, WA

REGIONAL LOCATION

Date: 20 May 2015
Drawn: B. Van der Wiele

Figure 1

Report No. HNP295_05

PINPOINT CARTOGRAPHICS (08) 9562 7136 HNP295_05-f02.dgn

EndPlan Environmental

Florida Partnership
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FLORIDA NORTH, LOT 9008 OCEAN ROAD, DAWESVILLE, WA

SURROUNDING ENVIRONS

Date: 20 May 2015
Drawn: B. Van der Wiele

Figure 2

Report No. HNP295_05

CADASTRAL SOURCE: Landgate, March 2015.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2015.

N

0 20 40 60 80 100m

SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easment Boundary
- Topographic Contour
- Proposed Subdivision
- Proposed Public Open Space
- 300m Buffer from WWTP

CADASTRAL SOURCE: Landgate, March 2015.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2015.
VEGETATION MAPPING SOURCE: Ecoscape, Project No. 2645-11, November 2011.
PROPOSED SUBDIVISION AND CONTOUR SOURCE: CLE, Dwg No. 688-169A-01, 09-04-2015.

PINPOINT CARTOGRAPHICS (08) 9562 7136 HNP295_05-f03.dgn

EndPlan Environmental

Florida Partnership
S.38 REFERRAL
FLORIDA NORTH, LOT 9008 OCEAN ROAD, DAWESVILLE, WA

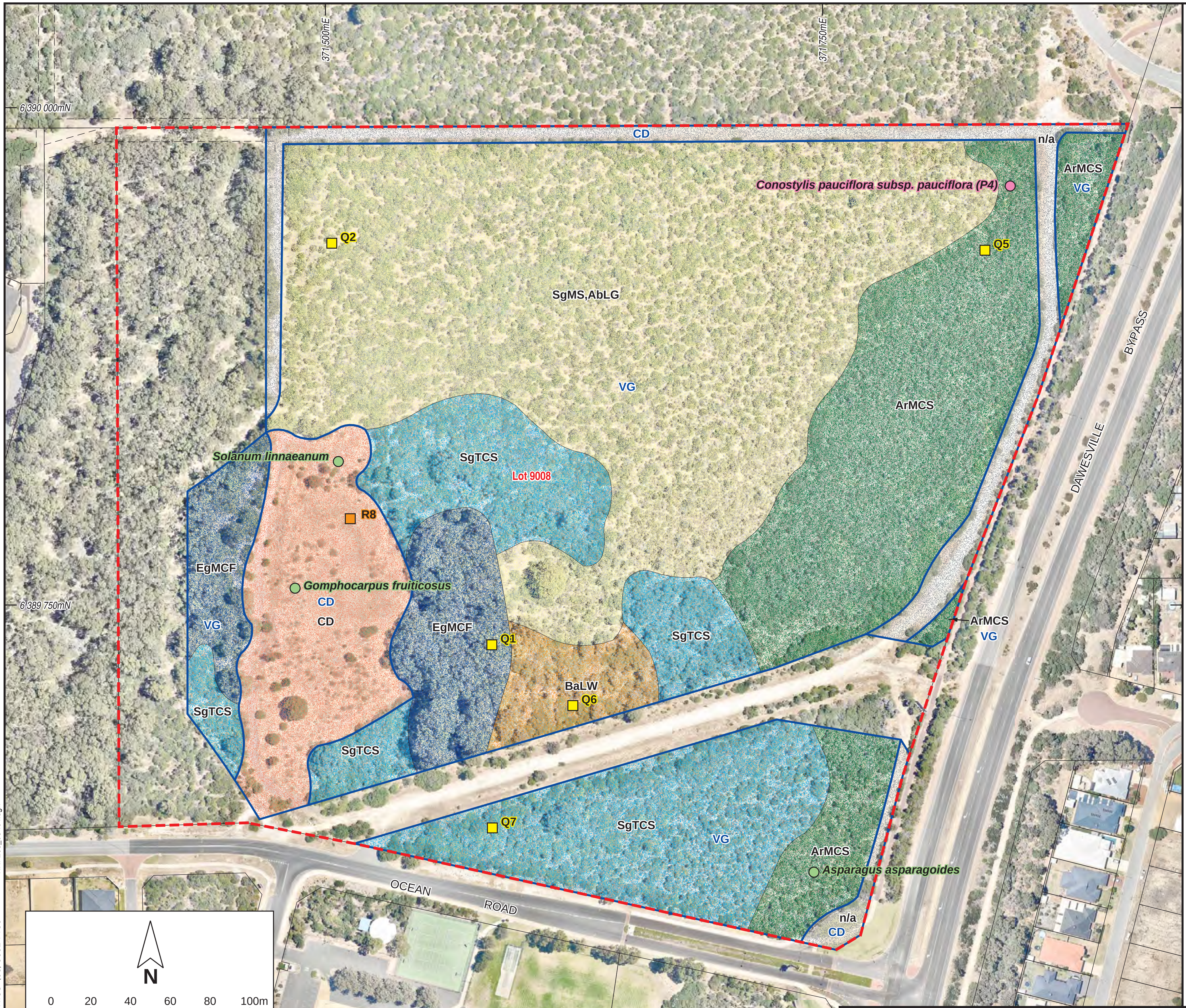
PROPOSED SUBDIVISION

Date: 20 May 2015

Drawn: B. Van der Wiele

Figure 3

Report No. HNP295_05



CADASTRAL SOURCE: Landgate, March 2015.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown January 2015.
VEGETATION MAPPING SOURCE: Ecoscape, Project No. 2645-11, November 2011.

HNP295_05-f04.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Legend

- Site Boundary
- Cadastral Boundary
- Easment Boundary
- Quadrat Location
- Releve Location
- Conservation Significant Flora Location
- Declared Weed Location

Vegetation Types

ArMCS - *Acacia rostellifera, Spyridium globulosum, Santalum acuminatum* mid-high closed shrubland over **Briza maxima, Parietaria debilis, Trachymene pilosa* low grassland/forbland.

BaLW - *Banksia attenuata* low woodland over *Spyridium globulosum, Acacia rostellifera, Melaleuca systena* mid-high closed shrubland over **Briza maxima, *Avena barbata, *Centranthus macrosiphon* low grassland/forbland.

CD - Completely degraded: **Ricinus communis* mid-high open shrubland over **Trachyandra divaricata, *Oxalis pes-caprae, Senecio pinnatifolius* var. *latilobus* low forbland.

EgMCF - *Eucalyptus gomphocephala* mid-high closed forest over *Spyridium globulosum* mid-high shrubland over *Acanthocarpus preissii, Desmocladus flexuosus* low sparse forbland/rushland.

n/a - Cleared

SgMS,AbLG - *Spyridium globulosum, Olearia axillaris, Acacia rostellifera* mid-high shrubland over **Avena barbata, *Trachyandra divaricata, Desmocladus flexuosus* low grassland/forbland/rushland.

SgTCS - *Spyridium globulosum, Banksia sessilis* tall closed shrubland over *Hibbertia hypericoides* low sparse shrubland over **Centranthus macrosiphon, *Hypochaeris glabra, *Lysimachia arvensis* low forbland.

Vegetation Condition

- Vegetation Condition Boundary
- VG Very Good
- CD Completely Degraded

EndPlan Environmental

Florida Partnership
S.38 REFERRAL
FLORIDA NORTH, LOT 9008 OCEAN ROAD, DAWESVILLE, WA

VEGETATION TYPE AND CONDITION

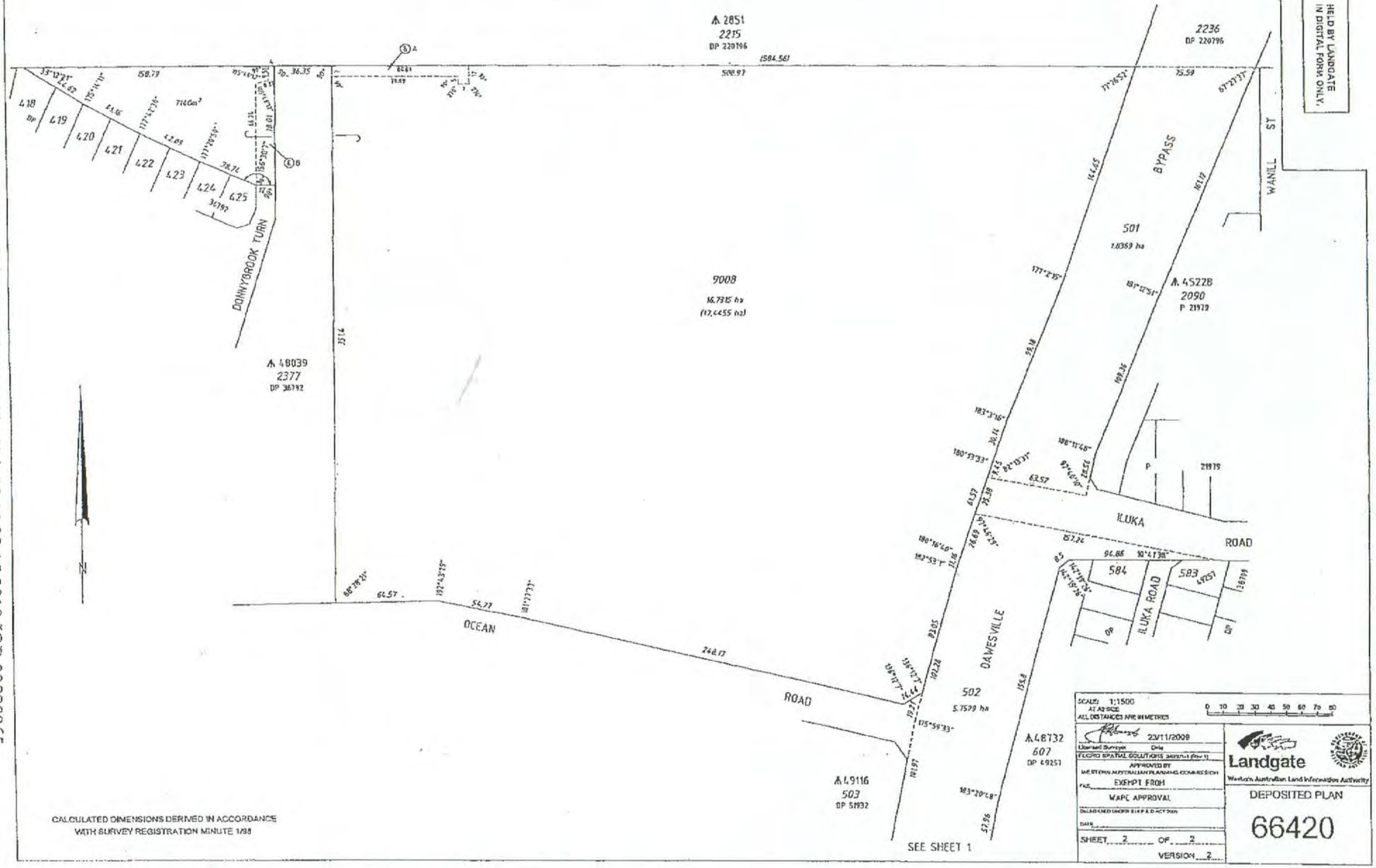
Date: 20 May 2015
Drawn: B. Van der Wiele

Figure 4

Report No. HNP295_05

FOR HEADING SEE SHEET 1

FOR INTERESTS AND NOTIFICATIONS SEE SHEET 1



All road carriageway detail depicted on this subdivision plan including road pavements, road treatments, medians or parking, are for illustrative purposes only and are subject to final engineering design and separate approval processes. The detail reflects the preferred urban design intent for the road network standards.

All dimensions and areas depicted on this plan are subject to pre-cal and final survey and will vary from the figures shown. This plan remains the property of CLE.

LEGEND

- Subject Area (17.4445ha)
- WWTP 300m Buffer
- Public Open Space (2.7739ha)

LOT SUMMARY	
Number of Lots	161
Total Area of Lots	107532m²
Average Area of Lots	668m²
Minimum Lot Area	582m²
Maximum Lot Area	2709m²

CLE TOWN PLANNING + DESIGN

PROPOSED SUBDIVISION - PRELIMINARY CONCEPT

Lot 9008 Ocean Road, Dawesville - Florida Beach Estate
City of Mandurah

plan no: 688-169A-01
scale: 1:2000 @ A3
date: 09.04.2015

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ASSESSMENT OF ODOUR IMPACTS FROM CADDADUP WASTE WATER TREATMENT FACILITY ON PROPOSED REVISED DEVELOPMENT OF FLORIDA BEACH ESTATE

Prepared for EndPlan Pty Ltd

by

ENVALL

Environmental Alliances Pty Ltd

August 2014

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Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. It is assumed that normal activities were undertaken at the site on the day of the site visit(s) unless explicitly stated otherwise.

ENVALL has not attempted to fully verify the accuracy or completeness of the written or oral information supplied for the preparation of this report. While ENVALL has no reason to doubt the information provided, the report is complete and accurate only to the extent that the information provided to ENVALL was itself complete and accurate.

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Client: EndPlan Pty Ltd

Job No: L4127	**Version**	**Prepared by**	**Reviewed by**	**Submitted to Client**	
Status				**Copies**	**Date**
Draft Report	1a	DP	OP (Air Assessments) 14/7/2014	*.pdf	15/7/2014
Final Report	1b	DP	EndPlan	*.pdf	21/7/2014
Final Report (Exec Summary added)	1c	DP	-	*.pdf	8/9/2014

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ABN: 75 103 600 620

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EXECUTIVE SUMMARY

The Florida Partnership wishes to develop land south of the Caddadup Waste Water Treatment Plant (WWTP) for residential use.

The current structure plan includes a 400 metre buffer around the WWTP. The Florida Beach development approval already covers the area up to the 400 metre buffer on the south side.

The Florida Partnership would like to extend the approved development approximately 100 metres further north into the southern extent of the 400 metre buffer (leaving an approximate 300 metre buffer distance to the development).

This report contains an assessment of the odour levels from the WWTP within the proposed extended development.

The CALPUFF dispersion model was used to predict ambient odour concentrations. Meteorological data for the modelling was derived primarily from the CSIRO's TAPM model, supplemented by cloud cover data from Perth Airport. Odour emissions were scaled from an odour modelling study of the Alkimos WWTP.

Two field odour surveys were also undertaken at the southern boundary of the Caddadup WWTP. The odours from the WWTP were undetectable for almost all of the time. Odour concentrations were estimated from the field surveys using conservative assumptions.

A comparison of modelling predictions with the estimated odour concentrations from the field surveys showed that the modelling over-predicted odour. Notwithstanding, modelling over a full year showed that, at worst, the predicted odour levels at the closest point of the extended development were approximately one-third of the criterion. The total level of conservatism in the modelling predictions is considered to be up a factor of four, hence the predicted odour levels at the extended development could be as low as one-twelfth of the criterion.

This outcome need to be cautioned by the uncertainties in the variability in odour emissions due to aspects such as seasonal factors, operating conditions and equipment failures (albeit that these issues were also not addressed in the Alkimos odour modelling study).

As far as can be determined, the predicted odour levels from the Caddadup WWTP easily meet all relevant criteria for residential acceptability within the revised proposed development area – that is, 100 metres further north into the southern extent of the current 400 metre odour buffer .

1. INTRODUCTION

The Florida Partnership wishes to develop land south of the Caddadup Waste Water Treatment Plant (WWTP) for residential use, as shown in Figure 1. The proposed development is also bordered by Public Open Space to the west, Ocean Road Primary School to the south and Mandurah Road to the east.

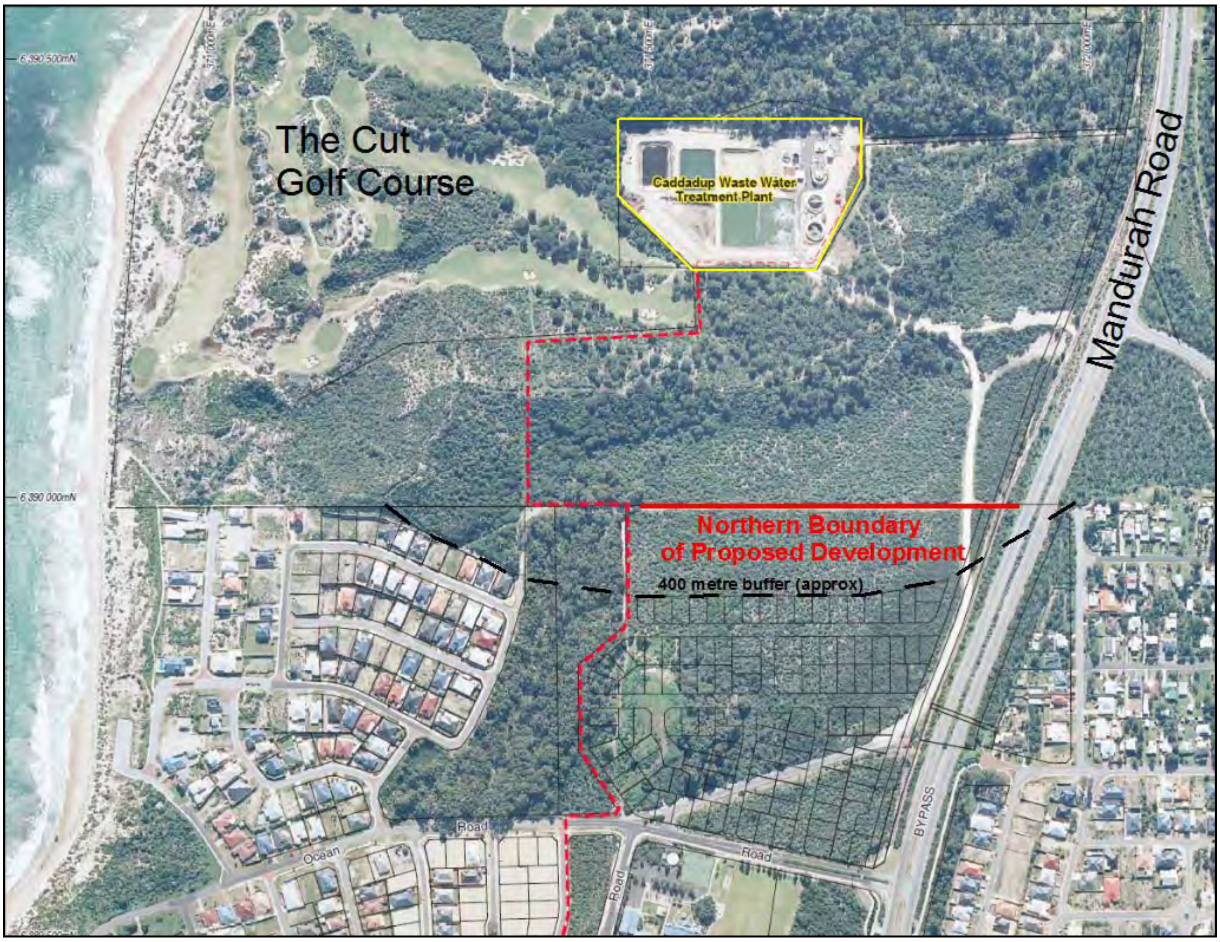

Figure 1 Location of proposed development land

The current structure plan includes a 400 metre buffer around the WWTP. The Florida Beach development approval already covers the area up to the 400 metre buffer, as indicated by the residential plots shown in Figure 1. The proposed revision to the development (i.e. the subject of this study) would extend the approved development approximately 100 metres further north into the southern extent of the 400 metre buffer, which if approved, would still leave a residual buffer of some 270 metres from the southern boundary of the WWTP to the northern boundary of the proposed, revised development.

The WWTP is within a low-lying area as illustrated by Figure 2 and Figure 3. There are local ridges to the north, east and south with only the adjacent golf course to the west being near to the same local height level as the WWTP.

The vegetation surrounding the WWTP is dense and about 2 to 5 metres in height.

Figure 2 View of Caddadup WWTP from ridge to the west, facing NE

Note:

The start of the northern boundary of the proposed development running East to West from the intersection with Mandurah Road is shown as red line.

Figure 3 Ground level terrain elevations above AHD (m)

Environmental Alliances Pty Ltd (ENVALL) has been engaged to undertake an assessment of the odour levels from the WWTP within the 100 metre southern portion of the buffer being the northern portion of the revised proposed development.

2. CADDADUP WWTP DESIGN

From 2008, the Caddadup WWTP was upgraded as part of a program of works designed to increase treatment capacity and efficiency, produce treated wastewater suitable for reuse, as well as reduce odour emissions.

The scope of works included[1]:

1 Sunset Coast Waste Water Treatment Plant Upgrade (see http://www.leighton.com.au/our-business/projects/completed-projects/sunset-coast-waste-water-treatment-plant-upgrade accessed 8/5/2014).

- upgrade to a 3 ML/d capacity;
- installation of bioscrubbers and sealing of inlet works to reduce odour emissions;
- construction of in-tank mechanical screening;
- construction of additional aeration tank and clarifier;
- construction of aerated biosolids storage and thickening tank;
- construction of a common biosolids dewatering facility. The new dewatering facility will eliminate the need for existing sludge lagoons at the three plants, reducing odour and simplifying transport of biosolids for reuse or disposal; and
- increased opportunities for reuse.

3. ODOUR IMPACT ASSESSMENT METHODOLOGY

The approach recommended by the Department of Environmental Regulation (DER) to assess air quality impacts from industrial proposals is modelling the dispersion of air emissions as described of "Air Quality Modelling Guidance Notes" (DEP 2006) and comparing the predictions to criteria for acceptable impacts. With respect to odour more specifically, the DER has published an "Odour Methodology Guideline" (DEP 2002).

4. ODOUR CRITERIA

4.1 DER CRITERIA

The criteria currently used by the DER to assess acceptable odour impacts is[2]:

- for sources other than wake-free stacks: C99.9,1hr=8ou[3] and C99.5,1hr=2.5ou; and
- for wake-free stacks: C99.9,1hr = 1.6 ou and C99.5=0.5ou.

4.2 WATER CORPORATION CRITERION FOR WASTE WATER TREATMENT ODOUR

For WWTP odours, the Water Corporation uses a maximum odour level at the boundary of the buffer zone of 5 ou for 99.9 per cent of the time (CEE 2009). The Water Corporation has ascertained that the 5 ou level of odour encompasses the zone of odour complaints from the urban community and also the zone in which odour can be perceived as annoying, based on correlation of odour complaints and odour modelling around the existing Halls Head, Broome, Subiaco, Mandurah, Woodman Point and Beenyup treatment plants. This criterion has recently been endorsed by the EPA in determining an acceptable level of odour for sensitive land uses (EPA Bulletin 1272, October 2007) (CEE 2009). This criterion is abbreviated as:

- C99.9,1hr=5ou.

This criterion applies to WWTP sources other than wake-free stacks as well as WWTP wake-free stacks.

---

[2] D Griffiths *pers com* 19/10/2012.

[3] Also used by EPA.

4.3 RELEVANT CRITERIA FOR CADDADUP WWTP

All odour sources at the Caddadup WWTP are wake-affected (see Section 5.3.2). Therefore the criteria that can be applied are:

- C99.9,1hr=8ou (DER/EPA);
- C99.9,1hr=5ou (Water Corporation); and
- C99.5,1hr=2.5ou (DER).

Assessments against these form of criteria – that is, an odour concentration over a specified averaging time occurring at a specified frequency over a year, requires a modelling assessment of odour emissions.

5. ASSESSMENT OF CADDADUP WWTP ODOURS

5.1 MODEL

A computer dispersion model uses continuous meteorological and emission data to predict the concentrations of an air pollutant around the source of the emissions.

The CALPUFF modelling system was used for modelling odour dispersion from the Caddadup WWTP. The “model” consists of three main components; CALMET - a diagnostic 3-dimensional meteorological model, CALPUFF - an air quality dispersion model, and CALPOST - a post-processing package.

This model has been adopted by the U.S. Environmental Protection Agency (US EPA) in its “Guideline of Air Quality Models” as the preferred model for assessing long range transport of pollutants and their impacts on Federal Class I areas and on a case-by-case basis for certain near-field applications involving complex meteorological conditions (Environmental Protection Agency 2003). The combination of low level, non-buoyant emission sources at the Caddadup WWTP and the various different surrounding land types and roughness lengths imply that local plume dispersion will be subject to complex influences. These issues necessitate the use of this type of model for realistic predictions of dispersion.

Key assumptions used for the CALPUFF modelling included:

- cartesian 61 x 65 grid with 25 m spacing;
- PG dispersion coefficients (see Appendix 4);
- rural wind profile exponents ; and
- terrain heights obtained from the 1s (approximately 30 metres) SRTM 2010 Smoothed Digital Elevation Model (DEM-S).

  These data comprise a regular grid representing ground surface topography where possible excluding other features such as vegetation and man-made structure and subsequently smoothed to reduce random noise typically associated with the SRTM data in low relief areas (Geoscience Australia 2010).

Full details of the CALPUFF configuration are shown in Appendix 1.

5.2 ANNUAL METEOROLOGICAL DATA

A site-specific meteorological data set suitable for input into CALMET was developed from:

- surface and upper air meteorological data from the CSIRO's TAPM model as described in Appendix 2);
- cloud cover data from the BoM at Perth Airport (since TAPM does not predict cloud cover very well, and Perth Airport cloud data was considered adequately representative of the Mandurah/Caddadup region); and
- geophysical data as described in Appendix 3.

Further details and analysis of the final CALMET meteorological data are provided in Appendix 4.

5.3 ODOUR EMISSION RATES

A preliminary estimate of odour emission rates from the Caddadup WWTP was derived from data used for modelling odour dispersion from the upgraded Alkimos WWTP as described in CEE (2009), as the Alkimos facility also uses Oxidation Ditch treatment. The details of the extent of technological similarity between Alkimos and Caddadup WWTPs is not known, hence the derived emissions for Caddadup are "nominal" for the primary purpose of being able to compare modelling results with estimated ambient odour concentrations from field surveys.

5.3.1 Alkimos odour emissions

The base capacity used for modelling odour dispersion at Alkimos was 20 ML/day (for 2010 to 2025) with the next highest capacity modelled being 40 ML/day for 2025 to 2035. The estimated total odour emissions for Stages 1 and 2 summarised in Table 1. It is noted that the emissions for Stage 2 are largely pro rata from the Stage 1 emissions, based on the capacity increase.

Table 1 Estimated Odour Emissions from Alkimos WWTP for Stage 1 and Stage 2

Treatment Unit	Stage 1 (20 ML/day capacity) odour emission rate (ou/s)	Stage 2 (40 ML/day capacity) odour emission rate (ou/s)
Inlet Area	800	1,000
Secondary Area	5,000	10,000
Sludge Handling	400	500
Sub-total Ground level sources	6,200	11,500
Stack (see Table 2 for treated sources)	72,000	140,000
Total for plant	78,500	151,500

From CEE (2009).

It is seen from Table 1 that the largest single odour source from the Alkimos WWTP is the stack. The derivation of the stack odour emission rate in CEE (2009) was from the estimated air extraction rates for each covered odour-emitting equipment item, and a commensurate odour concentration of 2,400 ou as shown in Table 2.

Table 2 Air extraction rates used to calculate stack odour emissions for Alkimos WWTP Stage 1

Odour Source	**Air Extraction Rate for Stage 1 (20 ML/day capacity), (m^3/hr)**
Inlet sewer	2,500
Screens and bins	7,500
Grit tanks	900
Bioselectors	1,200
DAF tanks	300
Sludge storage tank	2,500
Combined stream	15,000
Oxidation ditch	90,000
Total to stack	105,000
Stack discharge odour concentration	2,400 ou
Stack discharge odour emission rate	70,000 ou.m^3/s

Data from CEE (2009). Note there is a slight inconsistency in the stack odour emission rates in the two tables in the CEE report.

5.3.2 Estimated Caddadup WWTP odour emissions

Stack

The Alkimos facility has a much larger treatment capacity than the upgraded Caddadup facility.

The odour emission estimated for the Caddadup WWTP stack based on pro rata capacity from Alkimos Stage 1 is therefore; 3ML/day / 20ML/day x 72,000ou.m^3/s = 10,800 ou.m^3/s.

The emission parameters for the Caddadup stack based, similarly, on the Alkimos stack parameters (except for height) are shown in Table 3.

Table 3 Emission parameters for Caddadup stack

Parameters	**Value**
Release height (m)	10
Internal diameter[(a)] (m)	0.61
Exit temperature (°C)	Ambient
Exit velocity (m/s)	15
Volumetric flow rate (m^3/s @ actual)	4.4
Building wake effects	Included - Prime

[(a)] Scaled from scaled volume flow to give a reasonable estimate of exit velocity of 15 m/s.

Ground level sources

The emissions from the ground level odour sources at Caddadup were also scaled from the Alkimos odour study, and for the Caddadup modelling, located from the Oxidation Ditch and associated facilities. Given the uneven nature of the Oxidation Ditch infrastructure, this emission was modelled as a single volume source with the initial plume dimensions taken as ½ of the height and width of the Oxidation Ditch, and the release height taken as the height of the infrastructure.

Clarifiers

This study has also included an odour emission rate from the Caddadup clarifiers even though odour from WWTP clarifiers is "organic in nature" and not normally considered to have the potential for off-site odour impacts (CH2M Hill 1997), and was not included in the Alkimos odour modelling. Measured data from the Subiaco WWTP sampling showed a specific odour emission rate (SOER[4]) of 1.6 ou.m^3/m^2/s. More recent data has an SOER of 0.1 ou.m^3/m^2/s (Hunter Treatment Alliance 2011). The higher value of 1.6 ou.m^3/m^2/s was used for Caddadup modelling.

The resulting wind speed dependent emissions for each Clarifier are shown in Table 4.

Table 4 Wind speed dependent odour emissions for each of two clarifiers at Caddadup

Wind speed at 10 m (m/s)	0-1.54	1.54-3.09	3.09-5.14	5.14-8.23	8.23-10.8	+10.8
Stability Class	**Odour Emission rate (ou.m3/m2/s)**					
1	981	1389	1792	2267	2597	2839
2	981	1389	1792	2267	2597	2839
3	915	1297	1672	2116	2424	2649
4	816	1156	1490	1886	2160	2361
5	515	729	940	1190	1363	1490
6	325	460	593	751	860	940

Summary of estimated source emissions

The estimated average annual odour emission rates for all of the Caddadup WWTP sources are shown in Table 5.

Table 5 Estimated annual average odour emissions from Caddadup WWTP

Treatment Unit	Caddadup WWTP (3 ML/day capacity) odour emission rate (ou.m^3/s)
Stack [(a)]	10,800
Combined-total Ground level sources[(b)]	930
North Clarifier [(c)]	1,288
South Clarifier [(c)]	1,288
Total for plant	14,306

[(a)] Odour emissions scaled from Alkimos Stage 1 in CEE (2009).

[(b)] Scaled emission = 3ML/day / 20ML/day x 6,200ou.m^3/s = 930 ou.m3/s. Modelled as constant volume source from Oxidation Ditch.

[(c)] Wind-speed dependent odours.

[4] Measured using a wind tunnel with an air velocity of 0.05 m/s at 0.1 m above the surface.

6. COMPARISON OF MODEL PREDICTIONS WITH ODOUR OBSERVATIONS

A methodology to verify modelled ground-level odour concentrations and by implication source odour emissions and commensurate modelling methodology, is to undertake field odour surveys as described in the DEC's Odour Methodology Guideline (see http://www.dec.wa.gov.au/component/docman/doc_download/1011/Itemid,/ accessed 7/5/2014).

The protocol for the field odour assessments follows the German VDI 3940 assessment method in which field assessors who have been checked beforehand for olfactometry response, are located downwind of an "odour plume", and an odour intensity rating made and recorded every 10 seconds over a 3-10 minute period. The assessments are repeated over 4-6 hours. This allows ambient odour concentrations to be estimated from the recorded odour intensities using a defined relationship for the odorant. This method has been used extensively by ENVALL and other practitioners over the last decade or so to determine ambient odour levels arising from odour-emitting sources (see Pitt, 2014[5]).

Field odour surveys following the general approach in VDI (1993) were undertaken around the Caddadup WWTP during the afternoons on 31 May 2014 and 7 June 2014. These are described in Appendix 5.

A quantile:quantile comparison of the odour concentrations estimated from the two field surveys and modelling predictions for the same times and locations is shown in Figure 4.

Although the odour concentrations are extremely low, the comparison is reasonable and generally indicates higher odour concentrations predicted from the modelling than were observed. This provides confidence that the model predictions over the longer time period necessary to compare to odour criteria will be credible.

[5] Pitt, D, 2014, "Field odour assessments for estimating odour concentrations", Air Quality and Climate Change, Vol 48, No 1, February 2014.

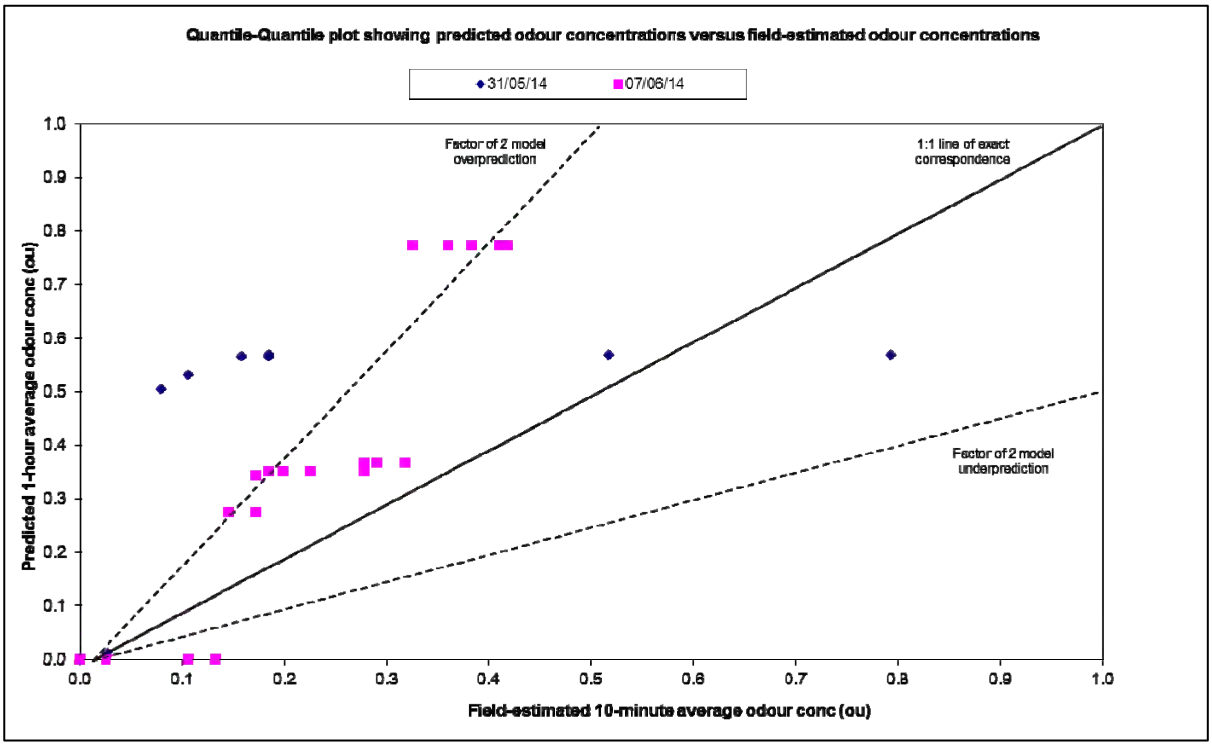

Figure 4 Quantile-Quantile plot of predicted odour concentrations versus field-estimated odour concentrations

Note: It assumed in the VDI Standards that 10-minute field assessments are 80% reliable in estimating the hourly levels. Therefore 10-minute odour concentrations from the field assessments are assumed to represent the average concentration over the hour.

7. PREDICTED ANNUAL ODOUR LEVELS FOR COMPARISON TO CRITERIA

7.1 MODELLING RESULTS

In order to compare the odour levels from the WWTP to the EPA's criterion for acceptable odour impacts at residential areas, the dispersion of the odour emissions must be modelled over a full year.

In this case, the period from 1 July 2013 to 30 June 2014 was used.

The 8,760 1-hour average concentration values predicted by the model at each grid point are then ranked from highest to lowest. The 99.9 percentile is the 9th highest ranked concentration. The 99.5 percentile is the 44th highest ranked concentration. The 9th or 44th highest 1-hour average concentrations at each gridded receptor, may then be contoured using a computer software package to draw continuous lines of equal concentrations. The software interpolates the concentrations required for the contours as selected by the user between the values predicted at each discrete grid point.

A summary of the annual odour levels predicted from the Caddadup WWTP is shown in Table 6.

Table 6 Summary of annual odour levels from Caddadup WWTP

Statistic	Predicted concentration anywhere on modelling grid (i.e. within WWTP) (ou)	At most affected location of proposed development (ou)				
		Predicted concentration (ou)	DER criterion (ou)	Percent of DER criterion (%)	Water Corporation criterion (ou)	Percent of Water Corporation criterion (%)
99.9 percentile	5.0	1.4	8	**18**	5	**28**
99.5 percentile	3.4	0.8	2.5	**32**	NA	**NA**

The highest 1-hour average 99.9 percentile ground-level concentration predicted anywhere on the modelling grid was only 5 ou. This is within the WWTP boundary. Therefore, both the DER’s and Water Corporation’s 99.9 percentile criterion are actually met at the boundary of the WWTP.

The highest 1-hour average 99.9 percentile ground-level concentration predicted at the most affected location of proposed development area is only 18% and 28% of the DER’s and Water Corporation’s criterion respectively.

The highest 1-hour average 99.5 percentile ground-level concentration predicted anywhere on the modelling grid was 3.4 ou, This is within the WWTP boundary.

The highest 1-hour average 99.5 percentile ground-level concentration predicted at the most affected location of proposed development area is only 32% of the DER’s criterion. The predicted 2.5 ou 1-hour average 99.5 percentile contour is shown in Figure 5. The closest part of the criterion contour is still some 300 metres away from the northern boundary of the proposed development.

Figure 5 Predicted 2.5 ou, 99.5 percentile, 1-hour odour concentration from Caddadup WWTP

Notes:

1. DER criterion concentration of 2.5 ou shown in solid white.
2. The 1 ou contour is shown is dashed white to illustrate the general nature of the odour dispersion.

7.2 COMPARISON OF RESULTS TO ALKIMOS WWTP

The very low odour level predicted from the Caddadup WWTP are not surprising in view of the predicted odour levels from the much larger Alkimos WWTP.

For Alkimos Stage 1 (20 ML/day capacity), the distance to the predicted 5 ou contour extends about 300 metres from the boundary of the plant. For Alkimos Stage 2 (40 ML/day capacity), the distance to the predicted 5 ou contour extends about 500 metres from the boundary of the plant. (CEE 2009).

These results indicate the even the Alkimos WWTP at the Stage 1 capacity may be acceptable at the Caddadup location – albeit perhaps marginally.

7.3 SUMMARY

It is noted that these modelling results have incorporated the following conservative assumptions:

- Constants in Weber-Fechner equation to estimate field odour concentrations (DOC=10ou) likely to over-state the concentrations. The Water Corporation's odour assessment methodology assumes a DOC=5ou for WWTP odours hence this assumption may be conservative by a factor of two;
- Even with the over-estimated field odour concentrations, the modelling predictions for the field conditions were generally a factor of two higher;

It is therefore considered that the level of conservatism in the modelling results is up a factor of four.

Even with this:

- the maximum predicted odour concentrations from the Caddadup WWTP at the most affected location of the proposed development for the statistic closest to the criterion (DER's 99.5 percentile) is only 32 % giving a margin of safety of odour concentrations of approximately three; and
- the odour at the criterion level (DER's 99.5 percentile) is still at least 300 metres away from the northern boundary of the proposed development – in other words, giving a margin of safety of approximately 300 meters.

These outcomes need to be cautioned by the uncertainties in the variability in odour emissions due to aspects such as seasonal factors, operating conditions and equipment failures (although these issues were also not addressed in the CEE (2009) Alkimos odour modelling study).

Nevertheless, as far as can be determined, the predicted odour levels from the Caddadup WWTP easily meet all relevant criteria for residential acceptability within the revised proposed development area – that is, 100 metres further north into the southern extent of the current 400 metre odour buffer .

8. GLOSSARY OF TERMS

"CALPUFF" means CALifornian PUFF model.

"DER", "DEC", "DoE", "DEP" means Department of Environmental Regulation (WA), formally Department of Environment and Conservation, formerly Department of Environment, formerly Department of Environmental Protection.

"EPA" means Environmental Protection Authority (WA).

"km" means kilometres.

"km" means kilometres.

"ML/d" means Mega Litres per day.

"m/s" means metres per second.

"m" means metres.

"m^2" means square metres.

"m^3/s" means cubic metres per second.

"m^3/hr" means cubic metres per hour.

"^oC" means degrees Celsius.

"OER" means odour emission rate with units of $ou.m^3/s$.

"$ou.m^3/s$" means odour units multiplied by the associated air volume in cubic metres, per second.

"ou/s" means odour units per second.

"ou" means odour units. An odour unit is a dimensionless ratio defined as the volume which an odorous sample would occupy when diluted to the odour threshold, divided by the volume of the odorous sample.

"US EPA" means United States Environmental Protection Agency.

"SOER" means specific odour emissions rate which is the odour emission rate per unit area with units of $ou.m^3/m^2/s$.

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[6] (See revision http://www.nasalranger.com/Operations/TP%202000%2006086V2.2.pdf) accessed 3/6/2014).

Appendix 1 CALPUFF detailed modelling parameters

```
CALPUFF.INP     2.0           File version record
Caddadup WWTP odour annual


---------------- Run title (3 lines) ----------------------------------------

                    CALPUFF MODEL CONTROL FILE
! METDAT =M:\L4127\CAL\MET\CALMET.MET   !
! PUFLST =M:\L4127\CAL\PUF\CADDADUP.LST  !
! CONDAT =M:\L4127\CAL\PUF\CADDADUP.CON     !
! AUXEXT =AUX     !
! LCFILES = F !
! NMETDOM =   1   !
! NMETDAT =   1   !
! NPTDAT =   0   !
! NARDAT =   0   !
! NVOLDAT =   0   !
!END!
! METRUN =   1  !
! IBYR  =  2013  !
! IBMO  =  0  !
! IBDY  =  0  !
! IBHR  =  0  !
! IBMIN =  0  !
! IBSEC =  0  !
! IEYR  =  0  !
! IEMO  =  0  !
! IEDY  =  0  !
! IEHR  =  0  !
! IEMIN =  0  !
! IESEC =  0  !
! ABTZ= UTC+0800 !
! NSECDT =  3600  !
! NSPEC =  1   !
! NSE =  1   !
! ITEST =  2   !
! MRESTART =  0   !
! NRESPD =  0   !
! METFM =  1   !
! MPRFFM =  1   !
! AVET = 60. !
! PGTIME = 10. !
! IOUTU =  2   !
! IOVERS =  2   !
!END!
! MGAUSS =  1   !
! MCTADJ =  2   !
! MCTSG =  0   !
! MSLUG =  0   !
! MTRANS =  1   !
! MTIP =  1  !
! MRISE =  1  !
! MBDW =   2  !
! MSHEAR =  0  !
! MSPLIT =  0  !
! MCHEM =  0   !
! MAQCHEM =  0   !
! MLWC =  1   !
! MWET =  0   !
! MDRY =  0   !
! MTILT =  0   !
! MDISP =  3   !
! MTURBVW =  3  !
! MDISP2 =  3  !
! MTAULY =  0  !
! MTAUADV =  0  !
! MCTURB =  1  !
! MROUGH =  0  !
! MPARTL =  1  !
! MPARTLBA =  1  !
! MTINV =  0  !
! MPDF =  0  !
! MSGTIBL = 0  !
```

```
! MBCON = 0  !
! MSOURCE = 0  !
! MFOG =  0   !
! MREG =  0   !
!END!
! CSPEC =         ODOR !
!         ODOR  =         1,                1,           0,                  0   !
!END!
! PMAP = UTM  !
! FEAST  = 0.000  !
! FNORTH = 0.000  !
! IUTMZN =  50   !
! UTMHEM = S  !
! RLAT0 =  0N  !
! RLON0 =  0E  !
! XLAT1 =  0N  !
! XLAT2 =  0N  !
! DATUM = WGS-84  !
! NX =  61   !
! NY =  65   !
! NZ =  7   !
! DGRIDKM = .025 !
! ZFACE = .0, 20.0, 40.0, 80.0, 160.0, 320.0, 640.0, 1280.0 !
! XORIGKM = 370.988 !
! YORIGKM = 6389.488 !
! IBCOMP =  1   !
! JBCOMP =  1   !
! IECOMP =  61   !
! JECOMP =  65   !
! LSAMP = T !
! IBSAMP =  1   !
! JBSAMP =  1   !
! IESAMP =  61   !
! JESAMP =  65   !
! MESHDN =  1  !
!END!
!  ICON =  1   !
!  IDRY =  0   !
!  IWET =  0   !
!  IT2D =  0   !
!  IRHO =  0   !
!  IVIS =  0   !
! LCOMPRS = T !
!  IQAPLOT =  1   !
! IPFTRAK =  0   !
! IMFLX =  0  !
! IMBAL =  0  !
! INRISE =  0  !
! ICPRT =  1   !
! IDPRT =  0   !
! IWPRT =  0   !
! ICFRQ =  3   !
! IDFRQ =  1   !
! IWFRQ =  1   !
! IPRTU =  5   !
! IMESG =  2   !
!         ODOR =     1,           1,           0,           0,           0,           0,
0   !
! LDEBUG = F !
! IPFDEB =  1  !
! NPFDEB =  1  !
! NN1 =  1   !
! NN2 =  10  !
!END!
! NHILL =  0   !
! NCTREC =  0   !
! MHILL =  2   !
! XHILL2M = 1.0 !
! ZHILL2M = 1.0 !
! XCTDMKM = 0 !
! YCTDMKM = 0 !
! END !
!END!
!END!
!  RCUTR = 30.0 !
!    RGR = 10.0 !
! REACTR = 8.0 !
```

```
!   NINT =  9  !
!   IVEG =  1   !
!END!
!END!
! MOZ =  0   !
!  BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00
!
! MNH3 =  0   !
! MAVGNH3 =  1   !
!  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00
!
! RNITE1 = .2 !
! RNITE2 = 2.0 !
! RNITE3 = 2.0 !
! MH2O2 =  1   !
!  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
!  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
!  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
!  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00
!
! NDECAY =  0   !
!END!
! SYTDEP = 5.5E02 !
! MHFTSZ =  0   !
! JSUP =  5   !
! CONK1 = .01 !
! CONK2 = .1 !
! TBD = .5 !
! IURB1 =  10  !
! IURB2 =  19  !
! ILANDUIN =  20  !
! Z0IN = .25 !
! XLAIIN = 3.0 !
! ELEVIN = .0 !
! XLATIN = -999.0 !
! XLONIN = -999.0 !
! ANEMHT = 10.0 !
! ISIGMAV =  1  !
! IMIXCTDM =  0  !
! XMXLEN = 1.0 !
! XSAMLEN = 1.0 !
! MXNEW =  99   !
! MXSAM =  99   !
! NCOUNT =  2   !
! SYMIN = 1.0  !
! SZMIN = 1.0  !
! SZCAP_M = 5.0E06 !
! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370, 0.370, 0.370, 0.370!
! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!
! CDIV = .0, .0 !
! NLUTIBL =  4  !
! WSCALM = .5 !
! XMAXZI = 3000.0 !
! XMINZI = 50.0 !
! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !
! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !
! PTG0 = 0.020,   0.035 !
!  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !
! SL2PF = 10.0 !
! NSPLIT =  3  !
!  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !
! ZISPLIT = 100.0 !
! ROLDMAX = 0.25 !
! NSPLITH =  5  !
! SYSPLITH = 1.0 !
! SHSPLITH = 2.0 !
! CNSPLITH = 1.0E-07 !
! EPSSLUG = 1.0E-04 !
! EPSAREA = 1.0E-06 !
! DSRISE = 1.0 !
! HTMINBC = 500.0 !
! RSAMPBC = 10.0 !
! MDEPBC =  1  !
!END!
!  NPT1 =  1  !
!  IPTU =   5  !
!  NSPT1 =  0  !
```

```
!  NPT2 =  0  !
!END!
! SRCNAM = STACK !
! X =  371.619, 6390.419,    10.0,  13.0,        .6,  15.0,  293.0,  1.0,1.08E04 !
! ZPLTFM  =       .0 !
! FMFAC  =      1.0 !
! SRCNAM  =   STACK !
 1    ! HEIGHT  =  5.0,   5.0,   5.0,   5.0,   5.0,   5.0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   5.0,   5.0,   .0,
                   5.0,   5.0,   5.0,   5.0,   5.0,   5.0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   5.0,   5.0,   5.0!
 1    ! WIDTH  =   25.75,   33.75,   40.75,   46.5,   51.0,   53.5,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   33.75,   25.75,   .0,
                   25.75,   33.75,   40.75,   46.5,   51.0,   54.0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   33.75,   25.88,   17.0!
 1    ! LENGTH =   54.0,   55.0,   53.5,   51.0,   46.5,   40.75,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   55.0,   54.0,   .0,
                   54.5,   54.5,   53.5,   50.5,   46.5,   40.75,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   54.5,   54.0,   52.0!
 1    ! XBADJ  =   -64.5,   -64.0,   -61.5,   -57.5,   -51.0,   -43.5,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   5.5,   8.5,   .0,
                   10.0,   9.5,   8.0,   6.5,   5.0,   3.0,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   -60.0,   -62.5,   -63.0!
 1    ! YBADJ  =   -1.0,   -7.5,   -13.62,   -19.5,   -25.0,   -29.25,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   -17.88,   -11.87,   .0,
                   1.0,   7.5,   13.88,   19.75,   25.0,   29.5,
                   .0,   .0,   .0,   .0,   .0,   .0,
                   .0,   .0,   .0,   17.88,   11.81,   5.5!
!END!
!  NAR1 =  2   !
!  IARU =   5  !
!  NSAR1 =  2  !
!  NAR2 =  0   !
!END!
! SRCNAM = NTHCLA !
! X =          5.0,    13.0,         2.5,    1.0E00 !
! SRCNAM = STHCLA !
! X =          5.0,    13.0,         2.5,    1.0E00 !
! SRCNAM  =   NTHCLA !
!  XVERT = 371.679,    371.696,    371.696,    371.679!
!  YVERT = 6390.343,    6390.343,    6390.325,    6390.325!
!END!
! SRCNAM  =   STHCLA !
!  XVERT = 371.678,    371.696,    371.696,    371.678!
!  YVERT = 6390.311,    6390.311,    6390.293,    6390.293!
!END!
! SRCNAM = NTHCLA !
! IVARY  =  4  !
 1  ! ODOR         = 3.1,4.4,5.6,7.1,8.2,8.9,
                   3.1,4.4,5.6,7.1,8.2,8.9,
                   2.9,4.1,5.3,6.7,7.6,8.3,
                   2.6,3.6,4.7,5.9,6.8,7.4,
                   1.6,2.3,3,3.7,4.4,4.7,
                   1,1.4,1.9,2.4,2.7,3      !
!END!
! SRCNAM = STHCLA !
! IVARY  =  4  !
 2  ! ODOR         = 3.1,4.4,5.6,7.1,8.2,8.9,
                   3.1,4.4,5.6,7.1,8.2,8.9,
                   2.9,4.1,5.3,6.7,7.6,8.3,
                   2.6,3.6,4.7,5.9,6.8,7.4,
                   1.6,2.3,3,3.7,4.4,4.7,
                   1,1.4,1.9,2.4,2.7,3      !
!END!
!  NLN2 =  0   !
! NLINES =  0  !
!  ILNU =   1  !
!  NSLN1 =  0  !
```

```
! MXNSEG =  7  !
! NLRISE =  6  !
! XL = .0 !
! HBL = .0 !
! WBL = .0 !
! WML = .0 !
! DXL = .0 !
! FPRIMEL = .0 !
!END!
!  NVL1 =  1   !
!  IVLU =   5  !
!  NSVL1 =  0  !
!  NVL2 =   0   !
!END!
! SRCNAM = OxDtch !
! X =   371.693,  6390.382,     5.0,     13.0,      16.7,       2.5, 9.3E02 !
!  NREC =  16   !
!END!
! X =     371.364,   6389.987,       8.000,       2.000!
! X =     371.366,   6390.048,       9.000,       2.000!
! X =     371.366,    6390.12,      14.000,       2.000!
! X =     371.385,   6390.177,      12.000,       2.000!
! X =     371.433,   6390.179,      10.000,       2.000!
! X =     371.466,   6390.361,       7.000,       2.000!
! X =     371.479,   6390.181,       9.000,       2.000!
! X =     371.528,   6390.178,       9.000,       2.000!
! X =     371.551,    6390.26,       9.000,       2.000!
! X =     371.563,   6390.258,       9.000,       2.000!
! X =     371.603,   6390.244,      10.000,       2.000!
! X =     371.619,   6390.258,      10.000,       2.000!
! X =     371.657,   6390.248,      12.000,       2.000!
! X =      371.68,   6390.248,      13.000,       2.000!
! X =      371.69,   6390.245,      13.000,       2.000!
! X =     371.728,   6390.223,      14.000,       2.000!
```

Appendix 2 TAPM-predicted meteorology

Prognostically derived surface and upper air meteorological data (from TAPM) are frequently used in dispersion modelling where no local observational meteorological data exists or where the network is sparse. This method of coupling derived meteorological with observational data has been used in modelling the dispersion of pollutants for this study.

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research. Briefly, TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

TAPM incorporates the following databases for input to its computations:

- Gridded database of terrain heights on a longitude/latitude grid of 30 second grid spacing, (approximately 1 km). This default dataset was supplemented by finer resolution data at 9 second spacing (~300m) for this study.
- Australian vegetation and soil type data at 3 minute grid spacing, (approximately 5 km).
- Rand's global long term monthly mean sea-surface temperatures on a longitude/latitude grid at 1 degree grid spacing, (approximately 100 km).
- Six-hourly synoptic scale analyses on a longitude/latitude grid at 0.75-degree grid spacing, (approximately 75 km), derived from the LAPS analysis data from the Bureau of Meteorology.

The TAPM V4 set-ups used to generate surface and upper wind data for CALMET was as follows:

- Grid dimensions were 25 x 25 cells with nests at 30 km, 10 km, 3 km, 1 km and 300 m;
- Data period 1/7/2013 to 30/6/2014; and
- No incorporation of surface wind observations.

Appendix 3 Model geophysical parameters

Land uses across the modelling domain are shown in Figure 6. Note that proposed development land was assigned for residential – i.e. as for the land immediately eastwards and southwards. The assignment of corresponding geophysical parameters is shown in Table 7.

Figure 6 Land use assignments for modelling domain

Table 7 Geophysical parameters assignments based on land use

Physical Description	Specific Land Use Cat	Zo (m)	Albedo	Bowen Ratio-spring	Soil HF Parameter	Leaf Area Ratio	Anthropogenic HF
Urban residential	10	0.4	0.18	1.5	0.25	0.20	0.00
Utilities (WWTP)	14	0.4	0.18	1.5	0.25	0.00	0.00
Dense/Tall Native Shrubland	33	0.6	0.15	1	0.15	2.50	0.00
Inlet (Inland water)	54	0.001	0.1	0	1	0.00	0.00
Ocean	55	0.001	0.1	0	1	0.00	0.00

Appendix 4 Review and analysis of meteorological data used for modelling

Winds

Given the prognostic nature of TAPM-generated meteorological data, it is useful to check that the wind predictions are reasonable by comparing against the nearest available measured data.

The recently released EPA Victoria draft guideline on the use of meteorological data for (AERMOD) modelling (EPA Victoria 2013) suggests that where there are no measured “mandatory” (eg BoM) data within a 5 km radius of the application site, meteorological files constructed using meteorological data generated by prognostic models such as TAPM may be used.

The nearest BoM site to Caddadup is at Mandurah – approximately 13 km to the NE near the mouth of the Peel Estuary. The coast-line runs east-west at this location in contrast to the SSW-NNE coastline at Caddadup so for onshore winds, there are likely to be wind-turning effects at the BoM site which would not be representative of Caddadup winds.

Figure 7 shows a comparison of the TAPM generated site for the Caddadup site to the measured data from the BoM at Mandurah.

The main difference is the larger frequency of southerly winds at the BoM site, which is not evident from the TAPM data. This is, however, not important for odour impacts from the WWTP to the south. Otherwise the trend in direction frequency around the compass is quite similar.

The NNW-NNE arc is important for odour impacts from the WWTP to the proposed development area. The frequency of winds from the TAPM data is 10.3% versus 8.5% from the BoM data. This tends towards higher predicted odour levels the proposed development area than from using the BoM winds.

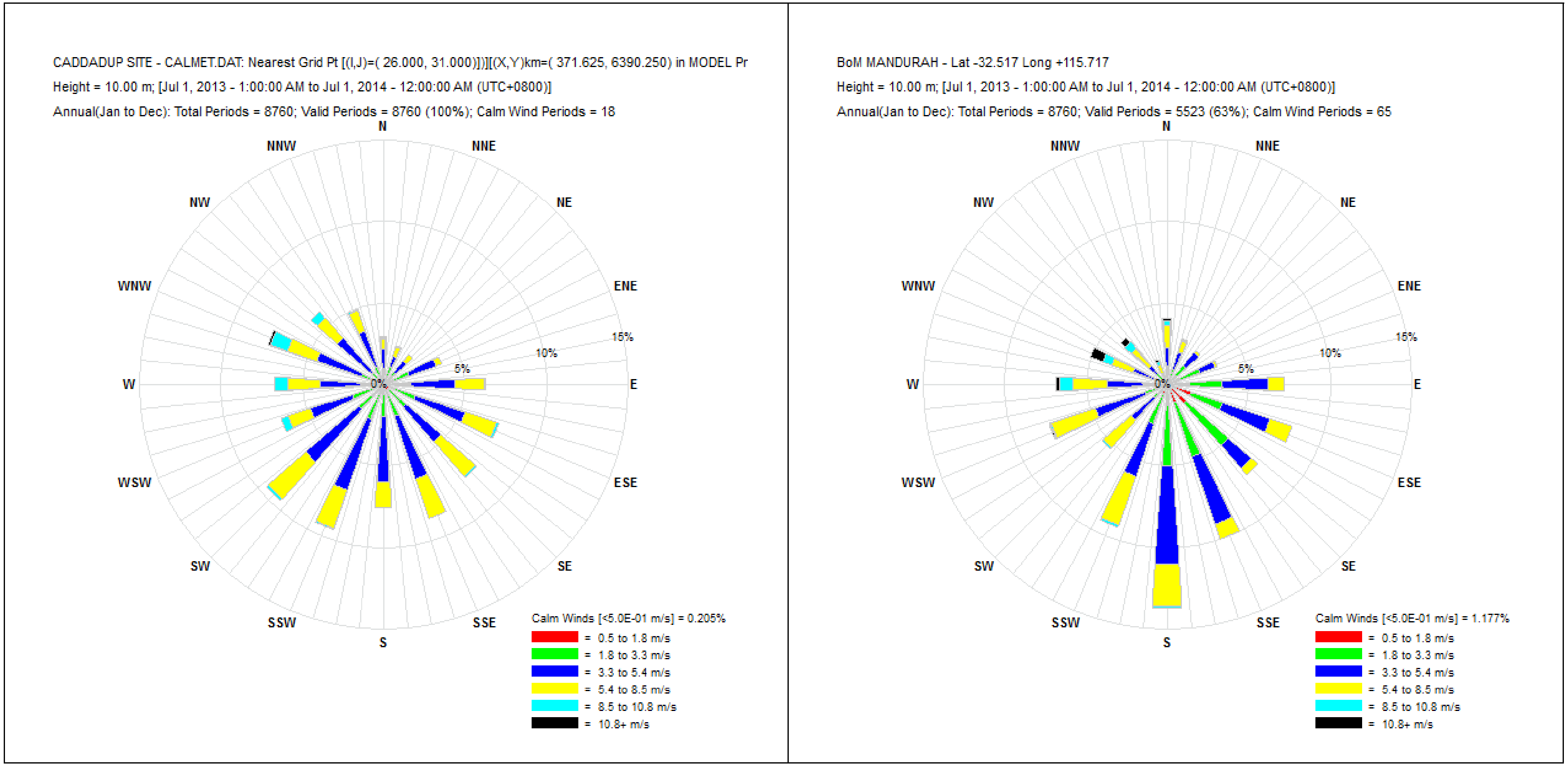

Figure 7 Comparison of TAPM-generated wind data for Caddadup site (left) and BoM data for Mandurah (right)

Stability distributions

Stability is a useful indicator of the turbulence characteristics of meteorological data use for modelling. The annual CALMET predicted stability distributions based on two classification schemes are shown in Table 8. The PG scheme is used by CALPUFF for the option of predicting dispersion using the Pasquil Gifford estimates of plume spread. The Golder (1972) relationship is more indicative of the dispersion calculated within CALPUFF if the micrometeorology scheme for determining dispersion (based on turbulence parameters), is selected.

For low-buoyancy near-surface releases, the distribution of D to F is the most important issue for far-field dispersion. Given that the PG distribution had the higher frequency of D to F conditions, the PG scheme was used in then CALPUFF modelling.

Table 8 Stability distribution for Caversham meteorological data set used for annual modelling

Stability Class	Frequency of occurrence (%)		
	Hope Valley (1980) from DER[(a)]	Caddadup (1/7/2013-30/6/2014) using PG scheme	Caddadup (1/7/2013-30/6/2014) using Golder scheme
A	2.3	1.4	1.5
B	6.8	7.9	6.8
C	21.1	16.7	30.2
D	33.8	46.9	41.6
E	19.8	16.8	12.3
F	16.2	10.4	7.6

[(a)] Included for comparison with a reasonably similar location.

Appendix 5 Details of field odour assessments

A methodology to verify modelled ground-level odour concentrations and by implication source odour emissions and commensurate modelling methodology, is to undertake field odour surveys as described in the DEC's Odour Methodology Guideline (DEC 2002)[7].

The protocol for the field odour assessments follows the German VDI 3940 assessment method in which field assessors who have been checked beforehand for olfactometry response, are located downwind of an "odour plume", and an odour intensity rating made and recorded every 10 seconds over a 3-10 minute period. The assessments are repeated over 4-6 hours. This allows ambient odour concentrations to be estimated from the recorded odour intensities using a defined relationship for the odorant. This method has been used extensively by us (and others) to verify ambient odour levels over the last decade or so (also see Pitt, 2014[8]).

Estimation of Odour Concentrations

The Odour Methodology Guideline (DEC 2002) describes the use of the Weber-Fechner relationship between odour concentration and odour intensity as:

$I = m.Log(C) + b$ **Equation 1**

where

I = Intensity as interpreted according to Table 9.

Table 9 Odour Intensity Categories

Odour strength	Intensity level [(a)]
Extremely strong	6
Very strong	5
Strong	4
Distinct	3
Weak	2
Very weak	1
Not perceptible	0

From DEP (2002).

C = Concentration.

m = Slope constant for the odour being assessed.

b = Intercept constant for the odour being assessed – by definition 0.5.

Relevant relationships between odour intensity and concentrations determined using VDI 3882 are shown in Table 10.

[7] See http://www.dec.wa.gov.au/component/docman/doc_download/1011/Itemid,/ accessed 7/5/2014.

[8] Pitt, D, 2014, "Field odour assessments for estimating odour concentrations", Air Quality and Climate Change, Vol 48, No 1, February 2014.

Table 10 Odour intensity and concentration relationships for WWTPs

Source	m	b[(a)]	DOC (ou)
Scrubber Inlet	3.391	0.452	5.6
Aeration	2.492	0.514	9.9
Clarifiers	3.113	0.020	9.1
Solids	3.099	0.984	4.5
Used for this study	2.5	0.5	10.0

Data from Jiang et al 2007.

[(a)] In theory, these should be 0.5 however are slightly different as these values have been determined from actual experimental data.

For this study, the calculation of estimated field odour concentrations assumed m=2.5, b=0.5 giving a DOC of 10 ou, which would lead to the most conservative (highest) resulting concentrations estimated from the odour surveys in view of the values in Table 10.

As mentioned previously, odour concentrations are calculated for each intensity observed over each 10 minute assessment period.

The estimated 10-minute average odour concentration for the assessment period is the arithmetic mean of the 60 calculated, individual, concentrations excluding observations of background or other odours.

A 10 minute period is considered to provide an estimate of the hourly concentration distribution which is at least 80% reliable (VDI 1993).

Field assessment locations

For assessing odour plumes, the key issues to be considered in the selection of specific locations are:

- Position assessors cross-wind to the plume such that the maximum impact at the plume centre-line is able to be determined in view of wind direction horizontal fluctuations.
- Position assessors at a downwind distance from the target source where odour levels are expected to be highest. For low-level, non-buoyant sources, this would normally be as close as possible to the facility boundary; for elevated/buoyant sources, this issue becomes more complex due to the influence of stability on the distance to the maximum downwind ground level impact locality.

Assessor requirements

The general requirements for field assessors are:

- undergo an olfactometry test as recommended by St Croix Sensory Inc (St Croix 2004) to confirm normal sensitivity to odorants – the results were for the two assessors were 11 and 9 which is within the acceptable range of 4 to 12 recommended by St Croix Sensory;
- not to have any pre-existing medical conditions that may be invoked by remote/outdoor work (eg asthma, allergies);
- to maintain appropriate personal hygiene standards;
- not to wear strong perfumes or deodorants; and
- not to have a cold or hay fever or other similar symptoms which may affect their sense of smell.

Field Surveys

Field odour surveys following the general approach in VDI (1993) were undertaken during the afternoons on 31 May 2014 and 7 June 2014.

Weather conditions for both survey days were reasonably similar with moderate winds from around NNE and overcast skies. These conditions are ideal for odour assessments because:

- dispersion is relatively poor and hence downwind odour concentrations should be high; and
- wind direction is consistent enough to identify suitable downwind assessment locations.

Results for 31 May 2014

None of the observed odours were strong enough for the character of the odour to be clearly identified.

Results for 7 June 2014

The odour levels were similarly extremely low. There were just four occurrences out of 1,740 “observations” where an odour was sufficiently strong to be rated as “distinct”.

As far as could be identified, the characters appeared to be variable with descriptions of “river water”, “limey” and “septage”. From previous experience, these could be from WWTP source areas such as clarifiers, aerated treatment and raw influent respectively. It is emphasised that these interpretations are largely speculative given the weakness of the odour strengths and how infrequent the odours were.

The tabulated results for all field assessments are shown in Table 11.

The estimated 10-minute average odour concentrations and wind directions are illustrated in Figure 8 and Figure 9 for 31/5/2014 and 7/6/2014 respectively.

Table 11 Results (percentage odour times) for all field assessments

Location		Date/ Start time	Number of odour "observations" (a)	Percentage odour time (%) (b)	Estimated odour concentration (ou)
GDA94 m East	GDA94 m North				
371364	6389987	31/05/14 11:37	6	0	0.00
371366	6390048	31/05/14 11:40	6	0	0.00
371366	6390120	31/05/14 11:42	6	0	0.00
371385	6390177	31/05/14 11:45	6	0	0.00
371433	6390179	31/05/14 11:47	6	0	0.00
371479	6390181	31/05/14 11:49	6	0	0.00
371528	6390178	31/05/14 11:51	6	0	0.79
371528	6390178	31/05/14 11:54	6	0	0.00
371563	6390258	31/05/14 11:56	6	0	0.00
371657	6390248	31/05/14 12:06	60	0	0.03
371690	6390245	31/05/14 12:18	60	0	0.16
371728	6390223	31/05/14 12:28	60	0	0.18
371728	6390223	31/05/14 13:15	60	0	0.08
371690	6390245	31/05/14 13:27	60	0	0.11
371657	6390248	31/05/14 13:38	60	0	0.52
371619	6390258	31/05/14 13:50	60	0	0.18
371657	6390248	31/05/14 14:02	60	0	0.00
371690	6390245	31/05/14 14:12	60	0	0.00
371728	6390223	31/05/14 14:23	60	0	0.00
371619	6390258	31/05/14 15:23	60	0	0.00
371619	6390258	31/05/14 15:34	60	0	0.00
371657	6390248	31/05/14 15:46	60	0	0.03
371657	6390248	31/05/14 15:57	60	0	0.00
371619	6390258	31/05/14 16:10	60	0	0.00
371619	6390258	31/05/14 16:20	60	0	0.00
371619	6390258	31/05/14 16:30	60	0	0.00
371680	6390248	07/06/14 13:21	60	0	0.41
371680	6390248	07/06/14 13:21	60	0	0.20
371657	6390248	07/06/14 13:35	60	0	0.32
371680	6390248	07/06/14 13:35	60	0	0.15
371619	6390258	07/06/14 13:46	60	0	0.00
371680	6390248	07/06/14 13:48	60	0	0.13
371657	6390248	07/06/14 14:16	60	0	0.18
371603	6390244	07/06/14 14:27	60	0	0.03
371657	6390248	07/06/14 14:30	60	0	0.17
371619	6390258	07/06/14 14:38	60	3	0.36
371657	6390248	07/06/14 14:42	60	2	0.42
371657	6390248	07/06/14 14:54	60	0	0.03
371619	6390258	07/06/14 14:54	60	0	0.29
371619	6390258	07/06/14 15:06	60	2	0.33
371466	6390361	07/06/14 15:12	60	0	0.00

Location		Date/ Start time	Number of odour "observations" [a]	Percentage odour time (%) [b]	Estimated odour concentration (ou)
GDA94 m East	GDA94 m North				
371619	6390258	07/06/14 15:24	60	0	0.03
371657	6390248	07/06/14 16:00	60	0	0.28
371619	6390258	07/06/14 16:01	60	0	0.00
371657	6390248	07/06/14 16:12	60	0	0.17
371603	6390244	07/06/14 16:14	60	0	0.00
371619	6390258	07/06/14 16:24	60	0	0.28
371551	6390260	07/06/14 16:27	60	0	0.00
371619	6390258	07/06/14 16:36	60	0	0.22
371551	6390260	07/06/14 16:37	60	0	0.00
371551	6390260	07/06/14 16:47	60	0	0.00
371619	6390258	07/06/14 16:48	60	0	0.11
371551	6390260	07/06/14 16:57	60	0	0.00
371619	6390258	07/06/14 17:04	60	0	0.38
371551	6390260	07/06/14 17:07	60	0	0.00

[a] Some preliminary assessments of 1 minute were undertaken to indicate the likely downwind extent of odours. These results are not used for model comparisons etc. The absence of any detectable odours during these led to the decision to undertaken the remainder of the assessments at the facility boundary.

[b] Calculated using the protocol in VDI 3940:3. Percentage odour time is simply the frequency (as a percentage) of odours rated as "distinct" or more, attributable to the source being investigated, over the assessment period.

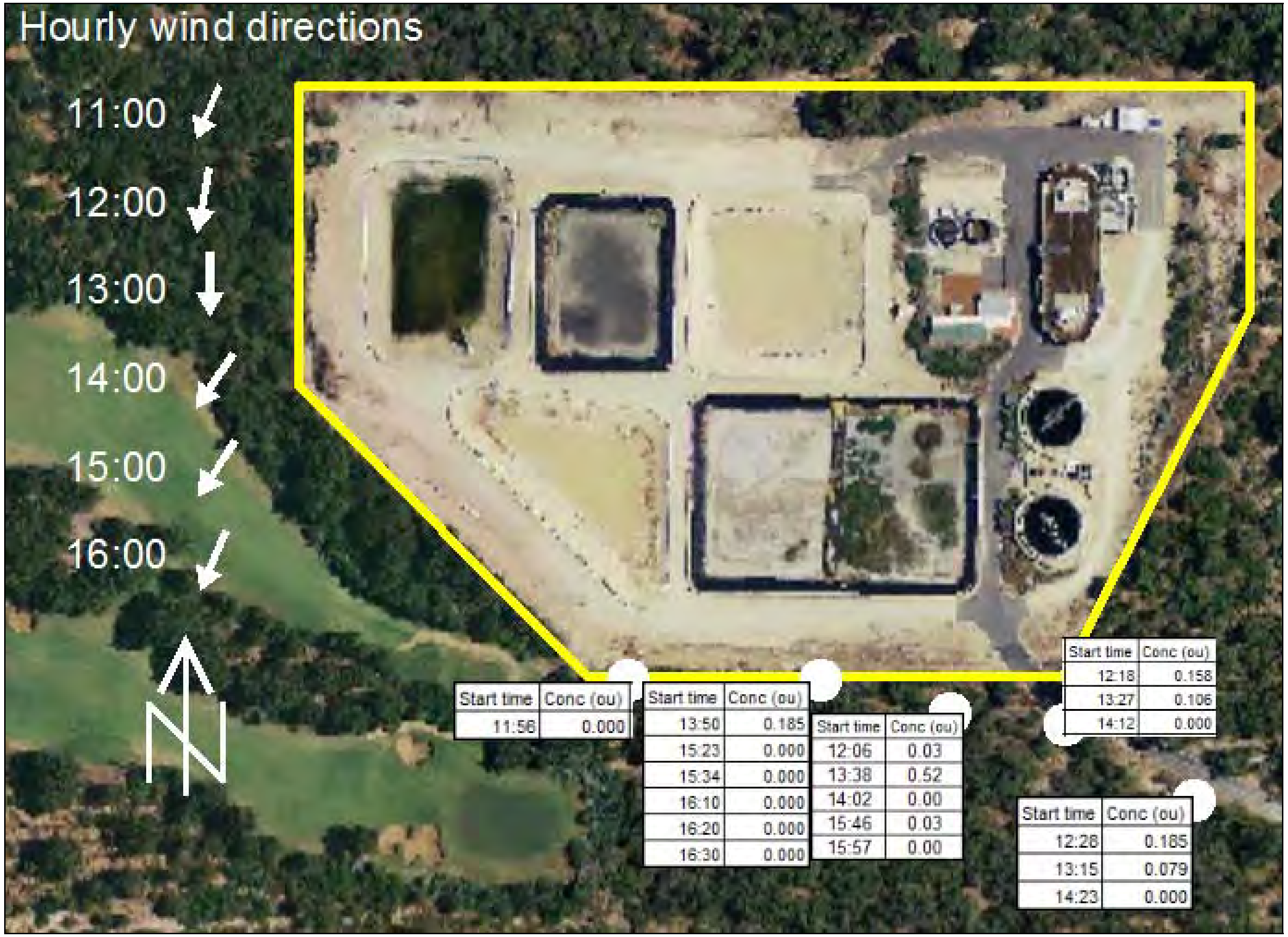

Figure 8 Estimated 10-minute average odour concentrations for each assessment 31/5/2014 and wind directions

Field assessment start times and estimated odour concentrations shown in Tables. BoM Mandurah wind direction arrows shown with 1-hourly start times.

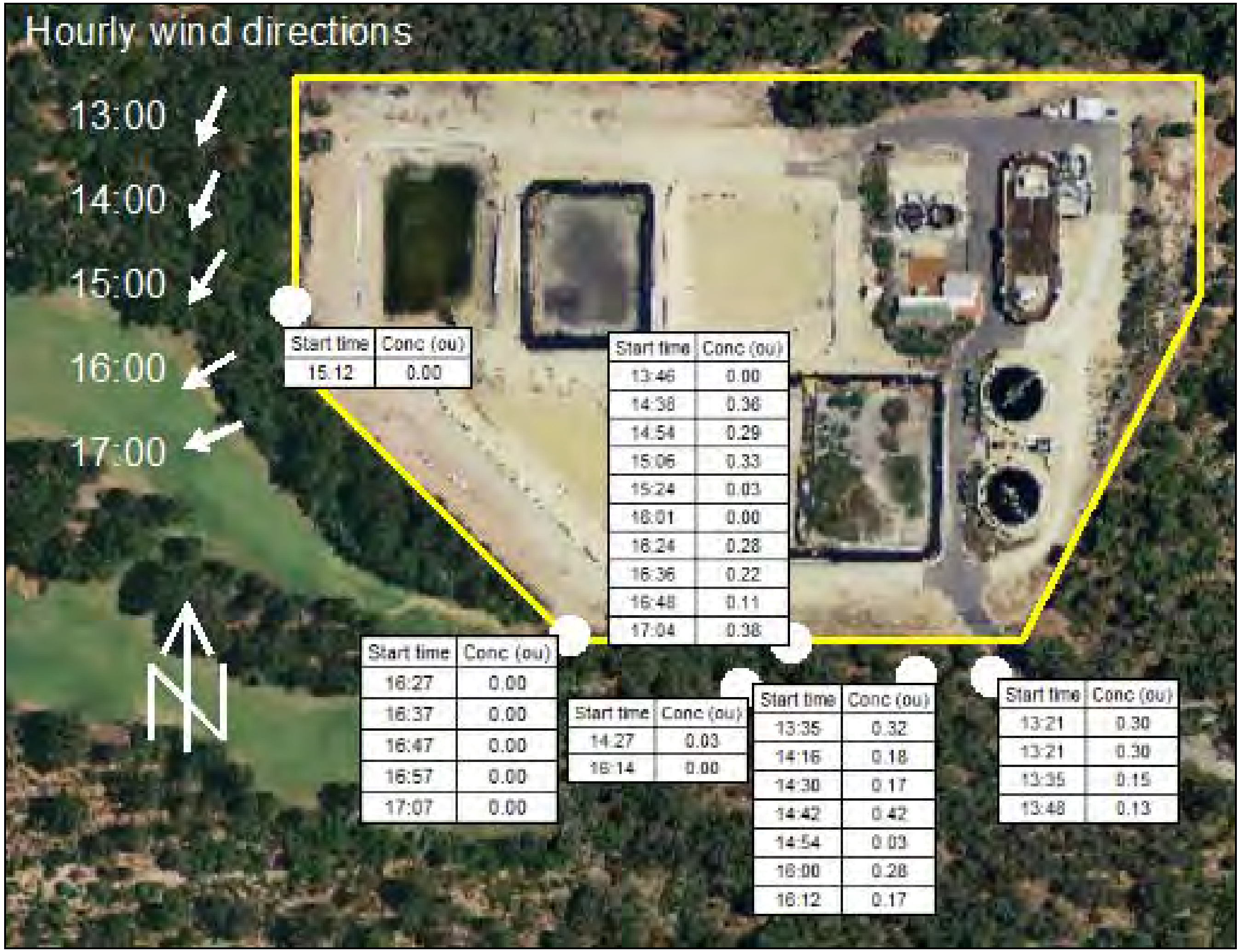

Figure 9 Estimated 10-minute average odour concentrations for each assessment 7/6/2014 and wind directions

Field assessment start times and estimated odour concentrations shown in Tables. BoM Mandurah wind direction arrows shown with 1-hourly start times.