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C2V+

Wigton WwTW Extension

Odour Modelling

September 2018

H&M2018/09/03 r09/11/18

Table of Contents

1 Introduction

H&M Environmental were commissioned by C2V+ to undertake an odour modelling assessment exercise for a new industrial wastewater treatment works (WwTW) to be constructed adjacent to Wigton WwTW, Cumbria. United Utilities own and operate the existing site which currently receives and treats effluents from a local, principally domestic in nature, catchment. A trader, located in Wigton, currently discharges trade effluent via a long pipeline that discharges to the Solway Firth at Raby Cote. This pipeline passes through the existing Wigton WwTW, where there are various facilities for chemical dosing into the trade effluent via a sealed manhole.

In future wastewater treatment will be provided to the trade effluent. This odour modelling assessment considers the intention to intercept the trade waste at Wigton WwTW and provide wastewater treatment in a new facility to be constructed immediately north of the existing Wigton WwTW. A pilot plant operated at the Wigton in 2017 treating a small proportion of the trade waste flow: the results from this pilot exercise were used to assist in the development of the proposals for the full scale trade waste treatment plant.

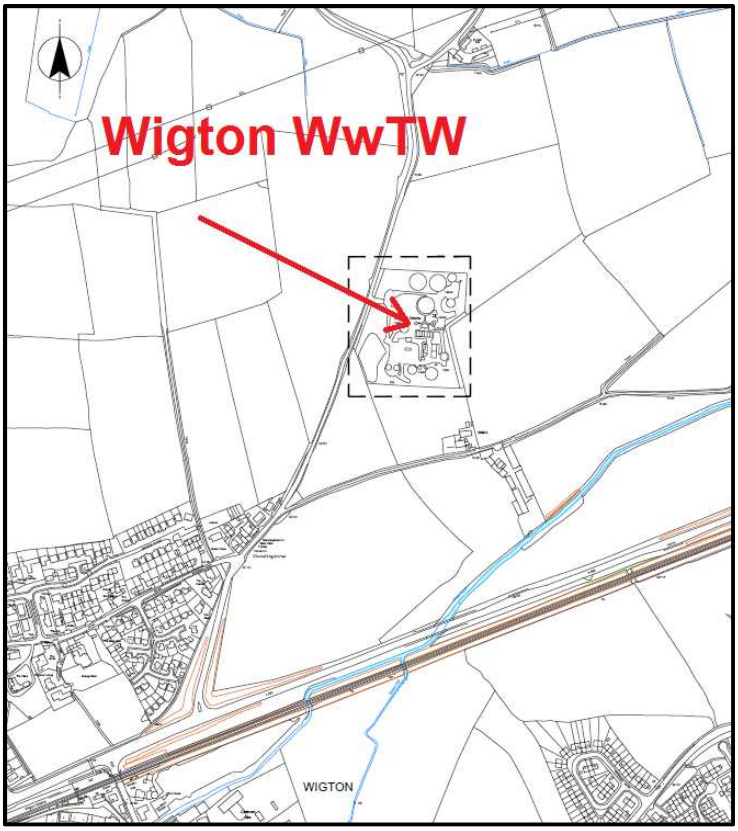
Odour sampling was undertaken in early August 2017, from the pilot plant, to provide indicative odour emission rate data for the new industrial WwTW. The gathered emission rate data has then been employed using predictive odour atmospheric dispersion modelling techniques to quantify odour impact beyond the site boundary.

The modelling exercise is reported below.

1.1 Existing Wigton WwTW Location & Description

The site for the new trade waste WwTW and co-located existing Wigton WwTW is approximately one kilometre to the north, north east of Wigton Town Centre. The immediate surroundings to the site are agricultural with a road running along the west boundary of the site. The A596 is approximately 300m to the south. The nearest properties are the Mains 100m to the south, south east , with further properties within 400m to the south west (Standingstone). The location of the WwTW is shown below as Figure 1.

Figure 1 Site WwTW Location:



There is an existing WwTW that receives and treats municipal flows from Wigton and surrounding communities, immediately to the north of the new WwTW. This is a separate installation and therefore not included within this exercise.

1.2 New Trade Waste WwTW

The new WwTW, to treat the trade waste, will be constructed to the immediate north of the existing WwTW. The layout of the new WwTW is shown below in Figure 2.

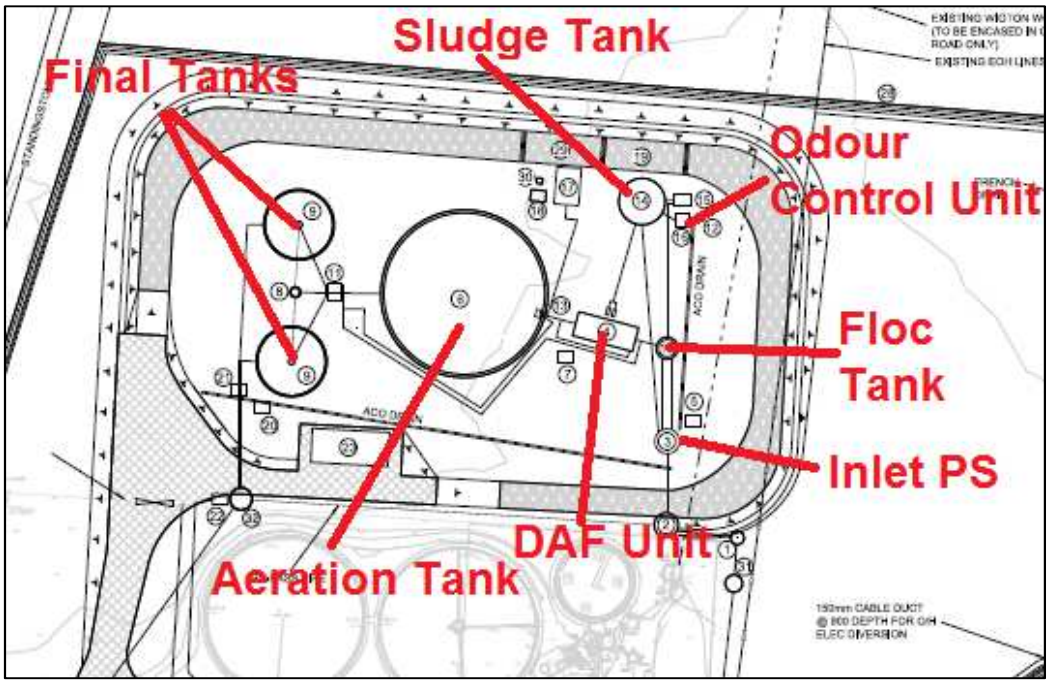


Figure 2: New WwTW Layout

The new WwTW will comprise an inlet pumping station, flocculation tank, DAF unit for solids separation, a surface aerated bioreactors (for biological wastewater treatment), two final settlement tanks, a sludge storage tank and various ancillary plant.

Historically the existing WwTW site is not thought to have been the subject of odour complaints. Within the new WwTW an odour control unit will extract and treat odorous air from the flocculation tank, and the sludge holding tank.

2 Odour Regulation & Assessment

The legislation under which odours are currently controlled in the UK is as follows:

- Environmental Protection Act, (EPA);
- Town & Country Planning Act, (TCPA);
- Environmental Permitting Regulations (EPR) and Industrial Emissions Directive (IED)

Unacceptable levels of odour impact/odour nuisance arising from emissions associated with a municipal wastewater treatment facility fall under the jurisdiction of the Local Authority, whereas odour pollution arising from an installation/facility

operating under Environmental Permitting Regulations (EPR) or Industrial Emissions Directive (IED) fall under the authority of the Environment Agency.

The Environment Agency Document H4 (H4 Odour Management, How to comply with your environmental permit, March 2011) provides guideline values for odour benchmarks based on the 98th percentile of hourly average concentrations of odour modelled over a year at the site/installation boundary. The benchmarks are:

- 1.5 odour units for most offensive odours;
- 3 odour units for moderately offensive odours;
- 6 odour units for less offensive odours.

Further guidance is given with respect to categorising a particular process with respect to one of the above categories:

Most offensive: *processes involving decaying animal or fish remains, processes involving septic effluent or sludge, biological landfill odours.*

Moderately offensive*: intensive livestock rearing, fat frying (food processing), sugar beet processing, well aerated green waste composting*

Less offensive: *brewery, confectionery, coffee roasting, bakery*

For this assessment the criteria considered is a planning condition applicable to the scheme of 1.5 ou_E/m^3 as a 98%ile hourly average applicable at the nearest sensitive receptors (the immediate surroundings to the site comprise agricultural land). This corresponds with the most stringent criterion contained within the EA guidance noted above.

Within the UK there are various key items of regulation that relate to odour. In addition to which there are also several industry Codes of Practices, and associated institutional policy statements that provide guidance on odour exposure/impact and the risk of odour complaints occurring.

2.1 DEFRA

Within the Odour Guidance for Local Authorities issued by DEFRA the following guidance is provided:

“The concentration at which an odour is just detectable to a “typical” human nose is referred to as the “threshold” concentration. This concept of a threshold concentration is the basis of olfactometry in which a quantitative sensory measurement is used to define the concentration of an odour.

Standardised methods for measuring and reporting the detectability or concentration of an odour sample have been defined by a European standard (BSEN 13725:2003). The concentration at which an odour is just detectable by a panel of selected human “sniffers” is defined as the detection threshold and as an odour concentration of 1 European odour unit per cubic metre (1 OU_E/m^3)”

The following guideline values indicate the significance of odour concentrations:

- 1 OU_E/m^3 is the point of detection
- 5 OU_E/m^3 is a faint odour
- 10 OU_E/m^3 is a distinct odour.

An odour at strength of 1 OU_E/m^3 is in reality so weak that it would not normally be detected outside the controlled environment of an odour laboratory by the majority of the population (that is individuals with odour sensitivity in the “normal” range). As an odour becomes more concentrated, then it gradually becomes more “apparent”.

Odour Exposure within the UK is typically assessed against the 98%ile hourly averaged concentration value of odour modelled over a year.

2.2 CIWEM Policy Statement

Excerpt from CIWEM policy Statement

“Given the differing odour impact criteria available, the selection of the most appropriate criterion should be determined by the objective of the assessment (whether this be against a standard of avoidance of nuisance or 'significant pollution') and the nature of the odour under assessment.

It is, therefore, the view of CIWEM that these and other odour impact criteria should be regarded as indicative guidelines and cannot be applied as over-arching statutory numerical standards. CIWEM considers that the following framework is the most reliable that can be defined on the basis of the limited research undertaken in the UK at the time of writing:

- >10 OU_E/m^3 - complaints are highly likely and odour exposure at these levels represents an actionable nuisance;
- >5 OU_E/m^3 - complaints may occur and depending on the sensitivity of the locality and nature of the odour this level may constitute a nuisance;
- <3 OU_E/m^3 - complaints are unlikely to occur and exposure below this level are unlikely to constitute significant pollution or significant detriment to amenity unless the locality is highly sensitive or the odour highly unpleasant in nature.”

2.3 IAQM Guidance

The Institute of Air Quality Management (IAQM) has produced "Guidance on the assessment of odour for planning". The IAQM state that the document has been prepared to assist practitioners primarily involved in odour assessment for planning, and that it is not intended to replace existing guidance produced by the Environment Agency or where a specific assessment method is already provided within existing guidance. However there is potentially nothing preventing Local Authorities/individuals/organisations adopting the criteria for their own purposes.

Within the guidance document, receptors are placed into one of three categories depending on land use, duration of exposure, and the anticipated level of amenity (these are summarised below):

- High Sensitivity – High level of amenity expected, prolonged or continuously present within the area examples include residential dwelling, schools, hospitals;
- Medium Sensitivity – Reasonable level of amenity expected, no prolonged or continuously presence within the area, examples include a place of work, commercial/retail, playing recreational fields;
- Low Sensitivity – no reasonable level of amenity expected or transient exposure, example include farms, industrial, footpaths/roads.

Based upon this categorisation the guidance document goes on to describe the proposed odour effect on the receptors, based on the numerical odour exposure value predicted by modelling. The "effect" descriptors are summarised in the table below which has been copied directly from the IAQM document.

The IAQM guidance on the assessment of odour for planning adopts a risk matrix approach. The combined impact of factors such as receptor sensitivity, risk of exposure, magnitude of exposure and offensiveness of the odour is assessed. The risk of odour exposure, combined with the sensitivity of the receptor is used to assess the magnitude of the impact on the receptor (Table 1).

Table 1: Likely magnitude of odour effect at the receptor location

Risk of Odour Exposure	Receptor Sensitivity		
	Low	Medium	High
High Risk	Slight adverse effect	Moderate adverse effect	Substantial adverse effect
Medium Risk	Negligible Effect	Slight adverse effect	Moderate adverse effect
Low Risk	Negligible Effect	Negligible Effect	Slight adverse effect
Negligible Risk	Negligible Effect	Negligible Effect	Negligible Effect

Alternatively the 98th percentile predicted exposure combined with the receptor sensitivity is used to gauge the odour impact on the receptor (Table 2). This assessment methodology has been used in this report.

Table 2: Proposed odour effect descriptors

Odour Exposure Level C_{98}, ou_E/m^3	Receptor Sensitivity		
	Low	Medium	High
>10	Moderate Adverse	Substantial	Substantial adverse
5-10	Moderate	Moderate	Substantial adverse
3-5	Slight	Moderate	Moderate
1.5-3	Negligible	Slight	Moderate
0.5-1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

2.4 United Utilities Odour Policy

United Utilities acknowledges that high levels of odour arising from wastewater treatment are not acceptable and that reasonable measures must be taken to minimise any inconvenience to the general public. Where possible, asset designs shall reduce the formation and release of odours so that odour control measures are not required. Where odour generation/impact is unavoidable, the foul air shall be contained and treated.

United Utilities does not operate under a single defined odour exposure standard. Each site must be considered individually taking into account the relevant legislation and local authority's conditions, as well as site specific factors such as site history with regard to odour complaints, potential future encroachment by residential or business developments, and the presence of particularly odour sensitive receptors (businesses/activities) within the vicinity of the works/facility

2.5 OIA Assessment Criteria

Proposed planning conditions for the WwTW require that a $1.5ou_E/m^3$ (98 percentile) criterion must not be exceeded at any residential receptors (resulting from odour emissions from the new site) surrounding the WwTW. This therefore has been selected as the criterion for this assessment. As noted above this criterion is also the most stringent H4 guideline value.

2.6 CLASSIFYING AN ODOUR NUISANCE

One of the main problems in controlling odours is in defining what exactly a nuisance odour is. A particular odour can be offensive to one person but not to another or a mixture of non-offensive smells can become an offensive odour. To simplify matters, in this report odours are not defined as good or bad, but simply quantified as odour.

The odour dispersion models used in the production of this report uses this principal, in order to remove personal bias from the results obtained.

3 Dispersion Modelling Exercise

3.1 Modelling Set Up and Protocol

Aermod Version 9.6.1 (a state of the art dispersion model) has been employed. This model is widely used, including for the prediction of odour impact, and was developed by the US EPA, to supersede the ISC3 model, and its use for odour modelling is now generally accepted.

From review of site maps and site visits a source file for the site was constructed, this in simple terms tells the model the geographical location and dimensions of all the sources of odour that need to be considered. The source file also contains odour emission rates for each source; these are discussed in more detail below.

3.2 Receptor File & Terrain Data

The second component is the receptor file; this is a set of graphical coordinates surrounding the site where the model predicts hourly averaged odour concentrations. This study has employed a receptor grid of 2 km by 2 km surrounding the treatment works and consisting of a 100m by 100m grid. A receptor height of 1.5 m has been employed. The surrounding area is undulating, the land rises to the south of the site, and therefore the file generated for the site and surrounding area has employed SRTM1/3 digital terrain data.

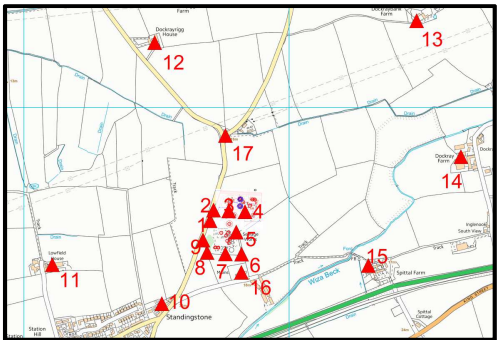
3.3 Sensitive Receptors

Discrete receptors have been included to indicate the locations of key receptors in the surrounding area. These receptors consist of boundary points and surrounding points of public access and are listed in Table 3 below and their location is shown on a map as Figure 3.

Table 3: Sensitive Receptors

№	Location	Easting	Northing
1	Site Gate	325702	549573
2	NW Site Corner	325715	549613
3	N Boundary	325772	549610
4	NE Site Corner	325834	549607
5	E Boundary	325801	549530
6	SE Site Corner	325821	549447
7	S Boundary	325760	549448
8	SW Site Corner	325691	549453
9	W Boundary	325675	549500
10	Properties SW	325520	549260
11	Lowfield House	325107	549407
12	Dockrayrigg House	325493	550245
13	Dockraybank Farm	326481	550328
14	Dockray Farm	326648	549815
15	Spittal Farm	326299	549404
16	Mains	325820	549378
17	Road Junction to N	325760	549895

Figure 3: Sensitive Receptor Locations



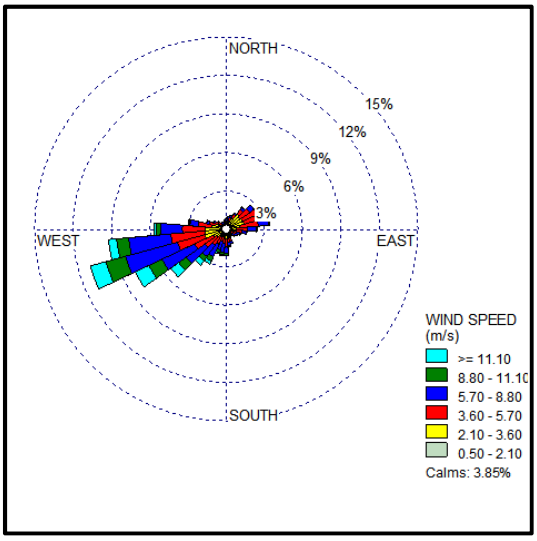
3.4 Meteorological Data

The model requires hourly averaged values for wind speed, wind direction and height of the mixing layer. Unstable conditions are the most favourable for dispersion of odours in the atmosphere. For this project, three years of hourly meteorological data (2014 to 2016) from the Met Station at Carlisle Airport (Crosby on Eden) has been employed and was chosen as this is the closest weather station to the site and located approximately twelve miles West / North West of the site. The local land use around the airport is similar to that around the WwTW site (mixture of pasture land and arable cropping.

The resulting wind rose is shown below. The wind rose indicates the direction from the where the wind blows; that is the winds in the area are predominately from a south westerly direction, with some lighter winds from the east, north east.

The values used for the surface roughness factor used in formatting the raw met data do impact upon the results from the model runs. The surface roughness factor is chosen depending upon land use in the area surrounding the site. For Wigton the site is largely surrounded by hedgerows, pasture and arable land; therefore a surface roughness factor of 0.3 has been employed.

Figure 4: Carlisle Airport Wind Rose 2014 to 16



A screening analysis based upon discrete receptor results from running each of the three met data years individually within the model indicates that the use of 2014 data results in slightly more conservative (slightly higher) predicted odour concentrations at a number of the receptor points. Therefore met data from 2014 has been employed for the remainder of this study. The results of modelling each met data year are given in Table 4 below.

Table 4: Results of screening runs to establish worse case met data year (98 percentile results).

		2014	2015	2016
		ou_E/m^3	ou_E/m^3	ou_E/m^3
1	Site Gate	12.0	10.4	8.8
2	NW Site Corner	17.2	13.8	11.6
3	N Boundary	27.0	26.5	26.2
4	NE Site Corner	16.0	21.1	8.5
5	E Boundary	8.1	5.9	2.9
6	SE Site Corner	1.8	1.6	1.1
7	S Boundary	3.0	2.5	1.4
8	SW Site Corner	6.0	4.3	3.1
9	W Boundary	7.1	6.6	5.7
10	Properties SW	1.1	1.0	1.0
11	Lowfield House	0.5	0.4	0.5
12	Dockrayrigg House	0.2	0.1	0.1
13	Dockraybank Farm	0.2	0.2	0.2
14	Dockray Farm	0.5	0.5	0.4
15	Spittal Farm	0.2	0.4	0.3
16	Mains	1.0	0.8	0.7
17	Road Junction to North	1.5	1.0	0.9

3.5 Building Downwash

Building downwash is the result of airflow over large obstacles, such as buildings, that are close to a point of odour emission. The plume from the odour source enters the wake zone created by the airflow around the building. The wake zone, sometimes called the “cavity”, is a zone on the leeward side of a building that is isolated from the main air stream. Within this zone air recirculates and odour emitted from the stack becomes “trapped”. Therefore both the trajectory and the turbulence of a plume that would normally be expected to disperse odour are likely to be restricted. Odour concentrations immediately downwind of the plume will be greater than without the presence of the building.

Downwash effects have been included within the Raby Cote model (current atmospheric dispersion models only calculate downwash effects for point source) for the following point sources:

- Odour control unit
- Activated sludge process (modelled as nine stacks)

The following building inputs have been employed:

- Sludge tank 7.54m
- Final settlement tanks 4.5m
- Final settlement distribution chamber 4.2m
- DAF unit 5.83m
- Flocculation tank 5.83m

3.6 Odour Emission Rate Estimates

Estimates of odour emission for site were compiled into a source file. The source file tells the model the geographical location and height, physical dimensions and estimated odour emission rate for each source of identified odour emission. The input emission rates are as per Table 5 below.

The odour emission rates are derived from odour sampling undertook at the site in August 2017. At this time a pilot plant was operating to treat the trade effluent. The results of the sampling are contained within a Report (H&M2017/08/03) that details the odour sampling undertaken in August 2017.

The results of the sampling, a combination of hydrogen sulphide (H_2S) data logging and olfactometric sampling (where samples were collected using a Lindvall hood and submitted for olfactometric analysis in accordance with BSEN13725) indicate that at times the trade waste effluent arriving at the site was odorous.

The emission rate calculated for the pilot plant activated sludge process was $61ou_E/m^2/s$; this is the geomean of the three samples taken from the pilot bioreactor plant. The odour emission rate for the DAF unit is based upon the measured value for the pilot plant primary tank. The odour emission rate for the sludge holding tanks is based upon the highest result of the three samples taken from the bioreactors. To mitigate the impact of times when the influent will be odorous, the scheme designers have designed a scheme where by the process that returns activated sludge to the influent wastewater will be enhanced, by mixing, aeration and retention within the flocculation tank, to promote a reduction in odour emission. Based on these provisions, a conservative reduction in odour emissions from the activated sludge of 25% (from the Geomean value of $61ou_E/m^2/s$) is assumed. This equates to a specific odour emission rate of $45.75ou_E/m^2/s$.

Emissions from the final tanks and final tank distribution have been pro-rated from the activated sludge plant emissions (ASP) on the same ratio measured elsewhere for the difference in odour emission between surface aerated activated processes and final tanks; most notably ASP 2 at Davyhulme WwTW, Manchester. Emissions for the inlet pumping station (PS) are as per the value measured for the pilot plant primary tank. The value for the DAF unit is as per the inlet PS, but assuming a 25% reduction as the DAF unit is downstream of the flocculation tank (the operation of the flocculation tank will be enhanced to achieve odour reduction).

Table 5: Raby Cote WwTW Emission Data

Source	Surface	Release	Emission	Fugitive rate		Percentage
	Area	Height	Specific		Source	Total Emission
	m^2	m	$ou_E/m^2/s$		ou_E/s	%
Source						
Inlet PS	9.6	0.55	106	106	1018	3.4
Floculation Tank	9.2	5.83	106	0	975	0
DAF	6.8	5.83	106	79.5	541	0.02
ASP	550	6.32	61	45.75	25163	85.1
FST (x2)	194	4.5	16	16	3104	10.5
FST Distribution	9.2	4.2	16	16	147	0.5
OCU	-	11	$1000ou_E/m^3$	-	417	0.5
Total					31364	100

Notes:

- All sources are assumed to have a base level (finished ground level) of 16m AOD.
- The trade effluent is warm, and therefore an emission temperature of 30°C has been assumed. To facilitate the modelling of an above ambient temperature for the ASP emissions the ASP has been modelled as nine stacks, within the footprint of the ASP tank, each with an emission of $2{,}796ou_E/s$ and a nominal emission velocity of $0.36m^3/s$.
- The odour control unit will serve the sludge holding tank and the flocculation tank. The scheme designers have advised that the OCU will be rated at a volumetric flow rate of $1{,}500m^3/hr$ ($0.417m^3/s$). It is assumed that the outlet odour concentration from the OCU will not exceed $1{,}000ou_E/m^3$.
- The model has been run with a rural dispersion coefficient.

3.7 Sources not included in dispersion model

This model does not consider any odour emissions from the existing Wigton WwTW.

3.8 Varying Odour Emissions

For many wastewater treatment works a winter emission multiplier of 0.5 is typically applied. However, this multiplier has not been applied to the Raby Cote model: that is the model assumes that emissions do not decrease during the winter months. This is because the trade waste effluent is less likely to be affected by ambient weather conditions than domestic wastewaters.

The model assumes that all processes will operate 24 hours a day, seven days a week.

4 Results & Interpretation

4.1 Interpretation – General

The results of the modelling are presented in the form of contours, (lines connecting equal frequency of occurrence) for $1.5ou_E/m^3$ (and above) as 98 percentiles.

The maximum ground level concentrations from which the contours have been determined are based upon the meteorological data from Carlisle and the emissions from the sources included within the models. Thus, the contours do not necessarily represent an average condition, but indicate the worst-case possible for the area surrounding the site as defined by the 2014 Carlisle meteorological data. The shape of the contours is determined by the emission rate, height and location of odour source, topography of the locality and the prevalent meteorological conditions over the model run time. The predicted ground level concentrations are above background concentrations and only relate to odour originating from the sources included within the model.

4.2 Results – Raby Cote WwTW

The results for the model are presented graphically as Figures 5 (All Sources) & 6 (ASP Only). The predicted 98 percentile odour concentrations at each of the discrete receptor locations, for the model run, are given below in Table 6. As the

ASP contributes 85% of the total emissions, the predicted sensitive receptor results for the ASP emissions only are also given.

Table 6: Sensitive Receptor 98 percentile results, Carlisle 2014 Met Data

		All Sources	ASP
		ou_E/m^3	ou_E/m^3
1	Site Gate	12.0	7.3
2	NW Site Corner	17.2	10.7
3	N Boundary	27.1	24.5
4	NE Site Corner	16.0	6.6
5	E Boundary	8.2	2.8
6	SE Site Corner	1.9	0.9
7	S Boundary	3.0	1.6
8	SW Site Corner	6.1	3.8
9	W Boundary	7.1	4.8
10	Properties SW	1.1	0.8
11	Lowfield House	0.5	0.4
12	Dockrayrigg House	0.2	0.1
13	Dockraybank Farm	0.2	0.2
14	Dockray Farm	0.5	0.4
15	Spittal Farm	0.2	0.2
16	Mains	1.0	0.6
17	Road Junction to North	1.5	1.0

Figure 5 indicates that $1.5ou_E/m^3$ (98%) is not predicted to occur at any of the sensitive receptor locations (residential properties). Note: the buildings to the north of the WwTW are an electricity sub-station. It follows that none of the sensitive receptor locations are predicted to be exposed to the 3, 5 and $10ou_E/m^3$ odour bench mark concentrations.

4.3 Conclusions

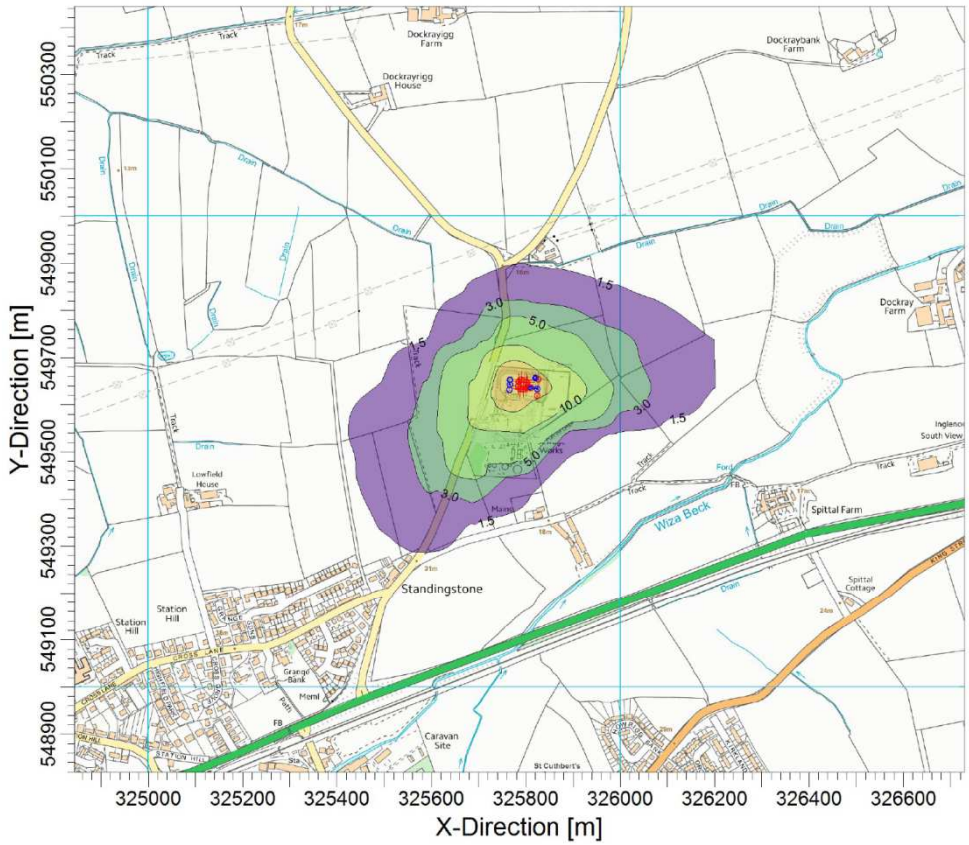
From the results of the modelling exercise, based upon odour sampling undertaken at the trade effluent treatment pilot plant in July/August 2017, the following conclusions are made:

- Although the odour sampling exercise (reported as H&M2017/08/03) indicated that the trade effluent, upon arrival at the site, can at times be odorous, no residential property (sensitive receptor) is predicted to be exposed to odour concentrations of $1.5ou_E/m^3$ (98%) or above as a consequence of the future operation of the trade waste WwTW.

- Emissions from the new activated sludge process (ASP) are predicted to constitute 85% of the total emission from the new WwTW: largely as a result of the large surface area of the process. Therefore the scheme designers have designed enhanced odour control measures into the return activated sludge return at the flocculation to reduce odour emissions from the site processes.

4.4 Figure 5: Predicted Results for All Sources: Carlisle 2014 Met Data

PROJECT TITLE:
Future Raby Cote WwTW
All Sources - OCU1500m3/hr



PLOT FILE OF 98.00TH PERCENTILE 1-HR VALUES FOR SOURCE GROUP: ALL OU/M**3

Max: 37.7 [OU/M**3] at (325794.99, 549637.41)

1.5 | 3.0 | 5.0 | 10.0 | 20.0 | 50.0 | 75.0

COMMENTS: Contours generated from 98percentile values Carlisle Met Data 2014	SOURCES: **16**	COMPANY NAME: **C2V+**	
	RECEPTORS: **458**	MODELER:	
	OUTPUT TYPE: **Concentration**	SCALE: 1:12,000 0 0.4 km	
	MAX: **37.7 OU/M**3**	DATE: **06/11/2018**	PROJECT NO.:

4.5 Figure 5: Predicted Results for ASP Emissions Only: Carlisle 2014 Met Data