Odour Impact Assessment - United Utilities Water Limited, Blackburn

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Executive summary

Blackburn Wastewater Treatment Works (WwTW) operated by United Utilities Water Limited (hereafter 'UU'), is located to the northwest of Blackburn within the Borough of Blackburn with Darwen.

Jacobs UK Limited (hereafter 'Jacobs') has carried out an Odour Impact Assessment (OIA) on behalf of UU to support an environmental permit application and assesses the potential impact of odour emissions from the on-site odour control units (OCUs) at the Blackburn WwTW, making comparison against the odour criteria of 1.5 ou_E/m^3 to demonstrate compliance.

The results indicate that the maximum predicted 1-hour mean (98th percentile) odour concentration at the assessed sensitive receptors is less than 0.1 ou_E/m^3, which is below the H4 odour benchmark for the most offensive odours of 1.5 ou_E/m^3. It should be noted 0.09 ou_E/m^3 predicted at R7 is less than 10% of the benchmark and emissions from the site could roughly increase by 90% without exceeding 1.5 ou_E/m^3. Therefore, applying an emission limit value of 1,000 ou_E/m^3 may be overly conservative and result in unnecessary replacement of odour control media (with associated impact of carbon emissions/footprint /utilisation of raw materials.

Based on the above assessment, it is concluded that the operation of the assessed OCUs is acceptable from an odour perspective.

Contents

Executive summary ..... **i**

1. Introduction **3**

1.1 Odour Regulation and Assessment 3

1.2 Objectives of the report 4

2. Odour Modelling **5**

2.1 Modelling software 5

2.2 Model limitations 5

3. Model Input Data **6**

3.1 Modelled receptor locations 6

3.2 Odour Sources 7

3.3 Modelled operational hours 9

3.4 Surface characteristics 9

3.5 Meteorological data 10

3.6 Output 10

4. Results **11**

5. Conclusion **13**

6. References **14**

Appendices

Appendix A. Meteorological Data – Wind roses **15**

Appendix B. Modelled results **17**

Appendix C. Figures **19**

Tables

Table 1. Modelled receptors **6**

Table 2. Point source odour parameters and emission rates **8**

Table 3. Building parameters **10**

Table 4. Predicted odour concentrations **11**

Table B-1. Full modelled results **17**

1. Introduction

Blackburn Wastewater Treatment Works (WwTW), operated by United Utilities Water Limited (hereafter 'UU'), is located to the northwest of Blackburn within the Borough of Blackburn with Darwen. The area surrounding the site comprises of farmland and strips of woodland, residential properties / farmsteads, commercial and light industrial land use.

Jacobs UK Limited (hereafter 'Jacobs') has carried out an Odour Impact Assessment (OIA) on behalf of UU to support the environmental permit application (and assesses the potential impact of odour emissions from the three on-site odour control units (OCU) at the Blackburn WwTW, making comparison against the relevant odour standards to demonstrate compliance.

1.1 Odour Regulation and Assessment

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

- Environmental Protection Act (EPA);
- Town and Country Planning Act;
- Environmental Permitting Regulations; and
- Industrial Emissions Directive.

Unacceptable levels of odour impact/odour nuisance arising from emissions associated with a WwTW fall under the jurisdiction of the Local Authority, whereas odour pollution arising from an installation/facility operating under Environmental Permitting Regulations or Industrial Emissions Directive fall under the authority of the Environment Agency.

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 Practice and associated institutional policy statements that provide guidance on odour exposure/impact and the risk of odour complaints occurring.

Odour Guidance for Local Authorities as issued by Defra (Defra, 2010) provides the following guidance:

'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 Environment Agency has issued the H4 Odour Management guidance document (Environment Agency, 2011), which covers the regulatory requirements with regard to odour for permitted installations.

1.1.1 Environment Agency H4 guidance

The Environment Agency H4 Odour Management guidance document (Environment Agency, 2011) covers the regulatory requirements with regard to odour for permitted installations or installations that require a permit, and in particular provides benchmark exposure levels with respect to modelling odour exposure at the site boundary or receptors.

The H4 odour benchmarks are based on the of 1-hour mean (98^{th} percentile) odour concentrations over a year at the site boundary.

The benchmarks are:

- 1.5 odour units (i.e. ou_E/m^3) for the most offensive odours such as odours from processes involving decaying animal or fish remains, processes involving septic effluent or sludge or biological landfill odours;
- 3 odour units for moderately offensive odours such as odours from intensive livestock rearing, fat frying, sugar beet processing or well aerated green waste composting; and
- 6 odour units for less offensive odours such as odours from a brewery, confectionary or coffee.

The H4 guidance also states that "*The condition and the benchmarks given in this guidance are based on odour levels at the boundary. If there are no receptors close to the boundary we will normally permit a facility that meets the criteria at the nearest receptor*." As described in more detail in Section 3.1 the closest residential property is approximately 320 m south southeast from OCU stack (A11) and so the assessment is based on the predicted odour concentrations at the identified receptor locations.

1.1.2 Selected Odour Criterion

For this modelling exercise, emissions of odour from the on-site OCUs were assessed against the benchmark level of 1.5 ou_E/m^3 at nearby sensitive receptors as set out in the Environment Agency's (EAs) H4 guidance document.

1.2 Objectives of the report

Odour dispersion modelling has been conducted using ADMS 5.2.4 software to quantify the odour impacts at relevant sensitive receptor locations, surrounding the site. The dispersion model included the site layout buildings and infrastructure (as appropriate), three OCU emission sources and associated odour emission parameters.

The objective of this report is to demonstrate that the operation of the three on-site OCUs are compliant with the H4 odour benchmark.

2. Odour Modelling

2.1 Modelling software

The odour assessment was carried out using an atmospheric dispersion modelling technique. Atmospheric Dispersion Modelling System (ADMS) version 5.2.4 was used to model odour releases. The ADMS model predicts the dispersion of operational emissions from a specific source (e.g. a stack), and the subsequent concentrations over an identified area (e.g. at ground level across a grid of receptor points) or at specified points (e.g. a residential property). ADMS was selected because this model is fit for the purpose of modelling odour emissions from WwTW and is accepted as a suitable assessment tool by local authorities and the Environment Agency.

The modelling assessment was undertaken in accordance with the H4 guidance (Environment Agency, 2011).

A summary of the dispersion modelling procedure is set out below.

1. Information on the odour emission parameters were provided by UU (UU, 2022). Where data gaps were identified, the data used in the model is based on professional judgment.
2. Five years of hourly sequential Numerical Weather Prediction (NWP) data based on the location of Blackburn WwTW and surrounding area (2017 – 2021, inclusive) (ADM Ltd, 2022) was applied in the model. The wind roses are presented in Appendix A.
3. The above information was entered into the dispersion model.
4. The 98th percentile of 1-hour mean odour concentrations were considered at the assessed receptor locations for any of the five years of meteorological data used.
5. The dispersion model was run to provide the odour concentration at the specific receptor locations.
6. The assessment of the modelled results was based on the numerical values outputted by the dispersion model at the specific receptor locations and were processed using Microsoft Excel.

2.2 Model limitations

Any modelling exercise is an approximation of the true behaviours of odours in the environment. It is impossible to account for every variation in atmospheric conditions and still keep the model within the bounds of practicability. The key limitations on the results are as follows.

- Variations considered in the model include the meteorological conditions predicted within the NWP dataset.
- The measured odour emission concentrations are generated from olfactometry studies, which by their nature can have an associated margin of error.
- Results are based on hourly-averaged data. When monitoring, it is possible that odour levels much higher than the average value could occur for short periods of time (i.e. even for a few minutes). If compliance is based on those relatively short duration odour measurements (over a period of minutes), then complaints could be recorded even though the overall hourly averaged data would suggest no exceedance had occurred.

Despite the limitations, dispersion modelling is a useful tool in the prediction of ground level concentrations. The use of dispersion models has been widely used in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

2.2.1 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below:

- to quantify the 1-hour mean (98th percentile) odour concentrations, odour emissions were assumed to be emitted continuously all year (i.e. 8,760 hours each calendar year); and
- the study is based on odour emissions being continuously at the emission rate calculated.

3. Model Input Data

3.1 Modelled receptor locations

Sensitive human receptors have been identified at 14 locations within close proximity to the Blackburn WwTW. These receptors comprise nearby residential properties and a hotel. The modelled receptors are presented in Table 1 and Figure 1 (see **Error! Reference source not found.**).

Table 1. Modelled receptors

Receptor[1]	Co-ordinates		Sensitivity to odour	Distance (km)[2]	Direction[2]	Description
	E	N				
R1	360620	429953	High	0.41	NE	Residential property on Spring Lane
R2	360678	429966	High	0.46	NE	Residential property on Spring Lane
R3	360707	429900	High	0.43	NE	Residential property on Spring Lane
R4	360873	429899	High	0.57	ENE	Residential property on Spring Lane
R5	361039	429686	High	0.67	E	Residential property on Spring Lane
R6	361112	429278	High	0.81	ESE	Residential property off Green Lane
R7	360537	429346	High	0.32	SSE	Residential property off Spring Lane
R8	360439	429096	High	0.53	S	Residential property off Green Lane
R9	360341	428816	High	0.81	S	Residential property on Green Lane
R10	359651	428821	High	1.08	SW	Residential property on Roach Road
R11	359599	429294	High	0.84	WSW	Residential property on Cuerdale Road
R12	359887	429736	High	0.50	WNW	Residential property on Cuerdale Road
R13	359888	429814	High	0.52	WNW	Residential property on Cuerdale Road
R14	360343	430218	High / Medium	0.59	N	Samlesbury Hotel

Note 1: Receptors were modelled at a height of 1.5 m or 'breathing zone'.
Note 2: Based on the geographic location of Stack A11 assessed emission source (National Grid Reference (NGR) E 360375, N 429624)).

3.2 Odour Sources

The locations of the modelled odour sources are presented in Figure 1 (see **Error! Reference source not found.**) and the modelled odour emission parameters are presented in Table 2. Information on the odour emission parameters were supplied by UU (UU, 2022). Information on the main buildings located on-site, which could influence dispersion of odour emissions from the assessed sources were estimated from on-site photography, Defra's environmental open-data applications and datasets (Defra, 2022) and Google Earth (Google Earth, 2022).

Table 2. Point source odour parameters and emission rates

Emission point	Source	Co-ordinates (m)	Stack height (m)	Effective stack diameter (m)[1]	Efflux velocity (m/s)	Design air flow rate (m^3/s)	Temp. (K)	Odour conc (ou_E/m^3)	Odour release rate (ou_E/s)
A10	Unthickened Sludge Tank OCU	E 360343 N 429488	3.50	0.21	15.0	0.528	Ambient	1,000	527.78
A11	EEH Feed Tank OCU	E 360375 N 429624	6.00	0.23	15.0	0.611	Ambient	1,000	611.11
A12	Centrate Buffer Tank OCU	E 360290 N 429529	14.40	0.06	15.0	0.037	Ambient	1,000	36.94

Note 1: An effective stack diameter has been calculated by dividing the design air flow rate by the efflux velocity.

3.3 Modelled operational hours

The assessed emission source was assumed to be in continuous operation (i.e. 24 hours a day, 365 days per year).

3.4 Surface characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes, and hence the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below.

3.4.1 Surface roughness

The surface roughness represents the aerodynamic effects of surface friction. This value is an important parameter used to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and turbulence levels.

The surface roughness is related to the height of surface elements, typically, the surface roughness is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. The higher the surface roughness value used the more mixing and dispersion of odours will occur. As the land use in the modelled domain is a primarily a mixture of farmland, woodland, residential dwellings and light industrial, a surface roughness length of 0.4 m has been applied.

3.4.2 Terrain

Topographical features such as hills can have significant effect on the dispersion of pollutants, generally when the ground level varies by more than 1:10 (i.e., a 100 m change in elevation per 1 km in horizontal distance in the horizontal plane). As the gradient is greater than 1:10 in areas to the south and east of the site, a terrain file has been included in the model.

3.4.3 Buildings

Atmospheric flow is disrupted by aerodynamic forces in the immediate vicinity of buildings. These disruptions generate an area of stagnation behind the structure known as the building cavity region. The flow within this region is highly turbulent and the area beyond the cavity region is known as the building wake, where air turbulence generated by the building gradually decays to background levels. The entire area covered by the cavity region and turbulent wake is known as the building envelope.

The above phenomena can result in a plume being drawn down towards the ground in the building envelope, resulting in elevated ground level concentrations, which is known as building-induced downwash. Generally, buildings that are more than one third of the stack height or are within a distance of 5L (where L is the stack height) from the base of the stack should be included in the model. The structures that have been included within this modelling assessment and are presented in Table 3 and Figure 1 (see **Error! Reference source not found.**).

Table 3. Building parameters

ID	Modelled building shape	Co-ordinates of building centre (m)		Height (m)	Length (m) / Diameter (m)	Width (m)	Angle to north (Deg)
		E	N				
Press House	Rectangular	360303	429524	12.9	41.4	19.3	169
Tank 1	Circular	360358	429459	14.1	13.7	-	-
Tank 2	Circular	360336	429523	10.3	8.7	-	-
Tank 3	Circular	360330	429474	2.6	13.5	-	-
Tank 4	Circular	360346	429479	2.6	13.5	-	-
Building 1	Rectangular	360333	429485	3.5	7.7	5.2	76
Tank 5	Circular	360386	429609	13.6	15.3	-	-

3.5 Meteorological data

The three closest meteorological sites to the Blackburn WwTW are Blackpool, Crosby and Manchester Airport. However, these meteorological sites are 28 km, 42 km and 47 km, respectively, from the Blackburn WwTW and are not considered representative of the likely meteorological conditions experienced at the site and surrounding area.

Therefore, NWP meteorological data for the Blackburn WwTW has been used for this assessment. The NWP meteorological data comprises five years of hourly sequential data (2017 – 2021 inclusive). Wind roses for each year of meteorological data used are set out in Appendix A. A surface roughness value of 0.4 m has been used to represent the site and surrounding area.

3.6 Output

The output of the models was based on the 1-hour mean (98th percentile) odour concentrations. The results presented in this report are based on the highest concentration predicted from any of the five years of meteorological data modelled. The predicted odour concentrations at the assessed receptors for each individual year are presented in Appendix B. As discussed previously, the model output was compared against the benchmark odour concentration of 1.5 ou_E/m^3.

4. Results

Table 4 presents the maximum 1-hour mean (98th percentile) odour concentrations at assessed receptor locations, as a result of odour emissions to air from the Blackburn WwTW for any of the five years of meteorological data used for the assessment.

The full results for each year of meteorological data are provided in Appendix B with an isopleth of the modelled results provided in Figure 2 (see **Error! Reference source not found.**).

Table 4. Predicted odour concentrations

Receptor	Description	Receptor sensitivity	Modelled 1-hour mean (98th percentile) concentrations (ou_E/m^3)
R1	Residential property on Spring Lane	High	0.04
R2	Residential property on Spring Lane	High	0.04
R3	Residential property on Spring Lane	High	0.04
R4	Residential property on Spring Lane	High	0.02
R5	Residential property on Spring Lane	High	0.02
R6	Residential property off Green Lane	High	0.02
R7	Residential property off Spring Lane	High	0.09
R8	Residential property off Green Lane	High	0.02
R9	Residential property on Green Lane	High	0.01
R10	Residential property on Roach Road	High	0.01
R11	Residential property on Cuerdale Road	High	0.01
R12	Residential property on Cuerdale Road	High	0.03
R13	Residential property on Cuerdale Road	High	0.02
R14	Samlesbury Hotel	High / Medium	0.02

The results in Table 4 indicate that the maximum predicted odour concentration at the assessed sensitive receptors is less than 0.1 ou_E/m^3. As discussed in Section 1.1.1, the H4 odour benchmark for the most offensive odours is 1.5 ou_E/m^3.

The maximum predicted 1-hour mean (98th percentile) odour concentration at a high sensitivity receptor is 0.09 ou_E/m^3, which is predicted at R7, representing a residential property off Spring Lane, approximately 240 m southeast of emission source A11.

It should be noted 0.09 ou_E/m^3 is less than 10% of the benchmark and emissions from the site could roughly increase by 90% without exceeding 1.5 ou_E/m^3. Therefore, applying an emission limit value of 1,000 ou_E/m^3 may be overly conservative and result in unnecessary replacement of odour control media (with associated impact of carbon emissions/footprint /utilisation of raw materials.

An isopleth of the odour emission concentrations is presented in Figure 2 (see **Error! Reference source not found.**). It should be noted the predicted concentrations presented in Table 4 are based on the maximum concentrations predicted from any of the five years of meteorological data, whereas the odour isopleth presented in Figure 2 is based on the year in which the maximum odour concentration was predicted at the

assessed high sensitivity receptors (i.e. 2018). The predicted odour concentrations for all years of meteorological data considered in this assessment are shown in Appendix B.

5. Conclusion

Detailed odour dispersion modelling has been undertaken to assess the potential impact of odour emissions from the three on-site OCUs at Blackburn WwTW, making comparison against the odour criteria of 1.5 ou_E/m^3 to demonstrate compliance.

The results indicate that the maximum predicted 1-hour mean (98th percentile) odour concentration at the assessed sensitive receptors is less than 0.1 ou_E/m^3, which is below the H4 odour benchmark for the most offensive odours of 1.5 ou_E/m^3.

R7 is less than 10% of the benchmark and emissions from the site could roughly increase by 90% without exceeding 1.5 ou_E/m^3. Therefore, applying an emission limit value of 1,000 ou_E/m^3 may be overly conservative and result in unnecessary replacement of odour control media (with associated impact of carbon emissions/footprint /utilisation of raw materials.

Based on the above assessment, it is concluded that the operation of the assessed OCUs is acceptable from an odour perspective.

6. References

ADM Ltd (2021). Numerical Weather Prediction meteorological data for Blackburn WwTW 2017-2022 [online] Further information available at: http://www.aboutair.com/met-data.htm.

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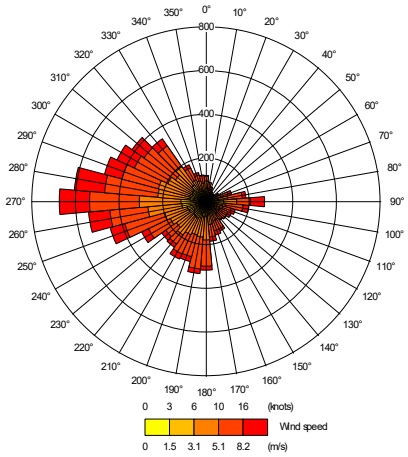
United Utilities Water Limited (UU) (2022). Data and information provided to Jacobs via email communication, October 2022.

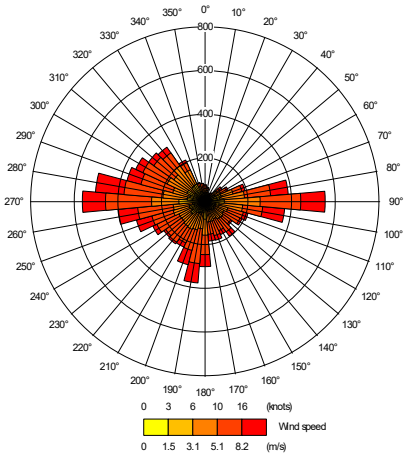
Appendix A. Meteorological Data – Wind roses

The wind roses for each year of meteorological data utilised in the assessment are shown below.

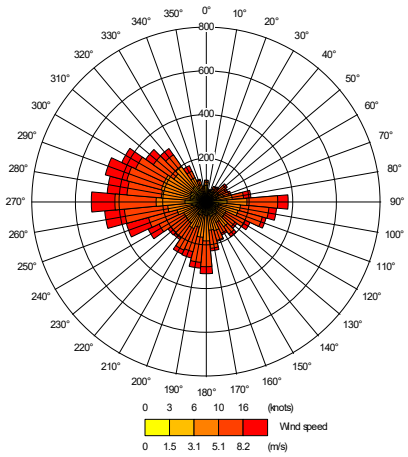
Blackburn NWP meteorological data, 2017



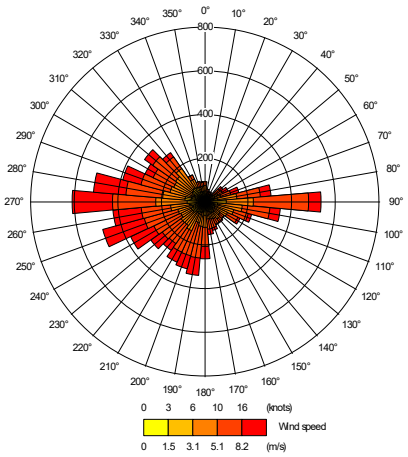
Blackburn NWP meteorological data, 2018



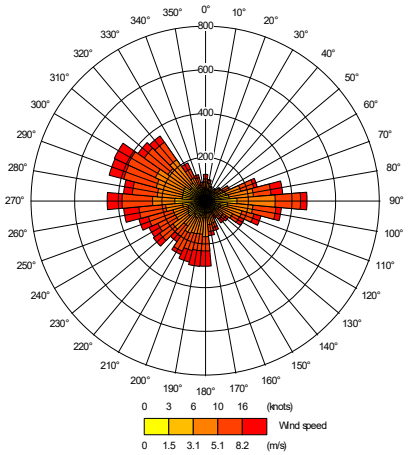
Blackburn NWP meteorological data, 2019



Blackburn NWP meteorological data, 2020



Blackburn NWP meteorological data, 2021



Appendix B. Modelled results

Table B-1. Full modelled results

Receptor	Description	Receptor sensitivity	Modelled 1-hour mean (98th percentile) odour concentrations (ou_E/m^3)					Year resulting in maximum prediction concentration
			2017	2018	2019	2020	2021	
R1	Residential property on Spring Lane	High	0.03	0.03	0.03	0.03	0.04	2021
R2	Residential property on Spring Lane	High	0.03	0.03	0.02	0.03	0.04	2021
R3	Residential property on Spring Lane	High	0.04	0.03	0.03	0.03	0.04	2021
R4	Residential property on Spring Lane	High	0.02	0.02	0.01	0.02	0.02	2021
R5	Residential property on Spring Lane	High	0.02	0.01	0.01	0.01	0.02	2021
R6	Residential property off Green Lane	High	0.02	0.02	0.01	0.01	0.02	2021
R7	Residential property off Spring Lane	High	0.09	0.09	0.07	0.08	0.09	2018
R8	Residential property off Green Lane	High	0.02	0.01	0.01	0.01	0.01	2017
R9	Residential property on Green Lane	High	0.007	0.005	0.006	0.006	0.006	2017
R10	Residential property on Roach Road	High	0.002	0.004	0.006	0.003	0.005	2019
R11	Residential property on Cuerdale Road	High	0.01	0.01	0.01	0.01	0.01	2021
R12	Residential property on Cuerdale Road	High	0.02	0.02	0.02	0.02	0.03	2021
R13	Residential property on Cuerdale Road	High	0.01	0.02	0.02	0.02	0.02	2021

Receptor	Description	Receptor sensitivity	Modelled 1-hour mean (98th percentile) odour concentrations (ou_E/m^3)					Year resulting in maximum prediction concentration
			2017	2018	2019	2020	2021	
R14	Samlesbury Hotel	High / Medium	0.02	0.01	0.01	0.01	0.01	2017

Appendix C. Figures

Figure 1: Approximate site fenceline, modelled emission sources, modelled buildings and sensitive human receptor locations

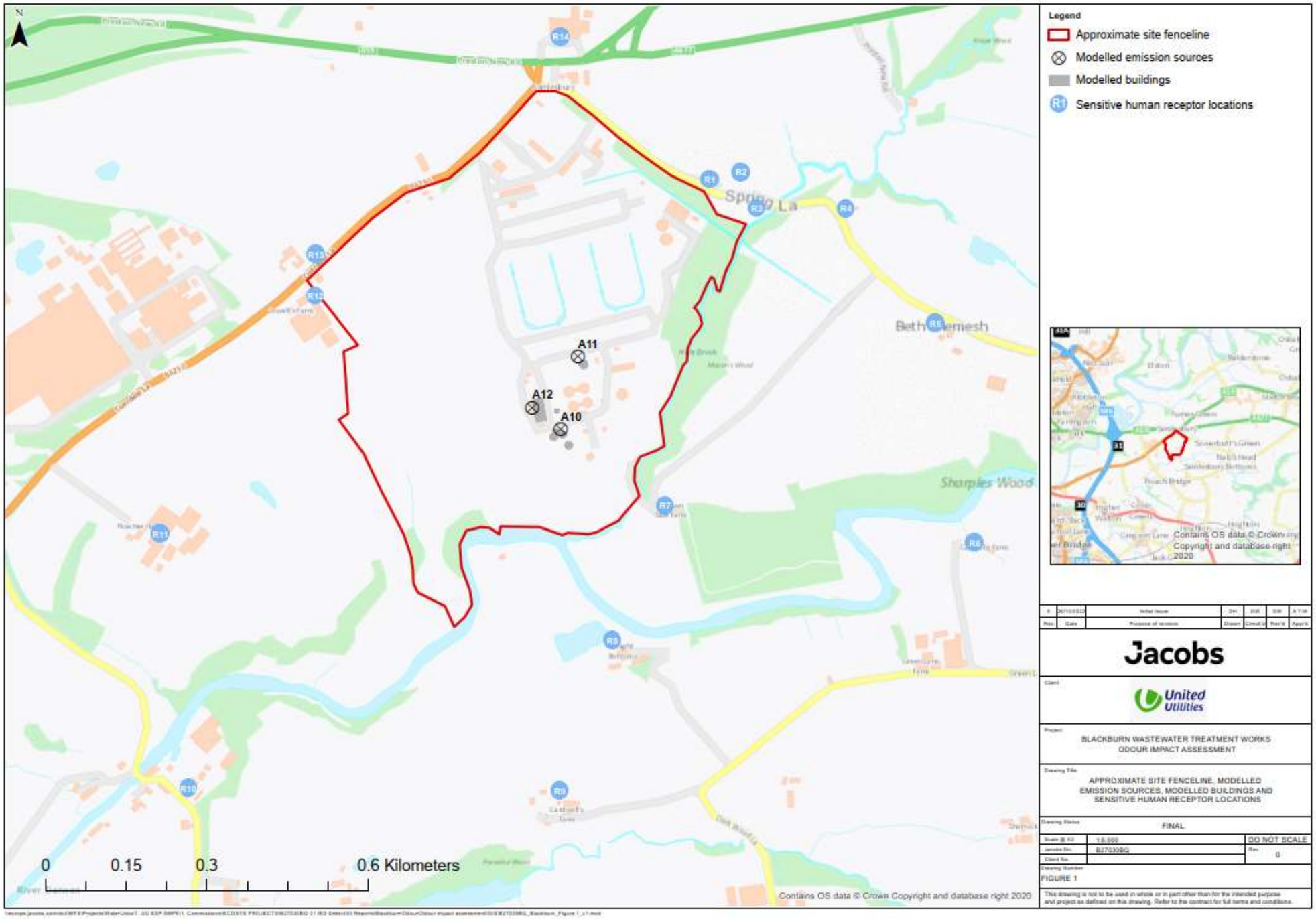


Figure 2: 1-hour mean (98th percentile) odour concentration, 2018 meteorological data