4.7 AIR: ODOUR

4.7.1 INTRODUCTION

TOBIN commissioned OdourNet UK Ltd to undertake an odour impact assessment at Carrick on Shannon Wastewater Treatment Works (WWTW), Co. Leitrim.

This study utilises an odour dispersion model for the works to provide an indication of the current odour impact of the works, in terms of potential community annoyance. This information can be used to aid identification of a suitable design for the upgraded works, once a Design / Build / Operate contractor has been appointed. This report presents the methodology adopted for quantifying the emission from each of the stages of treatment, and the results of the dispersion modelling exercise.

The objectives of the study are as follows:

1. To estimate the emissions from the current operation of the site using emission estimates from previous studies and site specific odour emission measurements collected at the existing works.
2. To predict the likely extent of odour impact in terms of potential community odour annoyance under current operational conditions, using atmospheric dispersion modelling techniques.

4.7.2 GLOSSARY OF TERMS

Appendix 7 contains information on odour sampling and measurement.

$C_{0.98, \text{1-hour}} = x \text{ ouE/m}^3$: A 1-hour average limit concentration of $x$ ouE/m$^3$ as a 98 percentile. The value of the criterion value $x$ is typically determined on the basis of dose effect relationships, relating odour exposure to a probability of annoyance occurring.

emission rate: The rate of odour released from a source. Measured in ouE/s. Emission rate can be calculated from concentration (in ouE/m$^3$) multiplied by volume flow (m$^3$/s)
European Odour unit (OUₚ): That amount of odorant(s) that, when evaporated into 1 cubic metre of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic metre of neutral gas at standard conditions.

European Reference Odour Mass (EROM): The accepted reference value for the European odour unit, equal to a defined mass of a certified reference material. One EROM is equivalent to 123 μg n-butanol (CAS 71-36-3). Evaporated in 1 cubic metre of neutral gas this produces a concentration of 0.040 μmol/mol.

Fugitive Sources: Elusive or difficult to identify sources releasing undefined quantities of odorants e.g. valve and flange leakage, passive ventilation apertures etc.

Odorant: A substance which stimulates a human olfactory system so that an odour is perceived.

Odorous gas: Gas that contains odorants.

Odour: Organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances. [ISO 5492]

Odour concentration: The number of European odour units in a cubic metre of gas at standard conditions.

Note: The odour concentration is not a linear measure for the intensity of an odour. Steven's Law describes the a-linear relation between odour stimulus and its perceived intensity. When using odour concentrations in dispersion modelling, the issue is complicated by the effects of the averaging time of the dispersion model, further complicating the use of the odour concentration as a direct measure for dose. To define a 'no nuisance level', the entire method of dosage evaluation, including the dispersion model, will yield a 'dose'. The relation between this 'dose' and its effect (odour annoyance) should be validated in practical situations to be a useful predictive tool for occurrence of odour nuisance.

Odour unit: One odour unit is the amount of (a mixture of) odorants present in one cubic metre of odorous gas (under standard conditions) at the panel threshold.

Note: See also "European odour unit"

Sample: In the context of this standard, the sample is the odorous gas sample. It is an amount of gas which is assumed to be representative of the gas mass or gas flow under investigation, and which is examined for odour concentration. [ISO 6879]

Specific emission rate (ouE/m²/s): The odorous emission released per surface area per unit time. Measured as ouE/m²/s.
standard conditions for olfactometry: At room temperature (293 K), normal atmospheric pressure (101.3 kPa) on a wet basis [as in ISO 10780].

Note: This applies both to olfactometric measurements and volume flow rates of emissions.

test result: The value of a characteristic obtained by completely carrying out a specific measurement, once.[ISO 5725-part 1]

4.7.3 EXISTING ENVIRONMENT

Carrick on Shannon is the county town of Co. Leitrim. The waste water treatment works (WWTW) is located on the south side of Carrick on Shannon (National Grid co-ordinates N 194800, E 299000).

The town and surrounding area have undergone significant housing development in recent years, and in addition to additional loading attributed to the tourist industry, extra pressure has been placed upon on the existing wastewater collection and treatment infrastructure. The existing wastewater treatment works was designed in the 1970's for 3000 PE. At present the works is overloaded, and receives flows of approximately 4000 PE. Given the projected growth up to 10000 PE by the year 2020, it is now proposed to expand the wastewater treatment works adjacent to the existing site.

The projected hydraulic and BOD loading of the upgraded works is estimated as follows:
Table 4.7.1 - WWTW flow parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Dry Weather flow (up to 2020)</td>
<td>m³/d</td>
<td>1964</td>
</tr>
<tr>
<td>Maximum flow to works (storm event)</td>
<td>l/s</td>
<td>114</td>
</tr>
<tr>
<td>Stormwater holding capacity required</td>
<td>m³</td>
<td>443</td>
</tr>
<tr>
<td>Design BOD load (up to 2020)</td>
<td>kg/d</td>
<td>600</td>
</tr>
<tr>
<td>Design Population Equivalent</td>
<td>PE</td>
<td>10000</td>
</tr>
<tr>
<td>Design Hydraulic Load for Full Treatment</td>
<td>m³/d</td>
<td>5892 (3DWF)</td>
</tr>
</tbody>
</table>

4.7.3.1 METHODOLOGY AND SOURCES OF INFORMATION

The study was divided into two stages as follows:

- Collection of odour emission data from the existing site.
- Assessment of the impact of the works using atmospheric dispersion modelling techniques.

The approach adopted for each stage of the project is described in the following sections.

4.7.3.1.1 Sampling

In order to maximise the confidence in the "odour source file" established for the works, a site specific measurement program was conducted to quantify the magnitude of emissions from the site. This information enabled each of the sources to be positioned within the range established by a large number of studies conducted by OdourNet UK Ltd and increased the confidence of the study for assessing the emissions from the site.

The following methodology was adopted:
Odour samples were collected in accordance with the requirements of the CEN prEN 13725\(^2\) from the principal sources of odour at the existing site. These were:

a. Aeration tank (3 replicates)
b. Settlement tank (3 replicates)
c. Sludge thickening building (3 replicates)

The collected samples were then transported to the OdourNet UK olfactometry laboratory in Bradford on Avon and analysed within 30 hours in accordance with CEN prEN 13725.

4.7.3.1.2 Dispersion Modelling

A predictive model was established of the potential site emissions. The purpose of this modelling was to determine the likely extent of odour annoyance from the site activities.

Using site maps and operational data supplied by the client, the emissions for each process element were estimated, based on the results of site-specific measurements and library data available in the OdourNet knowledge base from previous studies conducted in the UK and abroad, to arrive at a best estimate.

A model of the odour sources associated with the facility was then constructed on a Geographic Information System (GIS). The resultant source file was then used as input for an atmospheric dispersion model along with additional input data, such as hourly meteorological data for a nearby station, and digitised terrain data (topography).

Modelling was then conducted using the Complex-1 atmospheric dispersion model. A description of the input data is presented in section 4.7.3.1.3 below.

The results of the modelling were presented in the form of contours (or isopleths - lines connecting points with equal frequency of occurrence) for a 1-hour average limit concentration of \(x\) ouE/m\(^3\) as a 98 percentile. In short notation: \(C_{98, 1\text{-hour}} = x\) ouE/m\(^3\). The value of the criterion value \(x\) is typically determined on the basis of dose effect.

\(^2\)CEN prEN 13725, Air quality - Determination of odour concentration by dynamic olfactometry, CEN/TC264/WG2 'Odours', 2001
relationships, relating odour exposure to a probability of annoyance occurring. In this study, the following criteria were used:

- 5 \( \mu \text{g} / \text{m}^3 \) - 98-percentile of 1-hour average concentration — Odour annoyance may become an issue for a normal population where this exposure is exceeded.
- 10 \( \mu \text{g} / \text{m}^3 \) - 98-percentile of 1-hour average concentration — Odour annoyance is likely to become an issue for a normal population where this exposure is exceeded.

4.7.3.1.3 Input data used for the dispersion model

**Odour source data**

OdourNet have identified and included all relevant sources in the odour emission model. In addition, account has been made of specific design and operational measures aimed at minimising odour emissions from the plant. These data were used to construct a model of the source emissions providing the input data for odour dispersion modelling.

The site configuration for the proposed works was taken from AutoCAD drawings supplied by the client.

**Meteorological data**

The Complex-1 model requires hourly averaged values for wind speed, wind direction and height of the mixing layer. The mixing layer height enables the atmospheric stability to be classified into one of six Pasquill' categories, ranging from very stable to very unstable. Unstable conditions are the most favourable for dispersion of odours in the atmosphere from ground level sources.

For this study, sequential hourly average meteorological data for the years 1993 to 1995 (inclusive) recorded at Claremorris were used.
4.7.3.1.4 Description of model output.

The key features of the contours produced by the model are as follows:

- The modelling results cannot be assumed to be an exact mirror of reality. The model will be less effective in predicting the actual exposure in a single hour, especially at distances to the source of less than 100 m. The models are more effective in predicting the probability of exposure levels over a large number of hours, such as the data set used for this study.

- The contours represent the area where the maximum hourly average ground level concentration will be greater than $x$ ouE/m$^3$ for more than 2% of the hours in the year.

- The maximum ground level concentrations from which the contours have been determined are based on three years meteorological data. Hence, the contours do not represent the situation at one point in time, but reflect the locations where a certain concentration level is exceeded with a specific probability over the modelling period. To avoid the possibility of bias caused by a 'good' year producing a lower probability of high odour concentrations, the modelling period should cover several years. A minimum of three years is generally considered adequate to be representative of the general conditions in the locality. The shape of the isopleths 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.

- For example, if the model predicts that the 5 ouE/m$^3$ contour is located 100 m from the site boundary to the south of the site, this indicates that the 5 ouE/m$^3$ criterion would be exceeded for more than 2% of the year in this area over the modelling period. The predicted ground level concentrations are above background concentrations and only relate to odour from the site.
4.7.3.1.5 Odour emission estimation

The odour emission rate of specific processes at Carrick on Shannon WwTW were estimated based on the results of the site measurement program and a review of data collected at sewage treatment works of similar loading in the UK. Where directly applicable data for sources was lacking, an analysis of the data contained within the OdourNet emission library was conducted to identify the likely magnitude of emissions from these sources, considering the conditions prevalent at the site.

The samples were taken on a day with unseasonably low ambient temperatures and high rainfall. As such, the emission rates as measured have been increased in order to account for worst-case summer emissions for the purposes of modelling. The factor used is approximately 5, in accordance with previous OdourNet observation. The estimated emission rates applied in this study are presented in the table below:
Table 4.7.2 - Summary of source emission rates

<table>
<thead>
<tr>
<th>Emission source</th>
<th>Specific emission rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet works</td>
<td>30 ouE/m²/s</td>
</tr>
<tr>
<td>Aeration lane</td>
<td>10 ouE/m²/s</td>
</tr>
<tr>
<td>Settlement tank</td>
<td>5 ouE/m²/s</td>
</tr>
<tr>
<td>Sludge cake storage</td>
<td>3600 ouE/m²/s</td>
</tr>
</tbody>
</table>

Assumptions used to determine specific odour emission rates

The following assumptions were used to define the emission rates from the identified sources:

**Inlet Works:** Emissions have been calculated based on a surface area of 4 m² for the inlet channel. With a specific emission rate of 30 ouE/m²/s, this gives an emission of 120 ouE/s.

**Aeration Lane:** Emissions have been calculated based upon a surface area of 640 m². In addition, to reflect the elevated emissions associated with turbulence from the surface aerator, a multiplier of 12 was applied to the specific emission rate over a 20 m² area. The total odour emission rate from the tank was estimated at approx 8600 ouE/s.

**Settlement Tank:** The odour emission rate from this tank was calculated at approx 470 ouE/s. This is based upon an area of 94 m² and a specific emission rate of 5 ouE/m²/s.

**Sludge Cake Storage:** The odour emission rate from the uncovered cake skip was calculated at 1200 ouE/s. This is based upon an area of 18 m² and a specific emission rate of 3600 ouE/m²/s. This emission rate is significantly higher than would be found under normal circumstances. This level has been applied to reflect the poor sludge quality at the works.
4.7.4 IMPACTS OF THE PROPOSED DEVELOPMENT

A single modelling scenario was run to illustrate the likely odour emission under the current situation. Table 4.7.3 below gives the relative total odour emission from the site under this situation as modelled. A summary of the relative share of process components is given in Table 4.6.4 below:

Table 4.7.3 Overview of emissions in four scenarios

<table>
<thead>
<tr>
<th>Situation</th>
<th>Odour emission $10^3$ oue/s (continuous sources, summer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENT (SUMMER CONDITIONS)</td>
<td>13.4</td>
</tr>
</tbody>
</table>

Table 4.7.4 League table of odour sources, summary for the modelled scenario

<table>
<thead>
<tr>
<th>Process Components</th>
<th>Emission $10^3$ oue/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration Lane</td>
<td>8.6</td>
</tr>
<tr>
<td>Cake Skip + deposition</td>
<td>3.6</td>
</tr>
<tr>
<td>Return Activated Sludge (RAS)</td>
<td>0.6</td>
</tr>
<tr>
<td>Settlement Tank</td>
<td>0.5</td>
</tr>
<tr>
<td>Inlet Works</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>13.4</td>
</tr>
</tbody>
</table>

4.7.4.1 ASSUMPTIONS APPLIED IN DISPERSION MODELLING

The following assumptions were applied for each scenario during the odour impact assessment:

- The odour sources are located as indicated in Figure 1724/13
- The emission rates from turbulent sources have been estimated by applying a turbulence multiplier directly to the sum of the specific odour emission rate and the
source area. The multiplier used has been determined based on the nature of the source and according to established research\(^3\).

- Due to the low volume of tanker imports (approximately 1 m\(^3\)/day), this has not been included in the model. This is due to the dispersion model using hourly averaged data over a long period, and therefore not adequately reflecting short-term burst emissions. However, the emptying activity of landfill leachate may have a short-term, localised impact.

- It is assumed that the doors to the belt thickener room are kept closed to minimise fugitive emissions. Concentrations within this building during sampling were found to be low (< 250 ouE/m\(^3\)).

- The presence of open storage containers for dewatered sludge, gives rise to an increased occurrence of short term burst emissions due to the import and export of sludges from the site. This short term burst is not accounted for in the model.

### 4.7.4.2 MODEL OUTPUT

The output of the model was run to establish the frequency of hours in which an hourly average concentration of 5 and 10 ouE/m\(^3\) are exceeded. The concentration at the 98\(^{th}\) percentile or \(C_{98,\text{1-hour}}\) is used as to compare against criteria for exposure.

Figure 1724/13 shows isopleths of odour concentrations of 5 and 10 ouE/m\(^3\) as 98-percentiles for the existing works.

The following criteria have been applied to the modelling results:

- The 5 ouE/m\(^3\) - 98-percentile of 1-hour average concentration contour indicates the area where odour annoyance may become an issue for a normal population where this exposure is exceeded (notation \(C_{98,\text{1-hour}} \leq 5\) ouE/m\(^3\)).

• The 10 oue/m\(^3\) - 98-percentile of 1-hour average concentration contours indicates the area where odour annoyance is likely to become an issue for a normal population where this exposure is exceeded. (notation \(C_{98, \text{1-hour}} \leq 10 \text{ oue/m}^3\)).

This means that the hourly average odour concentration of 5 oue/m\(^3\) will be exceeded during 2% of hours in a year (equivalent to approximately 175 hours in a year). Although this does not give a direct model of odour perception and its frequency, it is a value that has been established on the basis of experience and a number of validation studies.

Figure 1724/13 shows the \(C_{98, \text{1-hour}} 5 \text{ oue/m}^3\) and 10 oue/m\(^3\) isopleths (odour contours) for the current site layout.

4.7.5 MEASURES TO MITIGATE ADVERSE IMPACTS

There are no measures in place to mitigate the odorous emissions from the current works. It is not possible to comment on mitigation methods from any proposed works until the final scheme is chosen, however measures will be put in place to reduce odorous emissions (such as, covering of treatment units; ventilation and treatment of the ventilated air).
4.7.6 CONCLUSIONS/RECOMMENDATIONS

The results of this study prompt the following conclusions:

- The emission from the current works is approximately 13,400 odE/m³. The odour footprint resulting from this emission is likely to impact upon some existing residential properties to the southeast of the site at levels exceeding those which may cause annoyance (represented by C₉₉ 1-hour 5 odE/m³).

- At the current works, some odour may however be perceived at the marina to the west of the works at levels greater than those which may cause annoyance (C₉₉ 1-hour 5 odE/m³) and those likely to cause annoyance (C₉₉ 1-hour 10 odE/m³). There is no exceedence of the level likely to cause annoyance (C₉₉ 1-hour 10 odE/m³) at any identified receptor locations.

- To date, the EPA have not designated guideline criteria for waste water treatment facilities. As such, it is not possible to suggest a criteria to which the redesigned works should adhere. However, it is suggested that the new works should be designed with the aim of not exceeding C₉₉ 1-hour 5 odE/m³ at the boundary of the extended wastewater treatment works site.

- The odour standard of C₉₉ 1-hour 5 odE/m³ which (see Figure 1724/14) must be achieved using Best Available Techniques by the successful Design, Build, Operate contractor. This odour standard is achievable using current technologies. This will result in an improved situation from an odour nuisance viewpoint.
4.7.7 NON-TECHNICAL SUMMARY

TOBIN commissioned OdourNet UK Ltd to undertake an odour impact assessment at Carrick on Shannon Wastewater Treatment Works (WWTW), Co. Leitrim.

This study utilises an odour dispersion model for the works to provide an indication of the current odour impact of the works, in terms of potential community annoyance. This report presents the methodology adopted for quantifying the emission from each of the stages of treatment, and the results of the dispersion modelling exercise.

The objectives of the study are as follows:

- To estimate the emissions from the current operation of the site using emission estimates from previous studies and site specific odour emission measurements collected at the existing works.

- To predict the likely extent of odour impact in terms of potential community odour annoyance under current operational conditions, using atmospheric dispersion modelling techniques.

The study was divided into two stages, collection of odour emission data from the existing site, and assessment of the impact of the works using atmospheric dispersion modelling techniques.

The results of this study prompt the following conclusions:

- The emission from the sources at the current works has been calculated. The odour footprint resulting from this emission is likely to impact upon some residential properties to the southeast of the works at levels exceeding those which may cause annoyance.

- Some odour may however be perceived at the marina to the west of the works at levels greater than those which may cause annoyance and those likely to cause
annoyance. There is no exceedence of the level likely to cause annoyance at any identified receptor locations.

- To date, the EPA have not designated odour guideline criteria for waste water treatment facilities. As such, it is not possible to suggest a criteria to which the redesigned works should adhere. However, it is suggested that the new works should be designed with the aim of not exceeding $C_{98}$ 1-hour 5 ouE/m$^3$ at the boundary of the extended wastewater treatment works site. This must be achieved using Best Available Techniques by the successful Design, Build, Operate contractor. This odour standard is achievable using current technologies. This will result in an improved situation from an odour nuisance viewpoint.
Insert Figure 1724/13