Appendix 7.1. Odour Management Plan

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ODOUR MANAGEMENT PLAN (OMP) FOR PROPOSED MORTARSTOWN WWTP LOCATED IN MORTARSTOWN, CO. CARLOW.

PERFORMED BY ODOUR MONITORING IRELAND ON THE BEHALF OF ATKINS GLOBAL.

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1. Introduction and scope

1.1 Introduction

Following a conversation with Ms. Nerita Venketasen, Atkins Global, Odour Monitoring Ireland Ltd was requested to develop an Odour Management Plan for the proposed waste water treatment facility to be located in Mortarstown, Co. Carlow. An overall odour management procedure is presented and will form an integral part of facility operations in order to ensure the minimisation of odour emissions from the operational facility. The primary of focus for this document includes:

1. Management tools and techniques to provide an integrated approach in odour management throughout the operating facility.
2. Proactive monitoring, maintenance and control of odours in a progressive manner to ensure the minimisation of odours from the operating facility.

Each individual aspect for the monitoring and management of odours will be discussed in detail. *Section 3* will provide a synopsis of the overall approach for the control of odours within the operating facility and risk assessment matrix and management approach to be used at the facility.

This core document will be continually reviewed and updated to ensure continued management of odour emissions from the facility. An overall document management and auditing system for odour management will provide the basis of a quality system for the control of odours from the facility. This will be integrated into the Environmental Management System (EMS) for the operation of the facility.

1.2 Scope of the work

The main aims of the study include:

1. Assessment of monitoring methodologies to be implemented at the operating Waste water Treatment Facility,
2. Assessment of management tools and techniques to provide an integrated approach in odour control and management throughout the operating facility.

2. Odour management plan format

The Odour Management Plan (OMP) is a core document that is intended to detail operational and control measures appropriate to management and control of odour at the site. The format of the OMP should provide sufficient detail to allow operators and maintenance staff to clearly understand the operational procedures for both normal and abnormal conditions.

An Odour Management Plan (OMP) should be prepared for all processes. The OMP should also include sufficient feedback data to allow site management (and regulatory inspectors) to audit site operations. An example of some of the issues to be considered is summarised as follows. More detailed guidance is provided within this document.

- A summary of the site and facility, odour sources and the location of receptors,
- Details of the site management responsibilities and procedures for reporting faults, Identifying maintenance needs, replenishing consumables, complaints procedure,
- Odour critical plant operation and management procedures (e.g. correct use of plant, process, materials; checks on plant performance, maintenance and inspection,
- Operative training and records,
- Housekeeping,
- Maintenance and inspection of plant (both routine and emergency response procedures),
- Spillage and drainage management procedures,
- Record keeping – format, responsibility for completion and location of records,
- Emergency breakdown and incident response planning including responsibilities and mechanisms for liaison with the local authority.
- Public relations and complaint management.
- Overall Standard and emergency Operating procedures for the operating site.

The Odour Management Plan is a living document and should be regularly reviewed and upgraded. It should form the basis of a documented Environmental and Odour Management system for the operating site. The Odour Management System documentation should define the roles of the Plant Operator and staff and sets out templates in relation to the operation of the facility and reporting procedures to be employed. Requirements for the Odour management plan should be implemented throughout out the site with a branched management system implemented in order to share responsibility around the site. The head manager should ensure all works are performed in accordance with the OMP while each supervisor reporting back to the appropriate manager. The OMP will be integrated in the overall Environmental Management System/Performance management system for the site including the EMS.

The operator will develop and implement a detailed odour management plan for the operational plant.

2.1 Site location and facility

The Proposed Development Site extends from the existing Kilkenny Road Pumping Station in the north, along the R448 to the existing location of the Mortarstown Wastewater Treatment Plant (WwTP) in the south. The Proposed Development Site has a total area of 9.392ha (hectares).

The Kilkenny Road Pumping Station is located in the north of the Proposed Development Site, to the south of Carlow Town centre and on the eastern banks of the River Barrow. The existing pumping station compound lies immediately to the west of the R448, which extends to the southeast from Carlow town. Here the Proposed Development Site is located in an urban area, with Carlow IT situated to the east of the R448. The western boundary of this section of the Proposed Development Site is marked by the River Barrow. The existing Kilkenny Road compound comprises of a pumping station, an ESB substation, a control building, a hardstand area and existing overflow pipes to the River Barrow. The existing compound is enclosed by palisade fencing and can be accessed via a locked gate from the R448. It is proposed to decommission the existing pumping station. Elevations in this area of the Proposed Development Site range from ~46 to 49mOD (metres above Ordnance Datum) with land sloping to the southwest, towards the River Barrow.

The Proposed Development Site extends southwards from the Kilkenny Road Pumping station along the R448 for ~750m until it reaches Mortarstown WwTP. A dual rising main is proposed along this section of the Proposed Development Site, connecting the Kilkenny Road Pumping Station in the north to the Mortarstown WwTP in the south. Topography ranges from 47 to 52mOD, rising gently to the south. This area of the Proposed Development Site is bounded by residential developments to the east and vegetated areas to the west along the River Barrow.

The existing Mortarstown WwTP is located in the south of the Proposed Development Site. The existing WwTP is located ~2.2km south of Carlow town on the eastern banks of the River Barrow. This WwTP serves Carlow town and its environs. Mortarstown WwTP is bounded by Carlow Institute of Further Education to the south; the River Barrow to the west and residential developments to the north The existing WwTP is accessible from the L4038 in the east via a remotely operated security gate. The existing works are enclosed with palisade fencing. The existing WwTP compound comprises administration buildings, air blowers , settlement tanks, stormwater storage tanks, sludge tanks, dewatering buildings and secondary treatment tanks. An area of poor agricultural land lies within the Proposed Development Site to the west of the existing treatment works and is currently being used for sheep grazing. The Proposed Development Site extends to the west of the R448, where the existing WwTP outfalls to the River Barrow. Ground elevations in this area of the Proposed Development Site range from ~48 to 53mOD (metres above Ordnance Datum) with land sloping to the west, towards the River Barrow.

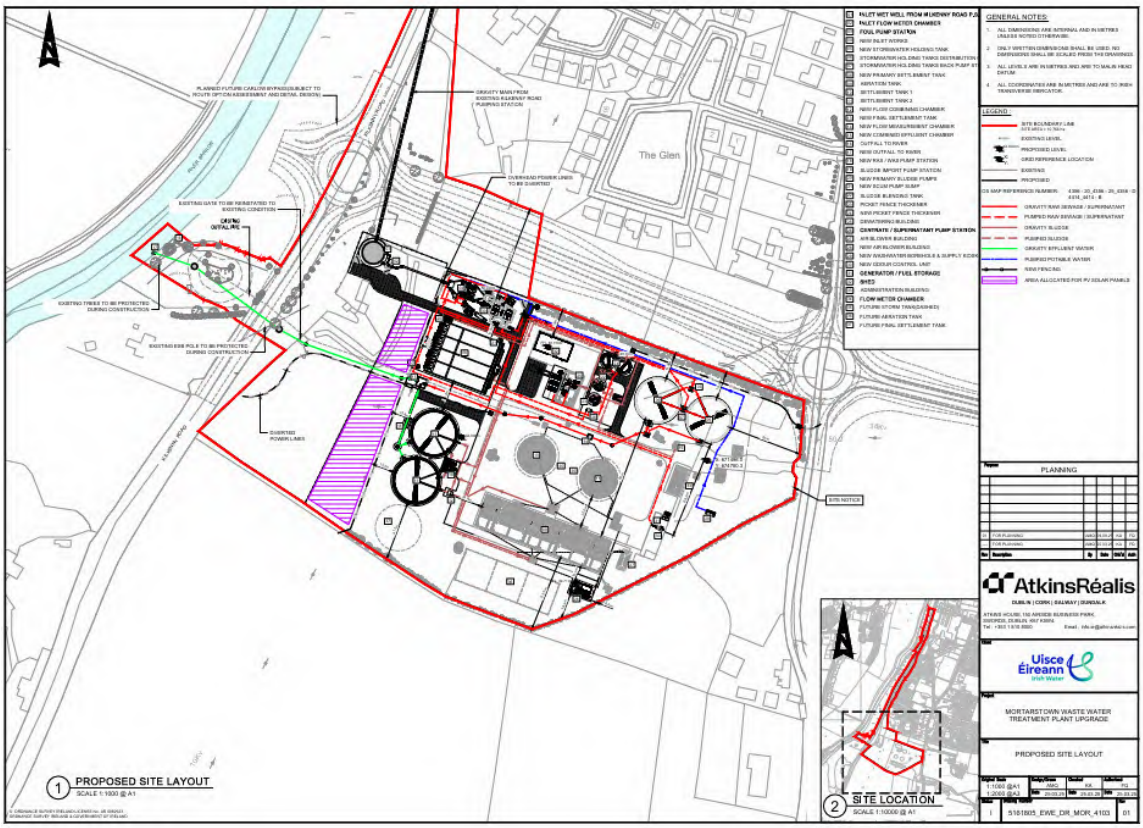

Figure 2.1. Overview of proposed Mortarstown WwTP facility.

2.2 Sensitive receptors

Figure 2.2 and *Table 2.1* illustrates the nearest sensitive receptors in the vicinity of the site. Residents living in proximity to the development can potentially be affected by odours. Twenty seven receptors are identified in the assessment.

A total of 27 sensitive receptors were chosen and these locations are used for the completion of an AG5 ambient air odour survey as deemed necessary. If any odour complaints are registered beyond these sensitive receptors, these are also included in the survey, if deemed necessary.

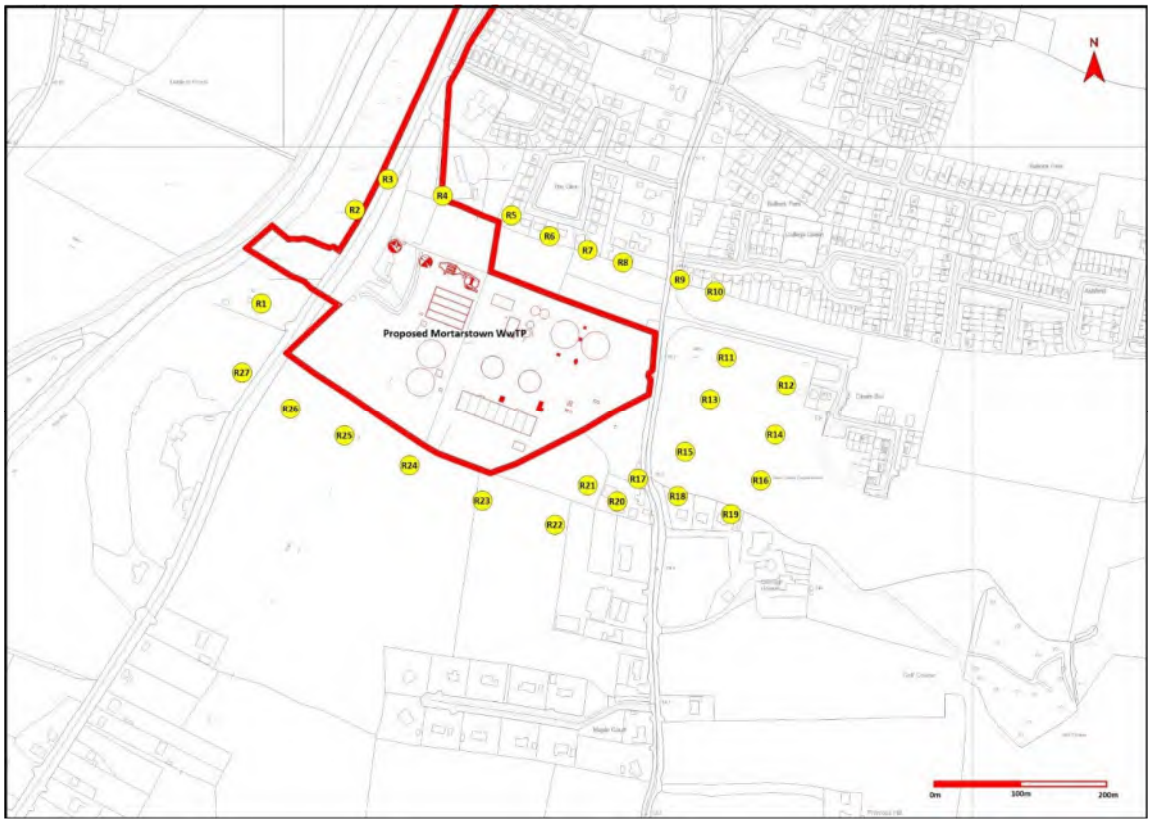

Figure 2.2. Sensitive receptor's locations in the vicinity of the facility.

Table 2.1. Residential sensitive receptors in the vicinity of subject site.

Receptor Identity	X Coordinate (m)	Y Coordinate (m)
R1	671109	674858
R2	671218	674967
R3	671256	675002
R4	671320	674983
R5	671400	674961
R6	671444	674936
R7	671488	674920
R8	671529	674906
R9	671595	674886
R10	671636	674872
R11	671649	674795
R12	671719	674763
R13	671630	674747
R14	671706	674705
R15	671601	674685
R16	671689	674652
R17	671546	674654
R18	671593	674634
R19	671654	674613
R20	671522	674628
R21	671488	674646
R22	671450	674601
R23	671366	674628
R24	671281	674669
R25	671206	674704
R26	671143	674735
R27	671087	674778

The Irish EPA define **Odour-sensitive -** Any dwelling house, hotel or hostel, health building, educational location establishment, place of worship or entertainment, or any other premises or area of high amenity which for its proper enjoyment requires the absence of odour at nuisance levels.

2.3 Typical performance requirements pertaining to odours for operational sites

Uisce Eireann detail odour specifications which operators of the WwTP are require to meet. This normally states that All sensitive receptors at or beyond the boundary of the WwTP will perceive an odour concentration less than or equal to 3.0 OuE/m3 for the 98th percentile of hourly averages for the worst case meteorological year for five years of screen data. This standard applies if all preliminary treatment / inlet works process and all sludge handling and processing activities as enclosed and negatively ventilated to an odour control system. If these activities are not enclosed, contained and maintained under negative extraction to an odour control system, then All sensitive receptors at or beyond the boundary of the WwTP will perceive an odour concentration less than or equal to 1.50 OuE/m3 for the 98th percentile of hourly averages for the worst case meteorological year for five years of screen data. All odour control systems shall achieve a minimum performance criterion whereby all exhaust odours shall be less than or equal to 500 OuE/m3 on the discharge exhaust stack.

Typically for EPA regulated sites, the odour control system performance criteria would be verified by using an ISO17025 accredited contractor for Odour and Flow who would test the odour control systems for Odour and Treatment volume in accordance with EN13725:2022 and EN16911:2013.

2.4 Odour Impact Assessment / Investigation using onsite expertise

Odour reporting form (sniff testing)

As a part of an investigation into a complaint and/or routine surveys to verify the site performance, the odour reporting form outlines the basis for what would expect to be completed;

Routine assessments can be used to build up a picture of the impact the odour has on the surrounding environment over time.

The company can develop ‘worst case’ scenarios by doing assessments during adverse weather conditions or during particularly odorous cycles of an operation.

The same methodology should be used to follow up complaints. Points of note in relation to odour assessments:

- Staff normally exposed to the odours may not be able to detect or reasonably judge the intensity of odours off-site. It may be better to use office staff or people who have not recently been working on the site to do this (e.g. the treatment plant operator may be used to the WwTP odour and therefore may not detect it off site to the extent that a local resident might);
- Anyone who has a cold, sinusitis or a sore throat, is likely to underestimate the odours;
- To improve (or to check) data quality, get two people to do the test independently at the same time intermittently;
- Those doing the assessment should avoid strong food or drinks, including coffee, for at least half an hour beforehand. They should also avoid strongly scented toiletries and deodorisers in the vehicle used during the assessment.

The location to test will vary depending on:

- Whether the company is responding to a complaint;
- Whether the company is checking a state of compliance at sensitive receptors;
- Whether the company is trying to establish the source of an odour;
- Wind direction.

The assessment may involve someone walking along a (pre) selected route due to the above factors, or in response to the conditions found on arrival.

Another option is to choose fixed points to evaluate the changing situation over several weeks or months (i.e. use a fixed number of locations out of the 27 defines receptors in Table 2.1 and Figure 2.2 (consider 12 to 14 fixed locations with 3 upwind and 9 to 11 downwind).

Or the test points may vary from test to test according to local conditions, which would help identify worst case conditions. Keep a note of any external activities (such as agricultural practices) that could be either be the source of the odour, contribute to the odour, or be a confounding factor. An odour will become diluted and may change character as this happens.

2.5 Operational Guidance

It is good practice required to have a notice board with contact details at the entrance to the site. These contact details should be used for logging odour complaints with experienced personnel available to answer calls during normal working hours;

A phone number should be available outside of normal working hours with a follow up call made as soon as possible to the caller by an appointed person;

The staff personnel taking the call should request the information as outlined in *Appendix II and III* of this plan including details on:

- Time, date and where the odour was detected;
- Duration of the odour;
- How strong is the odour;
- Describe the odour. The accuracy and consistency in reporting odour character can be achieved through the use of the odour wheel presented in *Figures 7.1 and 7.2*.

- The staff personnel should record any other relevant aspects of the call including the responses made to the complainant;
- The staff personnel should immediately arrange for a company representative to undertake an odour impact assessment in line with AG5 (*see Figure 2.3 and 2.4*). The survey should commence upwind from the facility with a visit to the location of the detected odour also undertaken to verify the nature of the odour;
- If the nature of the odour can be linked to the facility, the company should undertake a site audit to identify the source of the odour;
- Once identified, the odour source should be investigated to determine whether there has been an operational failure or a failure of an abatement system with steps implemented to rectify the problem;
- In the event that the odour source cannot be serviced / rectified immediately, it may be necessary to cease operations until the issue is resolved;
- Where no odour is detected by the company representative at the location of the complainant, the complaint should not be dismissed out of hand. Odour detection can be transitory whilst the company representative may have a higher odour threshold compared to the complainant. The odour complainant should complete the odour complainant diary sheet (*see Table 2.2*).
- A site audit should be undertaken in any case to confirm or otherwise the source of odour release. Once the odour investigation is completed, the company should follow up to brief the complainant as to the outcome of the investigation.

Odour Impact Assessment Guidance for EPA Licensed Sites (AG5)

Odour Investigation Field Record Sheet

General	**Licensee / Facility**	**EPA Reg. No.**	**Assessment by**	**Date of Inspection**	**Type of visit**
					O Announced O Unannounced

Pre - Assessment Preparation	Observer is free from medical conditions (cold, sore throat, sinus trouble)?		Observer abstinence (30 min) from smoking, flavoured drinks, scented toiletries and deodorisers?		Reason for odour assessment:		Map – Has a map showing assessment locations been attached?		Possible odour related incident (spillage, breakdown of abatement system, power failure.)	
	O Yes	O No	O Yes	O No	O Routine visit	O Other:	O Yes	O No	O Yes	O No

Notes (the ranking system in these notes must be used when completing the field observations table overleaf)

Note 1: Observation point sensitivity

1. Remote (no housing, commercal/industrial premises or public area within 500m of observation point)
2. Low sensitivity (no housing, commercial/industrial premises or public area within 100m of observation point)
3. Moderate sensitivity (housing, commercial/industrial premises or public area within 100m of observation point)
4. High sensitivity (housing, commercial/industrial premises or public area within area of observation point)
5. Extra sensitive (complaints arising from residents, business and users of public areas within area of observation point)

Note 2: Wind strength

0.	Calm	Smoke rises vertically
1.	Light air	Direction of wind shown by smoke drift, but not wind vanes
2.	Light breeze	Wind felt on face; leaves rustle, ordinary vane moved by wind
3.	Gentle Breeze	Leaves and small twigs in constant motion
4.	Moderate Breeze	Raises dust and loose paper; small branches are moved
5.	Fresh Breeze	Smal trees in leaf begin to sway
6.	Strong Breeze	Large branches in motion; umbrellas used with difficulty against the wind
7.	Near Gale	Whole trees in motion; inconvenience felt when walking against the wind
8.	Gale	Twigs break off trees; progress generally impeded
9.	Strong Gale	Slight structural damage occurs (chimney pots and slates removed)

Note 3: Weather conditions

Precipitation
1. Dry
2. Rained recently
3. Drizzle
4. Raining
5. Foggy

Temperature
1. Cold
2. Cool
3. Warm
4. Hot

Note 4: Odour Persistence

0. No Odour
1. Intermittent (detected intermittently during the period of assessment)
2. Persistent (detected throughout the period of assessment)

Note 5: Odour Intensity

0. No Detectable Odour
1. Faint Odour (barely detectable, need to stand still and inhale facing into wind)
2. Moderate Odour (easily detectable while walking and breathing normally, possibly offensive)
3. Strong Odour (bearable but offensive- might make clothes / hair smell)
4. Very Strong Odour (unbearable, difficult to remain in area affected by odour)

Time: From to		Do any of the odours experienced on-site match those recorded during the survey?	O Yes O No
List areas inspected to match odour	What processes were occurring during the off-site odour assessment?	Potential on-site odour sources identified	

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Figure 2.3 Odour investigation field record sheet Page 1.

Odour Impact Assessment Guidance for EPA Licensed Sites (AG5)

	Observer's Location			Wind			Weather		Time		Odour rating		General comments and odour description comments
Parameter	Map Location No.	Name of household / commercial site (easily identified)	Sensitivity (1-5)**Note 1**	**Direction** from which wind blows	**Orientation** (Observer vs facility)	Strength (0-9)**Note 2**	Precipitation (1-5)**Note 3**	Temperature (1-4)**Note 3**	**Start Time** 24h clock	**End Time** 24h clock	Odour Persistence (0-2)**Note 4**	Odour Intensity (0-4)**Note 5**	Description of any odours, other than source of odours, etc.
Thresholds (may indicate nuisance)	--		≥3	--	Downwind Approx DW, or Not detectable	--	--	--	--	--	1 or 2	≥2	**Guide**: A location where the score meets or exceeds all the threshold values may be deemed subject to nuisance/significant impairment, particularly if the observations are supported by public complaints on impact, frequency and duration of odours.
Field Observations					Upwind				:	:			
									:	:			
									:	:			
									:	:			
									:	:			
									:	:			
									:	:			
									:	:			
									:	:			
									:	:			
Brief details of any meeting with last/complaints received during assessment (include name, address, telephone numbers, etc.)													

Figure 2.4 Odour investigation field record sheet Page 2

Table 2.2. Odour diary form (for complainant to fill in).

Odour Diary – To be used along with Facility complaints form – See Appendix V						Sheet No
Name: Telephone Number:	Address:					
Date of odour:						
Time of odour:						
Location of odour, if not at above address:						
Weather conditions (dry, rain, fog, snow etc):						
Temperature (very warm, warm, mild, cold or degrees if known):						
Wind strength (none, light, steady, strong, gusting):						
Wind direction (e.g. from NE):						
What does it smell like? How unpleasant is it? Do you consider this smell offensive?						
Intensity – How strong was it? (see below 1-5):						
How long did go on for? (time):						
Was it constant or intermittent in this period:						
What do believe the source/cause to be?						
Any actions taken or other comments:						

Intensity (Detectability)
1 No detectable odour
2 Faint odour (barely detectable, need to stand still and inhale facing into the wind)
3 Moderate odour (odour easily detected while walking & breathing normally)
4 Strong odour
5 Very strong odour (possibly causing nausea depending on the type of odour

2.7 Description of Inputs

Figure 2.5 illustrates the process flow for the proposed Waste water treatment plant.

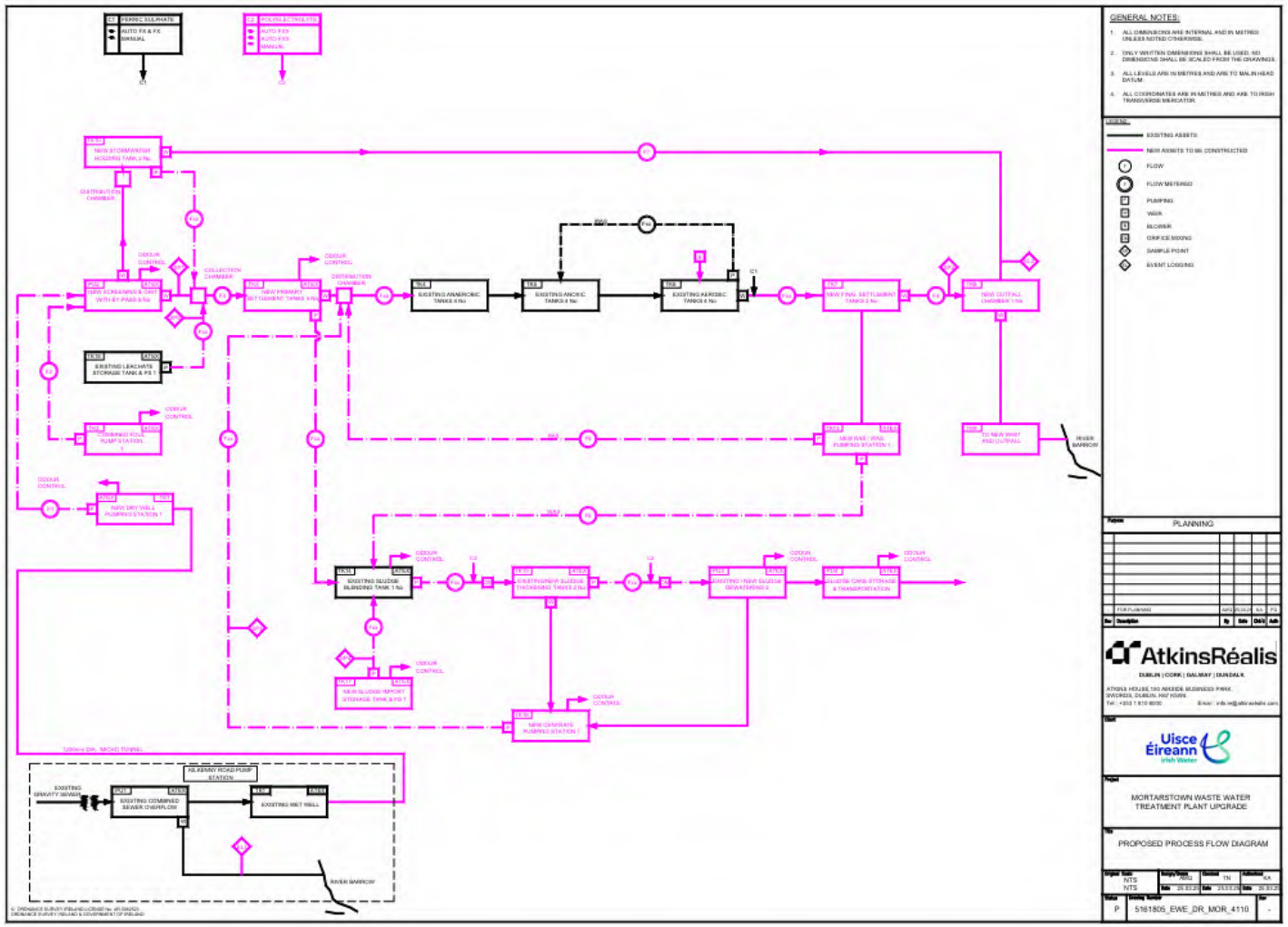


Figure 2.5. Waste water treatment process flow.

2.8 Odour Sources

The main odour sources the will be located in Mortarstown Waste water treatment plant include open tankage and Odour control unit stacks. Odour sources located within the WwTP would be considered offensive in nature.

The following sources are identified during the desktop audit of the site with a defined offensive odour.

Table 2.3. Identified Odour Sources on the Waste water treatment plant.

Location	Frequency	Intensity	Duration	Offensiveness
New Pumping Station	Continuous / High Risk	Strong	Continuous	Unpleasant
New Inlet Works	Continuous / High Risk	Strong	Continuous	Unpleasant
New Stormwater holding tanks	Intermittent / Low Risk	Weak	Continuous	Unpleasant
New Primary Settlement Tank	Continuous / High Risk	Strong	Continuous	Unpleasant
Aeration Tanks	Continuous / Low Risk	Weak	Continuous	Unpleasant
Anoxic / Anaerobic tank	Continuous / Medium Risk	Medium	Continuous	Unpleasant
New Final Clarifiers	Continuous / Low Risk	Weak	Continuous	Unpleasant
Sludge Blending Tank	Continuous / High Risk	Strong	Continuous	Unpleasant
Picket Fence Thickener - 1	Continuous / High Risk	Strong	Continuous	Unpleasant
Picket Fence Thickener - 2	Continuous / High Risk	Strong	Continuous	Unpleasant
Sludge Dewatering Building	Continuous / High Risk	Strong	Continuous	Unpleasant
Foul Pump Station	Continuous / High Risk	Strong	Continuous	Unpleasant
Centrate Pump	Continuous / High Risk	Strong	Continuous	Unpleasant
OCU 1 - New WWPS	Continuous / High Risk	Weak	Continuous	No distinct odour
OCU 2 - New Inlet Works	Continuous / High Risk	Weak	Continuous	No distinct odour
OCU 3 - New Primary Settlement Tank	Continuous / High Risk	Weak	Continuous	No distinct odour
OCU 4 - Sludge Dewatering Building	Continuous / High Risk	Weak	Continuous	No distinct odour
OCU 5 - New Local WWPS	Continuous / High Risk	Weak	Continuous	No distinct odour
OCU 6 - Anoxic / Anaerobic / Flow distribution chambers	Continuous / High Risk	Weak	Continuous	No distinct odour

A fugitive odour emission survey was carried out on the existing Waste water Treatment Plant in June 2025. Odour sampling and measurement techniques were utilised in line with EN13725:2022. This was used to inform the expected odour concentration levels for the proposed WwTP.

2.9 Odour sampling

2.9.1 Point sampling

In order to obtain air samples for odour assessment, a static sampling method was used where air samples were collected in 40 to 60 litre pre-conditioned Nalophan^{NA} bags using a vacuum sampling device over a 15/20 minute period. The sampler operates on the 'lung principle', whereby the air is removed from a rigid container around the bag by a battery powered SKC vacuum pump at a rate of 4 *l* min^{-1}. This caused the bag to fill through a stainless steel and PTFE tube whose inlet is placed in source air, with the volume of sample equal to the volume of air evacuated from the rigid container. All odour-sampling bags were pre-conditioned and flushed with odourous air to remove any interference from the sample material.

2.9.2 Area sampling

In order to measure the flux odour emission rate from area odour surfaces located within the Waste Water Treatment Plant, a calibrated wind tunnel method was used. This calibrated sampling hood allowed for the accurate determination of odour emission rate from the surface of the tanks. In combination with the point source static sampling method, a 60-litre sample over a fifteen to twenty-minute period was obtained (Jiang et al., 2002). Area source mass emission rates/flux was presented as $Ou_E/m^2/s^1$.

2.9.3 Olfactometry

Olfactometry using the human sense of smell is the most valid means of measuring odour (Dravniek et al, 1986) and at present is the most commonly used method to measure the concentration of odour in air (Hobbs et al, 1996). Olfactometry is carried out using an instrument called an olfactometer. Three different types of dynamic dilution olfactometers exist:

- Yes/No Olfactometer
- Forced Choice Olfactometer
- Triangular Forced Choice Olfactometer.

In the dynamic dilution olfactometer, the odour is first diluted and is then presented to a panel of screened panellists of no less than four (CEN, 2022) Panellists are previously screened to ensure that they have a normal sense of smell (Casey et al., 2003). According to the CEN standard this screening must be performed using a certified reference gas *n*-butanol. This screening is applied to eliminate anosmia (low sensitivity) and super-noses (high sensitivity). The odour analysis has to be undertaken in a low odour environment such as an air-conditioned odour free laboratory. Analysis should be performed within 30 hours of sampling.

2.9.4 Odour measurement in accordance with the EN13725:2022

An ECOMA TO8 dynamic yes/no olfactometer was used throughout the measurement period to determine the odour threshold concentration of the sample air. The odour threshold concentration is defined as the dilution factor at which 50% of the panel can just detect the odour. Only those panel members who pass screening tests with n-butanol (certified reference gas, CAS 72-36-3) and who adhered to the code of behaviour were selected as panellists for olfactometry measurements (CEN, 2022). Odour measurement was carried out in an odour free laboratory in accordance with EN13725:2022. The analyses were carried out in the laboratory of Odour Monitoring Ireland Ltd in Trim Co. Meath.

2.9.5 What is an odour unit?

The odour concentration of a gaseous sample of odourant is determined by presenting a panel of selected screened human panellists with a sample of odourous air and varying the concentration by diluting with odourless gas, in order to determine the dilution factor at the 50% detection threshold. The Z_{50} value (threshold concentration) is expressed in odour units (Ou_E m^{-3}).

The European odour unit is that amount of odourant(s) that, when evaporated into one cubic metre of neutral gas (nitrogen), 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 meter of neutral gas at standard conditions. One EROM is that mass of a substance (n-butanol) that will elicit the Z_{50} physiological response assessed by an odour panel in accordance with this standard. *N*-Butanol is one such reference standard and is equivalent to 123µg of n-butanol evaporated in one cubic meter of neutral gas at standard conditions (CEN, 2022).

2.9.6 Odour emission rate calculation.

The measurement of the strength of a sample of odourous air is, however, only part of the problem of quantifying odour. Just as pollution from a stack is best quantified by a mass emission rate, the rate of production of an odour is best quantified by the odour emission rate. For a chimney or ventilation stack, this is equal to the odour threshold concentration (Ou_E/m^3) of the discharge air multiplied by its flow-rate (m^3/s^1). It is equal to the volume of air contaminated every second to the threshold odour limit (Ou_E/s^1). For an area odour source, this is equal to the odour emission flux ($Ou_E/m^2/s$) multiplied by the total surface area (m^2) of the odour source to provide an odour emission rate in Ou_E/s.

The odour emission rate is used in conjunction with the dispersion model to generate odour concentration contours for comparison with the proposed guideline limit values for the existing and proposed Waste Water Treatment Facility. It will also estimate the approximate radius of impact for the existing and proposed facility (Hobson et al, 1995).

The overall odour emission rates estimated for the proposed Waste water Treatment Plant are presented in *Table 2.4*.

Table 2.4. Proposed Waste water treatment plant individual source odour concentrations / emission flux.

Source	Enclosed, Covered / Uncovered	Odour threshold conc. (Ou_E/m^3)	Odour emission flux ($Ou_E/m^2/s$)
New Pumping Station	Covered	-	-
New Inlet Works	Covered	-	-
New Stormwater holding tanks	Uncovered / Washdown	-	0.10
New Primary Settlement Tank	Covered	-	-
Aeration Tanks	Uncovered	-	1.50
Anoxic / Anaerobic tank	Covered	-	0
New Final Clarifiers	Uncovered	-	0.15
Sludge Blending Tank	Covered	-	-
Picket Fence Thickener - 1	Covered	-	-
Picket Fence Thickener - 2	Covered	-	-
Sludge Dewatering Building	Covered	-	-
Foul Pump Station	Covered	-	-
Centrate Pump	Covered	-	-
OCU 1 - New WWPS	Covered	<500	-
OCU 2 - New Inlet Works	Covered	<500	-
OCU 3 - New Primary Settlement Tank	Covered	<500	-
OCU 4 - Sludge Dewatering Building	Covered	<500	-
OCU 5 - New Local WWPS	Covered	<500	-
OCU 6 - Anoxic / Anaerobic / Flow distribution chambers	Covered	<500	-

As can be observed in *Table 2.4*, the most significant sources of odour will be the Aeration basins and Odour control units.

Predictive Air dispersion modelling was performed on the proposed design layout the of the WwTP.

With regards to the Proposed WwTP design, the maximum predicted GLC of Odour will be less than the guideline limit value with all receptors in the vicinity of the proposed facility percieving an odour concentration less than or equal to 2.30 OuE/m^3 for the 98^{th} percentile of hourly averages for the worst case met year Oak Park 2020.

3. Methodologies for the control of odours in Waste water Treatment Plant.

3.1 Additional considerations around odour management

- At the planning stage of any new developments, undertaking an upgrade, consideration will be given to locating any potential odorous operations furthest from any nearby residential / sensitive receptors. Consideration will also be given to the prevailing wind and thus to avoid locating any potential odorous activities immediately upwind of sensitive receptors. An SOP should be drafted and included in the EMS folder.

- Truck deliveries or removal of odorous materials should be sealed or enclosed. Truck staging areas should also be situated away from the nearby receptors. Locating truck staging areas near buildings will help to provide a wind break;

- Waste / sludge disposal should be undertaken as soon as feasible particularly if there is a risk of anaerobic conditions occurring;

- Mortarstown WWTP should define a preventative maintenance (PM) schedule for the facility including preparing relevant standard operating procedures (SOPs) for key odour control activities and odour control system. Maintenance should be proactive rather than reactive;

- Good housekeeping of all outdoor areas should be implemented particularly during periods of unfavourable meteorological conditions (for example, decomposition of organic material will accelerate during warmer periods);

- All spills, overflows and leaks should be cleaned up promptly with all operators aware and trained in the relevant SOP for this procedure;

- A waste storage plan should be developed to include minimal storage of odorous materials at the installation;

4. *Appendix I* - Complaints management procedures and recording procedure

It is generally accepted that waste water treatment facilities must deal with odour complaints. A systematic response to odour complaints will minimise the amount of effort spent dealing with the issue and minimise the potential for litigation and other negative outcomes. Odour Monitoring Ireland has significant experience in dealing with odour complaints. As part of an Environmental Management System, a dedicated recording system should be put in place to allow for the analysis of odour complaints. As part of this Environmental Management System, quickly accessible records should be available for odour abatement system controlling odour emissions on site. This allows for the analysis of system upset in conjunction with the receipt of complaint. The odour complaint investigation begins as soon as the complaint is received. Gathering information from the complainant is a crucial step in determining the source of the offending odour. Someone who can understand and act on the information received should immediately handle the investigation, typically a lead operator or plant manager. If they are not available, the person receiving the complaint should be trained and equipped to obtain the appropriate information. It is also important to maintain a professional and compassionate demeanour. The person registering the complaint should know that the issue is being taken seriously and that an investigation will be quickly undertaken. Don't take offence to the complaint and don't be surprised if the complainant is upset, odours can elicit strong emotional responses. The professionalism exhibited by the staff member taking the call can go a long way to calming someone upset by nuisance odours. Information from the complainant should be taken in a systematic process. A pre-prepared form for logging information should be available and used so important information is requested and recorded.

In order to analyse complaints accurate complaints recording should be performed. The most important factors associated with odour complaint recording include:

- Easily contactable phone number or web page for complainant to discuss their respective complaint. A free phone number is preferable. During normal working hours, an experienced person who is familiar with the WWTP process should answer the phone. Only during out of hours should an answer phone be used. The answer phone should clearly state the information required of the complainant. The complainant should always be contacted back if a message is recorded. The least desirable means of receiving a complaint is via an elected official or governing body. If someone has resulted to this method of complaining it probably means one of the methods noted above was not available or easy to work through. No matter what method is used to receive odour complaints, it is important that a system be established to provide prompt feedback.

- Clearly established questions and format of recording in order to isolate the most relevant information. This includes;
- Date and time of complaint (very important)
- Name of complainant,
- Location of complainant,
- Duration of complaint,
- Where they detected the odour,
- How strong the odour is (Intensity on a scale of 0 to 5 where 0 is not perceptible, 1 is very weak, 2 is weak, 3 is distinct, 4 is strong and 5 is very strong)?
- What did the odour smell like-A number of random descriptors should be proposed by the facility representative or offered by the resident (saying that the odour smells bad is not sufficient),
- Details of the responses made to the complainant.

- Continuous monitoring of meteorological data onsite using a met station recording data in accordance with World Meteorological Organization (WMO). Wind speed, wind direction, solar irradiance, barometric pressure, temperature and relative humidity. Minutely data should be recorded including, average, minimum, maximum, standard deviation, and max 3-second gust. The meteorological data for 30 minutes before and after the recorded odour duration should trend and added to the complaint register. Notes regarding precipitation and cloud cover can be used to help with the

understanding of atmospheric stability and odour dispersion. This information will be useful later in the investigation if atmospheric dispersion modelling is used to diagnose odour transport and impact.

- The person responsible for complaint recording if not exposed to odour should visit the complainant location immediately and perform subjective analysis of the immediate area. The most important of these tools are the investigators own nose, eyes and ears. If appropriate (i.e. characteristic rotten fish odour detected), continuous monitors should be put in place at the location. The complainant location should also be geo referenced and relative direction to north from the facility should be calculated and added to the complaint register. Monitoring odours in the field can be a difficult task. The odours detected by the complainant may have significantly or completely abated by the time the investigator arrives on the scene. Brief interaction with the complainant should be performed. It would be inappropriate to accept responsibility for the offending odours at the beginning of an investigation because you haven't determined the odour source. Don't promise to rectify a condition you may not be able to control, only that the odour will be investigated. Additionally, the personnel responsible with field inspections should be familiar with all major odour sources on site including odour characteristics.

- Visual observation of the complaint area is also important and should be recorded. If people are enjoying the area by having picnics or sporting events then the problem is probably not severe. However if people are running from the scene, you may have a significant problem on your hands. A camera is an invaluable tool for recording the scene and conditions of possible odour sources as well as activities ongoing in the vicinity. Photos can record the site where odours were detected in relation to the assumed odour source and record other odour sources that may have contributed to the problem (wastewater facility, rotting vegetation, waste bins, fish unloading, etc.) Photos can be very helpful both during the investigation by helping to focus on probable odour sources and later to recall specific details about the investigation. If it is possible to meet with the complainant, the investigator should gather as much additional information as possible. Details regarding the location where the odour was perceived, over how broad an area (extent) and whether the odour was detected indoors or outdoors should be discussed with the complainant. This will help determine if the odour is coming directly from your system and impacting the neighbourhood or through plumbing roof vent etc. and is impacting only one household. Also, the complainant should be asked if they think the source is strictly the fish production facility or if it is possible that other sources could be the cause or contributing to the odour impact. Often, raising the possibility of other odour sources can lead the complainant to recall other odour sources.

- Complaints should be assessed taking into account the following factors:
- The quality of the complaint (hypersensitive individuals, vexatious complaints, organised campaigns, whether there are other complainants, etc);
- The volume of complaints against the alleged nuisance;
- The frequency of complaints, e.g. is it a one-off event or a regular occurrence?
- Knowledge of potential sources other than the sewage treatment works (tie-up with wind direction from sewage treatment works and complainant, distance of complainant from site).

- The person responsible for complaint recording should contact processes operators/maintenance personnel and record any process anomalies, upsets or maintenance activities that may have led to the release of odours from your system. All data pertaining to abatement plant operation should be assessed in order to isolate any operational issues with abatement plant (this will be dealt with in more detail in *Appendix II*).

- All complainant response procedures should be filed and available for inspection by the relevant regulatory body.

Table 4.1 illustrates a typical odour complaint recording form for use within an Environmental Management System. This will be used in conjunction with the Odour abatement equipment management procedures/system.

Table 4.1. Odour complaint recording form.

Record No.:		**Odour complaint recording form**	
Complainant details			
Complainant name		**Date of complaint**	
Complainant location (grid reference-E & N)		**Time of complaint (24hr clock)**	
Duration of complaint (minutes)		**Type of complaint (i.e. odour, noise,)**	
Name of person logging complaint		**How was complaint received (phone, etc)**	
How long till complainant contacted back (minutes)		**Complainant address:**	
Notes:			

Odour characteristics			
Odour intensity (0 to 5)	**Please tick one**	Odour hedonic tone (0 to 4)	**Please tick one**
No odour (0)		Neutral odour (0)	
Very weak odour (1)		Mildly unpleasant (-1)	
Weak odour (2)		Moderately Unpleasant odour(-2)	
Distinct (they can clearly recognise the odour) (3)		Unpleasant odour (-3)	
Strong odour (4)		Very unpleasant odour (-4)	
Very strong odour (5)			

What did the odour smell like-Descriptor? Please refer to *Appendix III*	
Is the odour fluctuating or constant?	
Is the complainant a resident (R) of commercial receptor (C)?	
Notes:	

Weather condition ***Please append historical records from met station to this record***			
Wind speed (m/s)		**Temperature (^{0}C)**	
Wind direction (from plant to complainant)		**Relative humidity (%)**	
Solar irradiance (W/m^2)		**Cloud cover (0 to 8)**	
Precipitation & Rainfall (mm/m^2)		**Cloud height (low, medium, high)**	
Notes:			

Complaint logging personnel only			
Name of personnel:		**Did you detect an odour?**	
Have you received training (Y/N)		**What did it smell like-Descriptor?**	
How fast was your response time (minutes)		**Distance of odour detection to facility as crow flies (m)**	
Odour Intensity (0 to 5)		**Odour hedonic tone (0 to –4)**	
Is the odour fluctuating?		**Are there any other odour sources in the immediate location**	
Odour plume extent-graphically map odour area using mapping	*Please append to this record*		

Plant operation synopsis ***Please append odour abatement plant overview***			
Fish quantity into plant (tonnes/hr)		**TVN value of influent fish**	
Number of deliveries per hour		**Are there any process upsets (Y/N)**	
Describe upsets			
Are all odour abatement plant operating accordingly	Please refer to *Appendix II* for verification procedure.		
Notes:			

5. *Appendix II*-Odour abatement management system/procedures

Odour abatement/minimisation systems are installed with the aim of mitigating odours from the particular process(s). In some circumstances odour abatement system can become significant sources of odour especially, if sufficient treatment is not being achieved. For example, insufficient treatment could be associated with system failure, poisoning of media, exhaustion of media, insufficient gas removal volume, broken covers, open hatches etc. There is a tendency in many facility environments that when an odour control system is installed it requires very little system checking especially if SCADA controlled. A simple management system incorporated into site operations can significantly reduce the risk of odour control plant failure and also provide a valuable picture for operations and maintenances schedules.

Typical types of odour control technology include:

- Chemical scrubbers,
- Activated carbon polishing,
- Non thermal plasma technology,
- Regenerative thermal oxidation,
- Thermal oxidation through boilers,
- Fixed impermeable covers,
- Extraction ductwork located throughout production facility,
- Chemical addition/dosing to influent waste water
- Air curtains
- Rapid roller doors,

For each of the odour control technologies, an operational verification procedure should be performed from actually visiting each piece of equipment. For sensitive mechanical odour control plant, such as chemical scrubbers, biotrickling filters and biofilters, a daily check should be performed. Small changes in operational parameters could lead to significant emission of odours.

For odour control/minimisation plant such as odour control ductwork, fixed impermeable covers, air curtains, rapid roller doors, etc., which are less susceptible to breakdown, a weekly check should be performed.

All system checks should be document controlled and available for viewing by odour complaints verification personnel, chief maintenance personnel and plant manager. Response/Action plans should be established for system repair where by a repair team trained in the operation and maintenances (O&M) of this specific plant are available to perform dedicated repair. O&M manuals should always be available and a spares inventory should be maintained for essential spares.

Any recording of system performance should be compared to design specification and performance as outlines within a P&ID flow diagrams developed for the built site.

The overall check sheet process should be developed when the plant becomes operational and adapted accordingly to ensure each and every scenario is covered.

Check sheets should be developed for the rapid roller doors, air curtains, accepted fish quality, etc. A raw materials intake procedure and spillage and drain management procedure and check sheet should also be developed.

The implementation of such quality checking procedures will provide both system confidence and preventative maintenance thereby reducing any risk associated with odour control/minimisation equipment and indeed overall emissions.

The frequency and planning of sampling depend on the type of process. When the parameters are expected to develop gradual trends like dry chemical scrubbers and carbon filters rather than sudden changes like chemical scrubbers, the frequency of checking can be low (monthly, biweekly). If the system is more susceptible to cyclic loads, weekly or even daily monitoring may be required, depending on the history and the consequences that may arise

from not realising an issue. More importantly seasonal changes in odour loads on plant and equipment can affect the overall performance of the system and combined with the behaviour of people on the receptor side during changing weather conditions (i.e. warm summer days could result in higher odour loads due to higher metabolic activity of bacteria coupled with people enjoying outdoor activities, etc.). For some processes, continuous monitoring may be useful, especially when the consequences of failure are significant. Risk assessment of plant failure is important to define key operational and maintenance parameters for the odour control unit (OCU). On the basis of this risk assessment measures can be defined to reduce the probability of high consequence events or to mitigate their impact.

The public will remember unscheduled emission episodes with great tenacity. It is therefore important to not fully rely on the environmental performance of odour mitigation under normal operational conditions but also consider them under unscheduled emission events. It is therefore crucial to consider and manage risks of odour emissions during:

- Odour Control Unit (OCU) commissioning,
- Start-up and shutdown of odour abatement units with consideration for duty standby on particularly odour processes (i.e. this has been implemented into the design),
- Management of highly odorous materials
- OCU servicing, and unscheduled shutdown,

In assessing these risks, it must be taken into account that response to odours is almost immediate. In order to manage these odour detection and complaint risks, a number of actions may be considered:

- Plan high-risk activities in periods where receptor sensitivity to annoyance is low like during wet weather when they are indoors, or during colder winter months, or during early morning/late evenings during periods of low atmospheric turbulence, etc.
- Consider providing standby capacity, etc.

If all else fails, inform potentially affected residents of the probability of temporarily increased odours and explain potential benefits due to these increases (i.e. maintenance of OCU, etc.)

6. *Appendix III*-Odour units and descriptors for sniff survey

6.1 Odour Thresholds and Odour Units:

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 (EN 13725). 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 OuE/m^3).

At the detectability threshold, the concentration of an odour is so low that it is not recognisable as any specific odour at all, but the presence of some, very faint, odour can be sensed when the "sample" odour is compared to a clean, odour-free sample of air.

For a simple, single odorous compound (e.g. hydrogen sulphide), the "amount" of odour present in a sample of air can be expressed in terms of ppm, ppb or in mg/m^3 of air. More usually, odours are very complex mixtures of compounds and the concentration of the mixture can be expressed in European odour units per cubic metre (OuE/m^3).

6.2 Odour Unit

An odour unit is a sensory measurement of the concentration of a mixture of odorous compounds in a sample of odour.

The concept of odour concentrations, as odour units per cubic metre, is based on a correlation between a physiological response that is when odour is detected by the nose, and exposure to a particular sample at a specific concentration. The results of this assessment are expressed in terms of a single number. The odour sample assessed can be one of many individual odorous substances or a complex mixture of many substances, and so the odour unit or concentration will vary between test samples. A defined measurement standard for the odour unit is prescribed in a standard method set out in the EN standard on olfactometry using n-butanol (EN 13725). This gas is used to select and "calibrate" odour panel members.

An odour unit is defined by the EN 13725 standard as 1 ouE, a European Odour Unit.

An odour at a strength of 1ouE 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. Some guidance as to concentrations when this occurs can be derived from laboratory measurements of intensity. The following guideline values may help provide some context for discussion about exposure to odours:

- 1 ouE m^{-3} is the point of detection;
- 3 to 5 ouE m^{-3} is a faint odour; and
- 10 ouE m^{-3} is a distinct odour.

However, it is important to realise that these values are based on laboratory measurements and in the general environment other factors affect our sense of odour perception, such as:

- the population is continuously exposed to a wide range of "background" odours at a range of different concentrations, and usually people are unaware of there being any background odours at all due to normal "habituation". Individuals can also develop a "tolerance" to background and other specific odours. In an odour laboratory the determination of detection threshold is undertaken by comparison with non-odorous air, and in carefully controlled, odour-free conditions. Normal background odours such as those from traffic, vegetation, grass mowing's etc, can provide background odour concentrations from 5 to 60 ouE/m^3 or more;

- the recognition threshold, that is the concentration at which a person might be able to recognise or describe a specific odour may be about three odour units per cubic metre, although it might be less for offensive substances or higher if the receptor is less familiar with the odour or distracted by other stimuli; and
- an odour which fluctuates rapidly in concentration is often more noticeable than a steady odour at a low concentration.

6.3 Detection Threshold

The threshold of detection is the concentration at which an odour just becomes strong enough to produce a sensation of odour within the controlled conditions of an odour laboratory. As there is variation in sensitivity between different individuals, the threshold value defined in olfactometry is a statistically derived value that represents an "average" response from 50% of selected odour panellists.

Odours, which are effectively mixtures of odorous compounds are treated in the same way as the n- butanol test gas, in so much as the "strength" is considered in terms of the number of times that a sample of the mixture has to be diluted before it becomes just detectable to 50% of the panel of "sniffers". This concentration is equivalent to one odour unit per cubic metre (1 ouE/m^3). The concentration of the test sample is expressed in terms of the number of dilutions or in odour units per cubic metre. In the past the same value has been expressed as a Threshold Odour Number (TON) or Dilutions To Threshold (DTT).

6.4 Recognition Threshold

The concentration at which an odour becomes recognisable, as a specific odour, is not the same as the concentration at which it is detectable. Whilst the detection threshold is the concentration at which some odour can be sensed, a higher concentration is usually required before the odour can be recognised, i.e. it can be categorised or described by an observer. The recognition threshold is generally about three times the detection threshold, although this factor may be considerably higher outside the controlled environment of a laboratory.

The ability to "discriminate" one odour from another is an important attribute when describing an odour. We rely on being able to discriminate between odours for a whole range of reasons such as fresh and stale food, the addition of flavourings and when determining the source of an odour. This is a human ability to distinguish between odours and is important when needing to identify a source of odour.

6.5 Intensity

The "intensity" of an odour is also relevant. Intensity refers to the perceived strength of an odour when described by a recipient. Low concentrations of some compounds in a sample are capable of being perceived as having a high intensity even when close to threshold concentrations. These compounds are common in naturally unpleasant odours such as hydrogen sulphide (rotten eggs) and skatole (faeces).

Using a scale of very faint to extremely strong, the perceived intensity or magnitude of perception of an odour increases as concentration increases. This relationship is typically logarithmic with concentration.

The scale used by the EPA for defining Odour intensity is as follows:

0 No detectable odour;
1 Faint Odour (barely detectable, need to stand still and inhale facing into the wind);
2 Moderate odour (easily detectable while walking and breathing normally, possibly offensive);
3 Strong Odour (bearable but offensive – might make clothes/ hair smell);
4 Very Strong Odour (unbearable, difficult to remain in area affected by odour).

6.6 Hedonic Tone

Importantly, the hedonic tone (pleasantness or unpleasantness of an odour) can be responsible for the perception leading to complaint.

Here the relative pleasantness or unpleasantness of the odour alongside the association of its source, or the context in which it is received are relevant to investigating odour complaints. This judgement on the relative pleasantness or unpleasantness of an odour forms our common language when reporting unpleasant odours.

Outside of a laboratory setting, this parameter can be subject to substantial variation between individuals. Some odours may be pleasant when weak but unpleasant when strong, or when exposure is frequent. The table below shows a qualitative score range used by panellists for an odour sample compared to an offensiveness scale (*see Table 6.1*)

Table 6.1. Hedonic tone scoring

Score	Perceived Hedonic Tone
+4	Very pleasant
+3	Pleasant
+2	Moderately pleasant
+1	Mildly pleasant
0	Neutral odour / no odour
-1	Mildly unpleasant
-2	Moderately unpleasant
-3	Unpleasant
-4	Very unpleasant

6.7 Quality or Character

This attribute is expressed in terms of “descriptors", e.g. “fruity", “almond", “fishy". This can be of use when establishing an odour source from complainants descriptions. Alternatively, it may be possible to identify key chemical components by a description of the specific odour.

Odour quality, hedonic tone and concentration influence the potential for annoyance, although the response to a particular odour will vary between individuals. The attribute most commonly used is concentration, but the hedonic tone which is a consideration in “offensiveness" is also important.

6.8 Odour descriptors

Descriptors can help to establish the source of an odour and it is useful, when recording information from a complainant, to seek their description of the odour.

Table 6.2. Odour descriptors for commonly encountered compounds.

Substance	Odour	Substance	Odour
Acetaldehyde	Apple, stimulant	Dimethyl sulphide	Rotten vegetable
Acetic acid	sour vinegar	Diphenylamine	Floral
Acetone	chemical/sweetish/solvent	Diphenyl sulphide	Burnt rubber
Acetonitrile	Ethereal	Ethanol	Pleasant, sweet
Acrylaldehyde	Burning fat	Ethyl acetate	Fragrant
Acrolein	Burnt sweet, pungent	Ethyl acrylate	Hot plastic, earthy
Acrylonitrile	Onion, garlic, pungent	Ethylbenzene	Aromatic
Aldehydes C9	Floral, waxy	Ethyl mercaptan	Garlic/onion, sewer, decayed cabbage, earthy
Aldehydes C10	Orange peel	Formaldehyde	Disinfectant, hay/straw-like, pungent
Allyl alcohol	Pungent, mustard like	Furfuryl alcohol	Ethereal
Allyl chloride	Garlic onion pungent	n-Hexane	Solvent
Amines	Fishy, pungent	Hydrogen sulphide	Rotten eggs
Ammonia	Sharp, pungent odour	Indole	Excreta
Aniline	Pungent	Iodoform	Antiseptic
Benzene	Solvent	Methanol	Medicinal, sweet
Benzaldehyde	Bitter almonds	Methyl ethyl ketone	Sweet
Benzyl acetate	Floral (jasmine), fruity	Methyl isobutyl ketone	Sweet
Benzyl chloride	Solvent	Methyl mercaptan	Skunk, sewer, rotten cabbage
Bromine	Bleach, pungent	Methyl methacrylate	Pungent, sulphide like
Sec-Butyl acetate	Fruity	Methyl sulphide	Decayed vegetables
Butyric acid	Sweat, body odour	Naphthalene	Moth balls
Camphor	Medicinal	Nitrobenzene	Bitter almonds
Caprylic acid	Animal like	Phenol	Sweet, tarry odour, carbolic acid
Carbon disulphide	Rotten vegetable	Pinenes	Resinous, woody, pine-like
Chlorine	Irritating, bleach, pungent	Propyl mercaptan	Skunk
Chlorobenzene	Moth balls	Putrescine	Decaying flesh
2-Chloroethanol	Faint, ethereal	Pyridine	Nauseating, burnt
Chloroform	Sweet	Skatole	Excreta, faecal odour
Chlorophenol	Medicinal	Styrene	Penetrating, rubbery, plastic
p-Cresol	Tar-like, pungent	Sulphur dioxide	Pungent, irritating odour
Cyclohexane	Sweetish when pure, pungent when contaminated	Thiocresol	Rancid, skunklike odour
Cyclohexanol	Camphor, methanol	Toluene	Floral, pungent, moth balls
Cyclohexanone	Acetone-like	Trichloroethylene	Solventy
Diamines	Rotten flesh	Triethylamine	Fishy, pungent
1,1-Dichloroethane	Ether-like	Valeric acid	Sweat, body odour, cheese
1,2-Dichloroethylene	Chloroform-like	Vinyl chloride	Faintly sweet
Diethyl ether	Pungent	Xylene	Aromatic, sweet
Dimethylacetamide	Amine, burnt, oily		

6.9 Hedonic Scores

These scores are also referred to as "Dravnieks" and are derived from laboratory-based experiments. They give an indication of the relative pleasantness or unpleasantness of one odour when compared to another. When considering odours from industrial activities, the descriptors given in the previous table can be used.

Use of these scores
The higher the positive "score", the more "pleasant" the odour descriptor, and the greater the negative figure the more "unpleasant" the odour descriptor. The terms pleasant and unpleasant are used to indicate relative response rather than a sign of a positive or negative level of satisfaction. Zero cannot be considered to be neutral.

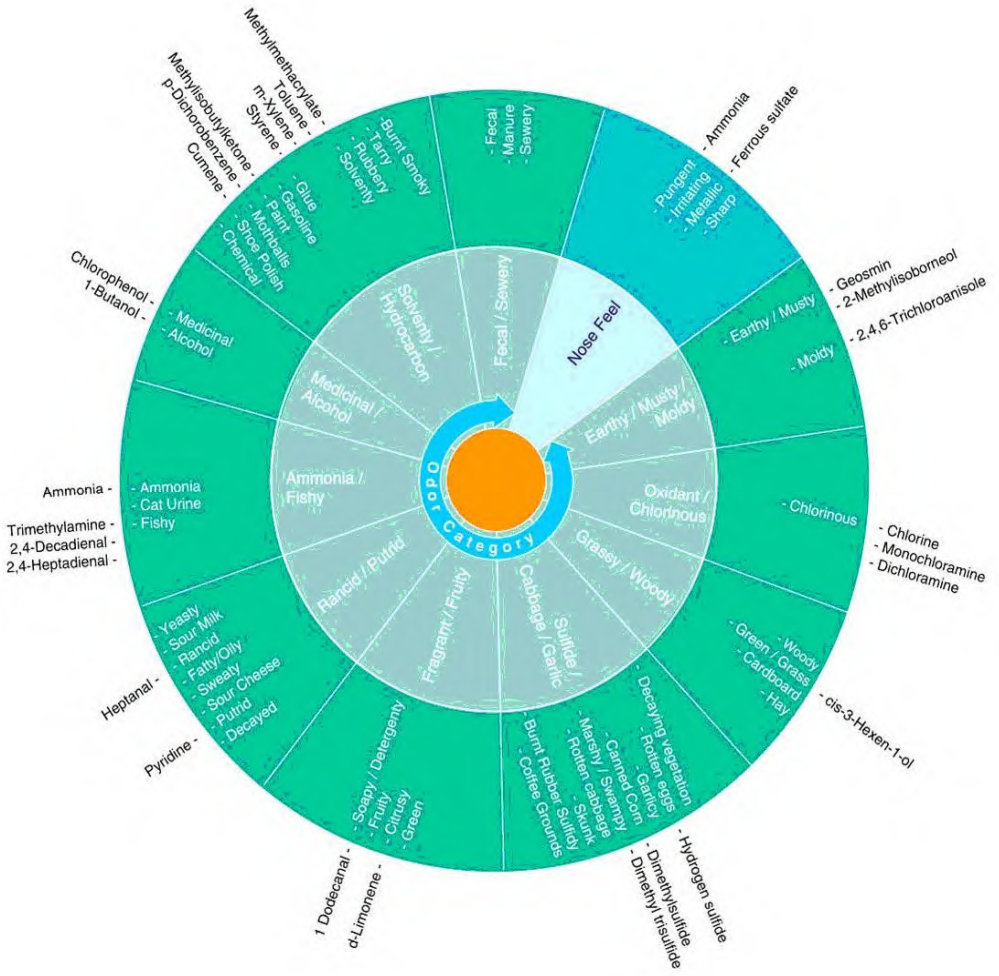
Table 6.3. Hedonic scores

Description	Hedonic Score	Description	Hedonic Score	Description	Hedonic Score
Cadaverous (dead animal)	-3.75	Fishy	-1.98	Wet paper	-0.94
Putrid, foul, decayed	-3.74	Musty, earthy, mouldy	-1.94	Medicinal	-0.89
Sewer odour	-3.68	Sooty	-1.69	Chalky	-0.85
Cat urine	-3.64	Cleaning fluid	-1.69	Varnish	-0.85
Faecal (like manure)	-3.36	Kerosene	-1.67	Nail polish remover	-0.81
Sickening (vomit)	-3.34	Blood, raw meat	-1.64	Paint	-0.75
Urine	-3.34	Chemical	-1.64	Turpentine (pine oil)	-0.73
Rancid	-3.15	Tar	-1. 63	Kippery-smoked fish	-0.69
Burnt rubber	-3.01	Disinfectant, carbolic	-1.60	Fresh tobacco smoke	-0.66
Sour milk	-2.91	Ether, anaesthetic	-1.54	Sauerkraut	-0.60
Stale tobacco smoke	-2.83	Burn, smoky	-1.53	Camphor	-0.55
Fermented (rotten) fruit)	-2.76	Burnt paper	-1.47	Cardboard	-0.54
Dirty linen	-2.55	Oily, fatty	-1.41	Alcoholic	-0.47
Sweaty	-2.53	Bitter	-1.38	Crushed weeds	-0.21
Ammonia	-2.47	Creosote	-1.35	Garlic, onion	0.17
Sulphurous	-2.45	Sour, vinegar	-1.26	Rope	-0.16
Sharp, pungent, acid	-2.34	Mothballs	-1.25	Beery	-0.14
Household gas	-2.30	Gasoline, solvent	-1.16	Burnt candle	-0.08
Wet wool, wet dog	-2.28	Animal	-1.13	Yeasty	-0.07
Mouse-like	-2.20	Seminal, sperm-like	-1.04	Dry, powdery	-0.07
Burnt milk	-2.19	New rubber	-0.96		
Stale	-2.04	- Metallic	0.94		

Table 6.3 continued. Hedonic scores.

Description	Hedonic Score	Description	Hedonic Score	Description	Hedonic Score
Cork	0.19	Crushed grass	1.34	Maple syrup	2.26
Black pepper	0.19	Celery	1.36	Pear	2.26
Musky	0.21	Green pepper	1.39	Caramel	2.32
Raw potato	0.26	Tea leaves	1.40	Coffee	2.33
Eggy (fresh eggs)	0.45	Aromatic	1.41	Meaty (cooked, good)	2.34
Mushroom	0.52	Raisins	1.56	Melon	2.41
Beany	0.54	Cooked vegetables	1.58	Popcorn	2.47
Geranium leaves	0.57	Clove	1.67 Minty, peppermint	2.50	
Grainy (as grain)	0.63	Nutty	1.92	Lemon	2.50
Dill	0.87	Coconut	1.93	Fragrant	2.52
Woody, resinous	0.94	Grapefruit	1.95	Fried chicken	2.53
Soapy	0.96	Perfumery	1.96	Cinnamon	2.54
Laurel leaves	0.97	Peanut butter	1.99	Cherry	2.55
Eucalyptus	0.99	Spicy	1.99	Vanilla	2.57
Molasses	1.00	Banana	2.00	Pineapple	2.59
Incense	1.01	Almond	2.01	Apple	2.61
Malty	1.05	Sweet	2.03	Peach	2.67
Caraway	1.06	Buttery, fresh butter	2.04	Violets	2.68
Soupy	1.13	Grape juice	2.07	Fruity, citrus	2.72
Bark, birch bark	1.18	Honey	2.08	Chocolate	2.78
Anise (liquorice)	1.21	Cedarwood	2.11	Floral	2.79
Oak wood, cognac	1.23	Herbal, green, cut grass	2.14	Orange	2.86
Seasoning (for meat)	1.27	Cologne	2.16	Strawberry	2.93
Leather	1.30	Fresh green vegetables	2.19	Rose	3.08
Raw cucumber	1.30	Fruity, other than citrus	2.23	Bakery (fresh bread)	3.53
Hay	1.31	Lavender	2.25		

7. *Appendix IV*-Odour wheels



Suffet, M (1999).

Figure 7.1. Odour wheel for WwTP's

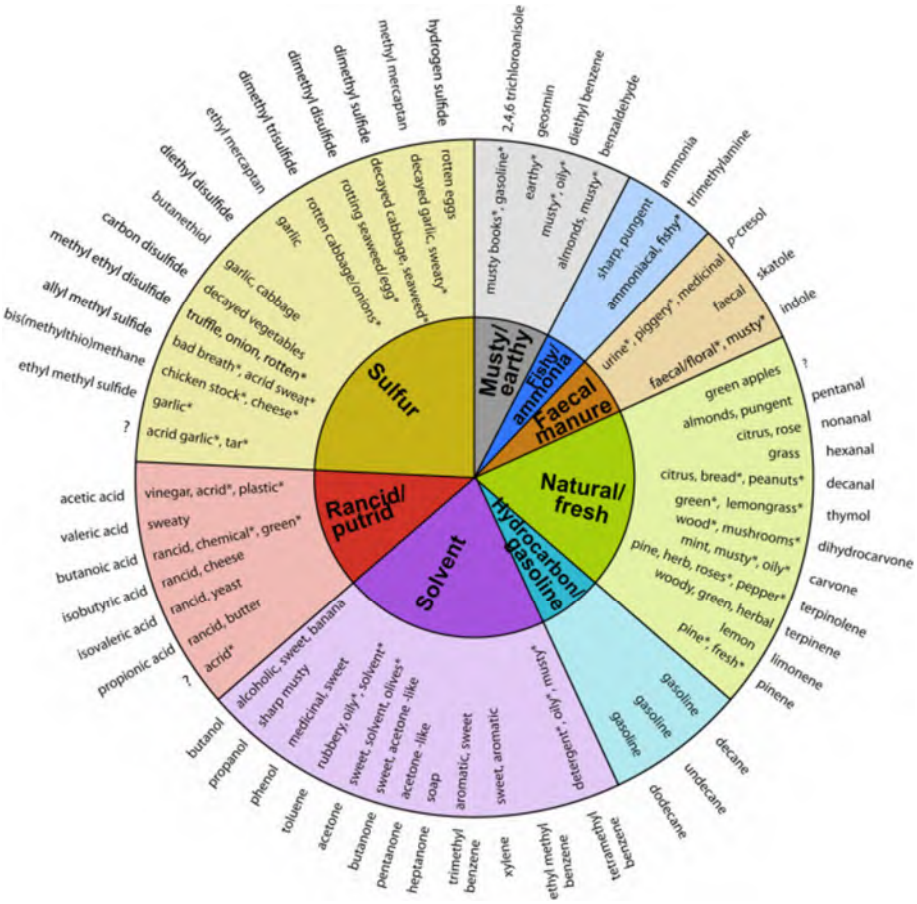


Figure 7.2. General odour wheel for commonly encountered odours

References

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