Scottish Water

Seafield Wastewater Treatment Works Strategic Odour Review

Final Report

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Amec Foster Wheeler Environment
& Infrastructure UK Limited

Cranfield University

Report for

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No.	Details	Date
1	Draft Final Report 17367i2	30th October 2017
2	Final Report 18122i1	28th March 2018

1. Summary

1.1 Purpose of this report

This report has been produced for the purpose of identifying the need for changes in capital assets and operation and management at Seafield wastewater treatment works (WwTW) in Leith, Edinburgh and its associated sewerage network in order to effect reductions in odour emissions from these locations.

Following completion of the measures in Spring 2011 of an Odour Improvement Plan, it was recognised that odour emissions from the Seafield WWT plant reduced significantly. However, as a result of continuing and increased numbers of complaints from the local community in Leith about malodours emanating from Seafield WwTW site, the Scottish Government and Scottish Water commissioned Amec Foster Wheeler and Cranfield University to undertake a strategic review of the site and network assets, operations and communications. The Terms of Reference for the review were drafted by Scottish Water and the Scottish Government and consultations were held with a wide range of stakeholders prior to final agreement and issuing to Amec Foster Wheeler and Cranfield University in August 2017. A copy of the Terms of Reference is contained in Appendix A to this report.

1.2 Review Scope

There were two distinct and related themes to the review:

- An evidence-based evaluation of the performance and operation of the sewerage network and the Seafield WwTW assets in relation to odour generation and minimisation; and
- An engagement exercise with all stakeholders (Scottish Water, Stirling Water (the PFI Company), the site operator Veolia Water Outsourcing Limited (Veolia) Regulators, the Leith Links Community Council, elected officials of CEC and the Scottish Parliament and local residents' groups) to elicit information on how odour from Seafield WwTW and, potentially, its associated sewerage network, affects their lives.

The review process commenced in late June 2017 and was concluded in mid-October 2017. On 29th September 2017, personnel from Amec Foster Wheeler and Cranfield University met with a range of stakeholders in the Scottish Government's offices at Victoria Quay in Leith and presented their study methodology, the overall purpose being to identify any omissions in the methodology. On Friday 27th October 2017, a draft report of the main findings and recommendations arising from the review were presented to stakeholders.

1.3 Main Findings of the Review

Regulation of Seafield WwTW – the CoP, OMP and monitoring of the OIP

- The Seafield WwTW site is subject to a "dual regulation" regime in respect of odour: the waste water treatment works (WwTW) processes are regulated under The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006

(CoP) by City of Edinburgh Council (CEC) and the sludge import and treatment centre (STC) is regulated under a Waste Management Licence (WML) by the Scottish Environment Protection Agency (SEPA);

- The odour management plan (OMP), a requirement of the CoP and compiled by the site operator (Veolia), covers the management and control of odours from both the WwTW and STC processes and both CEC and SEPA rely upon the measures in the OMP to assess compliance with their respective regulatory regimes;
- Regulation of the CoP by CEC requires a documented complaints administration procedure to ensure the investigation of all complaints. This review shows that the local authority responsibility to monitor and enforce the CoP is being undertaken with significant resource commitments and expertise by CEC;
- Under the terms of the WML, Veolia has compiled and operates a Working Plan (WP), which contains cross-references to the OMP. This is the primary mechanism for management and control of odours from the STC. The "UWWTD exclusion" temporary holding position currently excludes these sludge treatment processes from falling under the Industrial Emissions Directive (and requiring a PPC Part A permit). So, WML control will continue for the time being;
- The Odour Improvement Plan (2008) (OIP) was developed under the requirements of the CoP and so deployed an emissions modelling and cost/benefit approach when defining remedial measures for the preliminary and primary wastewater treatment processes. This method informed the design of mitigation measures to be implemented and resulted in a significant reduction in emissions and complaints once implemented by Spring 2011. The OIP developed by Scottish Water and the PFI Company specifically targeted the preliminary and primary wastewater treatment processes and not the sludge treatment processes. Subsequent to this, the PFI company that operates Seafield WwTW covered the digested sludge cake pad and brought this within the odour control regime for the site. This formed one of the potential incremental odour reduction actions identified within the OIP;
- Requirements within the CoP make provision for, “The Odour Management Plan (OMP) [to be] regularly reviewed and updated as new equipment or plant is installed… at least once in any 12-month period” (Paragraph 6(3)). It is clear that this is taking place and is ongoing. However, use of an emissions inventory and dispersion modelling comparison exercise would have been advisable following completion of the works implemented under the OIP, to review and evaluate the ongoing effectiveness of these controls;
- Monitoring and enforcement of the CoP is required by the local authority, as defined in The Water Services etc. (Scotland) Act 2005. Section 26 (2) of this Act requires that, ‘Where a local authority is satisfied that Scottish Water [or another…] is
  (a) not complying with’ or
  (b) likely to comply with,
  the code in material regard, the authority must serve an “enforcement notice”

on Scottish Water. The purpose of the notice is to define the steps necessary to secure compliance;

- Similarly, serving a regulatory notice to enforce the legislation of non-compliance resulting in odour from the STC requires the SEPA investigating officer to substantiate unacceptable odours off-site by reference to duration and intensity; attribute the odour to the site, i.e. from no other external source; identify the failure leading to the emission, then require the operator to abate the odour nuisance. This is necessary to demonstrate nuisance. However, by default, this is a 'reactive' process as opposed to a 'precautionary' approach. This is also a challenging exercise where the transient nature of intermittent, low-level, dispersing emissions makes demonstrating nuisance difficult; and
- Both regulatory regimes rely on the OMP to determine the performance criteria that define the conditions for compliance.

Stakeholder observations and opinions

- Many positive characteristics of the Leith neighbourhood were cited; the historical significance of Leith as an industrial area and working port; its strong connection with the history of social movements and the heritage of its industrial architecture. The sporting legacy and the history of Leith Links in establishing the rules for golf plus, in more modern times, the role of the Port of Leith and hosting the Royal Yacht Britannia;
- Many residents spoke of their enjoyment of the local area, the presence of a local community and the qualities and strengths of being part of the community. This included newcomers as well as long-term residents;
- The Leith Links area, park and allotments are valued greatly as they provide opportunities for individual and team sports, recreation, community and social events as well as educational activities within a densely populated area;
- There was general agreement that the works undertaken as a result of the OIP had made a significant reduction in odours. Prior to this, the Leith Links had a significant reputation for sewage odours from Seafield WwTW, which many described as horrendous. Stakeholders reported impacts prior to the OIP works including watering and stinging eyes, having to close windows, unable to hang out washing, not using gardens, not inviting neighbours, visiting friends away from the area and householders leaving the area. Householders described the land and housing area affected extending beyond the Links, and at times covering much of Leith;
- For all of the householders interviewed in the Leith Links area, Seafield WwTW continues to cause problems. However, there was general agreement that odours were less intense than in previous years (pre- the OIP implementation), with the worst instances caused by either specific site instances or aggravated by local weather or prevailing wind conditions, notably the haar or sea fret, a cold sea fog where dispersion is significantly reduced and odours remain close to source strengths;
- Where residents cited examples of specific incidents, notably sludge spills, the siloxane filter regeneration events and the April/May 2017 low flows, reports of the impact were consistent in their increased intensity, in comparison to

general background odours. Impacts included, 'being woken up in the night', having to close windows at all times', 'hosting events for families and friends away from the house', not being able to 'hang out washing'. It is also relevant to note that the breadth of examples given, including cancelling barbecues & social events, personal reputation, use of gardens & gardening, children noticing odours and the effect on visitors varied between respondents;

- An ongoing concern expressed by many individuals in the stakeholder interviews was the extent to which it was perceived that there was a poor demonstration of control over operations to prevent odour emissions. Confidence in the reliability of odour control was low, despite in some instances there being a good knowledge of the operational procedures reported to control odour;

- Experience of the complaints system reflected concerns about the split responsibility differing between ownership and operation as well as dual-regulation;

- Many interviewees expressed confidence in the attention given to responding to complaints and the professionalism given to complaint investigation by CEC, Scottish water and Veolia. However, few expressed confidence in any improvement or there being a likelihood of enforcement resulting from complaining. It was evident that specific locations had notably high levels of complaints. These were suspected by many residents to match the exposure pattern and dispersion corridors of site emissions;

- Many reported frustration that 'an authorised officer' was required to attend the location where odour had been witnessed by a complainant in order to substantiate that an odour was present and causing a statutory nuisance in relation to the CoP. This was recognised by some as an unavoidable requirement for a legal process, whereas others felt this conveyed a lack of trust of a resident's experience. Overall, a strong and commonly held view was that the community had to endure and report complaints before action, if any, would take place, i.e., a 'reactive' system of odour regulation, despite the CoP being in place;

- Some respondents amongst the household groups were aware of the dual-regulation by CEC and SEPA. All those aware of this expressed concern about the consistency of approach and information sharing. These concerns were also expressed by many non-resident respondents. Amongst some members of the community there was concern about the lack of transparency over decisions to serve a notice or prosecute;

- The current complaint system was often reported as time-consuming and slow, particularly when compared to the transient nature of odour emissions during 'low-level' incidents. Examples were given where individuals had not bothered to complain where they had in the past. The reasons cited were the time taken and low expectation of change, i.e., complaint fatigue. Feedback on the final outcomes of complaints were often reported as 'limited'. Other respondents explained how they had been encouraged to complain, particularly recently, to ensure there was a record of impact. The majority expressed an increased likelihood of complaining again if odours persisted; and

- When asked about what would be recognised as improvement, ‘no odour’ was the common statement. However, a number also explained that a marked difference from low-level persistent odours and control over major incidents would be noticed.

Operation of Seafield WwTW

- The site operator, Veolia, on the basis of our site inspections and discussions with managers and operatives over the period late June 2017 to end September 2017, is in good day to day control of the Seafield site. All staff are familiar with the contents of the OMP and are aware of the pressing need to control odour emissions from the site and to ensure that operations are strictly in accordance with the OMP;
- The OMP is comprehensive, was last updated in November 2017, and provides an acceptable level of detail in respect of odour risk assessment of individual unit processes and activities. In particular, the sections on Operational Maintenance Site Tours to control odour are detailed and explicit;
- There is a good system of “odour relevant” procedures in place, including:
  - The daily site inspection check list;
  - The odour assessment check sheet;
  - The odour site investigation procedure;
  - The odour complaint investigation report; and
  - The operational procedure for odour sensitive tasks
- Odour incidents caused by new equipment and processes are dealt with ‘reactively’ by identifying the cause, defining and implementing mitigating measures that then lead to a reduction in odour. A more pro-active approach to assessing the risks of odour from these sources is recommended. Incidents such as sludge spills and digester gas pressure releases could have been foreseen and prevented; and
- The review of current site controls shows that these are understood by managers and operators, in use and appropriate. However, it is evident that there is a lack of awareness of the significance of low-level emissions off-site. These are not addressed specifically within the OMP, other than through best practice operation of the WwTW and STC processes.

Analysis of odour complaints

- There are strong links between odour complaints, onshore winds, periods of low raw wastewater flow (e.g., in April-May 2017), raw wastewater septicity levels, readings from the boundary H_2S monitors and sludge blanket levels in the primary settlement tanks;
- During the exceptionally dry April-May 2017 period, there were elevated baseline odour emissions from the open processes (detritors, PSTs, ASP), owing to low wastewater flows and septicity in the incoming wastewater. This low level of rainfall (4 mm in April 2017) is very unusual. However, there are

other months from 2012 onwards with peaks in complaints where, for the majority of days, there was no or very little rainfall;

- This primary cause of odour during April and May 2017 was compounded by increasing sludge blanket depths in the PSTs, sludge spillages and unplanned digester gas releases. This does not, in our opinion, represent best practice operation of Seafield WwTW during this period; and

- Emissions of odour from regeneration of the resin filter of the PpTek biogas siloxane removal unit have, in the recent past, contributed strong and noticeable odours in the Leith residential areas. A vent air burner has now been commissioned (July 2017) and this thermally oxidises the emissions from the siloxane filter regeneration in a high-temperature enclosed flare. From our experience of similar installations at other WwTW sites in the UK, this should, where operated correctly, significantly reduce the emission of odorous gases.

Network

- Fugitive emissions of wastewater odours from manhole chambers and pumping stations in the sewerage network serving Seafield WwTW are possible sources of odour but there is no firm evidence that these could be the source of complaints from the community. The vent pipe on the 1889 Water of Leith sewer on the Ropeworks development site could be a localised source of odour but it has not yet been determined if it is still connected to the sewer. Scottish Water is progressing investigations into this facility;

- Trade effluent discharges make up approximately 3.3% of the total daily wastewater flow into Seafield WwTW and approximately 6.7% of the polluting load, expressed as BOD_5. There are no particularly odorous industrial discharges that could significantly influence odour emissions from Seafield WwTW. The results of check monitoring on samples of trade effluent indicated a very high level of compliance with the consented discharge limits, with very few minor exceptions;

- It is known that sludges are discharged into the network; primary sludge at Prestonpans pumping station and surplus activated sludge at Glencorse pumping station from Penicuik WwTW; and

- A survey of H_2S levels in manhole chambers at four locations in the sewer network during September 2017 identified relatively modest concentrations over this period, notably at Wallyford, the Siphon House and Portobello, where similar-timed peaks in H_2S levels were observed, coinciding with rainfall events and increased flow turbulence in the sewers. H_2S levels at MEPS, a lift pumping station for a proportion of the flow at Seafield WwTW inlet, were negligible over the same period.

Wastewater treatment processes

- Examination of measured odour emissions from unit processes at the Seafield WwTW site identified two past surveys (WRc in 2003/4 and Mott MacDonald in 2013). Neither of these is representative of how the site is operated today. A further emissions survey was conducted in September 2017;

- The results of the surveys were compared against each other and with typical values contained in UKWIR[1] and Amec Foster Wheeler's own in-house odour emissions database for WwTW sites in the UK. The lowest odour emission rates were found in the 2017 survey, the highest in the 2013 survey, with the 2003/4 survey results between these two;
- A review of the proportional contribution of the individual unit process to off-site odour concentrations has identified that the PSTs and storm tanks are high-risk in terms of the potential for triggering off-site odour complaints. For the PSTs, this is because of the large surface area of exposed wastewater and emissions from the sludge uplift carbon filters and their sensitivity to the quality of the incoming wastewater and the sludge blanket levels in the tanks. For the storm tanks, although the procedures now adopted by the site operator for emptying and cleaning will minimise the risk of odour annoyance, there is still the risk of this occurring, given the time-in-use of the storm tanks during a typical year and the scale of the likely odour emission rates;
- The ASP and FSTs, under normal operational circumstances, are not considered to present a significant risk of causing annoying odours off-site, given the relative inoffensiveness of odours from these sources. This observation is consistent with our experience of such unit processes elsewhere in the UK;
- It is considered, from observations made during the course of this review, that there is definite potential for fugitive odours to escape from the sludge cake pad building, based upon odours experienced at the adjacent site boundary and odours detected on Leith Links under light onshore wind conditions during a site walk-over in July 2017;
- Observations of sludge deliveries by road tanker revealed that, at the end of the tanker discharge period, there was a period of a few minutes when air was discharged from the tanker body direct to atmosphere. In addition, because of the arrangement of the coupling pipework from the sludge tank inlet valve to the tanker, there was an inevitable small spillage of sludge when the flexible pipework was disconnected. However, during all the observations, the spillages were cleaned-up quickly by the tanker drivers in accordance with site operating practices; and
- The odour control units on the site have been found, in general, to be operating efficiently, with a number of small exceptions, and are not considered to present a significant risk of causing annoying odours off-site.

Dispersion modelling to assess the impact of Seafield

- An updated odour dispersion model for the Seafield WwTW site has been compiled and has been used to assess the impact upon residential areas in the Leith area of the different sets of emissions referred to above. This shows that, for the residual "Option A" abatement scenario odour emission levels, there would still likely be sufficient levels of odour in the community to prompt complaints;

[1] United Kingdom Water Industry Research.

- Turning to the emission levels measured in 2013, these produce an odour "footprint" larger than the 2003/4 emissions. Use of averaged emissions from our in-house database produces a footprint somewhere between the two;
- However, it should be noted that these two above odour emissions "scenarios" are not representative of the site as it is today. When the model is run using the measured emissions from the September 2017 survey, incorporating the current site characteristics, a much smaller footprint is derived;
- The results of this modelling show, in essence, that odour concentrations in the Leith residential areas at times have been at levels that would likely generate annoyance and complaints, even taking into account the low level of emissions measured in September 2017;
- This is not a continuous occurrence – these odour concentrations would only arise when the wind is in an onshore direction, which occurs for approximately 25% of the hours in a typical year and then, only when the wind speed is relatively low and emissions are at a level sufficient to produce odour concentrations off-site likely to generate complaints. In addition, the modelling assumes that the emissions remain constant throughout the year. In reality, these will vary from day to day, depending upon weather, wastewater flow and operating conditions; and
- In summary, therefore, there exists the potential, under onshore winds and varying odour emission rates from the unit processes (particularly the PSTs, storm tanks and, to a lesser extent, the detritors), for odours at annoying levels to occur in Leith from time to time. In April and May 2017, this was exacerbated by a long dry period and other, uncontrolled releases of odour. These latter emissions should be controllable, moving forward. However, the risks of odour arising from the remaining uncovered sources remains.

1.4 Recommendations

Overall regulatory context

We are aware that Scottish Water operates within a regulatory framework established by the Scottish Parliament in which Scottish Ministers, acting on behalf of the people of Scotland, set the objectives for the water services to be delivered at least cost to customers. A key player in this regulatory framework is Scottish Water's economic regulator, the Water Industry Commission for Scotland. The Commission is a non-departmental public body with statutory responsibilities. Its role is to manage an effective regulatory framework which encourages the Scottish water industry to provide a high-quality service and value for money to customers. It acts independently of Ministers.

The current regulatory control period runs over a six-year period from April 2015 to March 2021. The next period runs until 2027.

There are also cost and benefit issues to consider, particularly in relation to some of the odour reduction measures that could possibly be implemented in the medium term. For example, if there were to be a longer-term vision for major redevelopment of Seafield WwTW and STC, either on the current site or on a new site, it may not be cost-effective to implement medium-term solutions if these issues would be solved by longer-term measures. It is also recognised that there may be other considerations (e.g., accommodating population growth within the sewerage network and at specific treatment assets, bathing water quality) which also need to be factored into Scottish Water's investment plans. As such, Scottish Water is required to consider all such matters in an holistic manner when developing such plans, rather than seeking to address them in isolation. That precise balance of costs and benefits is for Scottish Water and the Scottish Government to consider.

With this in mind, we have made our recommendations on the basis that short-term measures to improve the odour climate around Seafield WwTW, that is, over the next 0 - 2 years, will be unlikely to feature any high-cost capital measures. Rather, the thrust of the recommendations is focused upon generating evidence-based proposals to coincide with future capital investment that could be considered for the next regulatory control period(s). Therefore, short term measures focus upon a 0 to 2 years' time scale, medium term means 2 to 7 years (7 years being the middle of the next regulatory control period) and long term means 7 to 20 years. This is explained in greater detail in the main body of the report.

Summary of recommendations

Short-term measures

These are focused upon the next 2-year period and involve a combination of measures to address odours from the sewer network, Seafield WwTW and STC and a set of engineering and technical feasibility studies, incorporating cost/benefit assessments, which would feed into and facilitate medium-term and long-term measures. These cover engineering and technical capital matters, operational aspects and communication.

Sewer network

- Develop a contingency plan for dosing the network at key locations during periods of low or no rainfall to alleviate septicity, with the objective of having this in place for Spring 2018;
- Re-commission and implement the Nutriox dosing installation at Wallyford. Re-commissioning the Nutriox dosing would reduce septicity in the downstream network;
- Install and implement ferric chloride dosing facility at MEPS. This can be used to mop-up sulphide in the incoming wastewater and reduce odour emissions from the PSTs during treatment;
- Install H_2S monitoring at the Siphon House. Ferric dosing at MEPS to "mop-up" generated sulphides in the incoming wastewater (see above item) could be controlled by monitoring at the Siphon House;
- Investigate further the status of the vent pipe on The Ropeworks development site. A search of Scottish Water plans and documents has revealed little and the construction company on the Ropeworks site is unaware of the status of the vent. A detailed search of Scottish Water archives will be needed to ascertain exact status, possibly also involving intrusive investigations;
- Undertake an initial feasibility study for providing treatment of wastewaters at intermediate points in the network. This should focus upon the provision of

secondary treatment at Wallyford (additional land required and note that new-build residential is already encroaching closer to the site) and also for the coastal towns network. Land availability and acquisition and public acceptance will be significant issues;

- Extend the septicity survey in the sewer network. A 10-day survey was conducted at four locations in September 2017. With the acquisition of the OdaLog instruments, Scottish Water has the ability to conduct additional studies which will feed into the dosing locations and intermediate treatment studies; and
- Review the practice of feeding sludges into the network at Prestonpans and Penicuik in the light of the above sewer network septicity survey.

Seafield WwTW and STC – technical & engineering

- Engineering feasibility study for conversion of the storm tanks to sequential and selective filling and for installation of automated cleaning procedures (scrapers, AmJets, Swing Jets);
- Engineering feasibility study for reconfiguration of Primary Settlement Tanks (PSTs) – identification of alternative processes and options for providing enclosed or covered process;
- Carry out a detailed ventilation, air flow and damper evaluation of the current covered and extracted areas of Seafield WwTW (inlet works, PST weirs & launders, inlet channels, secondary pumping station, ASP main distribution chamber, ASP sub-distribution chambers);
- Undertake a review of sludge storage capacity on the Seafield site and determine what, if any, additional capacity is required. In the majority of cases where high PST sludge levels have occurred, this has been a consequence of issues with downstream processing or storage capacity. Additional storage, even of a temporary nature, with appropriate odour control, is desirable;
- Carry out a detailed air balance and ventilation study on the sludge cake building to identify improvements to achieve better containment of air during normal operation; and
- Undertake a detailed review of the quality of sludge thickening and dewatering liquors and their potential impact upon odour emissions from the PSTs. Identify options for pre-treatment prior to return to the wastewater flow upstream of the PSTs.

Seafield WwTW & STC - operational

- Introduce a tight H_2S emission limit value (of the order 0.1 to 0.5 ppm) on the measured emissions from the air uplift carbon filters on the PSTs. Measured H_2S concentrations during the September 2017 site survey were 5.1 ppm on PST 3 and 7.8 ppm on PST 5. Odour concentrations were 41,868 and 48,900 ou_E/m^3 respectively. Also introduce regular monitoring of emissions (weekly or monthly, as appropriate) to identify when carbon replacement is necessary;

- Carry out odour emissions surveys and dispersion modelling at two-yearly intervals (initially annually) to assess the ongoing odour footprint of Seafield WwTW and STC and to allow for remedial measures to be implemented between surveys;
- Develop or acquire a medium-term (1-10 days) weather forecasting system from which it is possible to identify forthcoming dry and high odour risk periods;
- Develop a HAZOP-type odour risk identification procedure for any changes in plant/process operation or introduction of new processes on-site;
- Carry out a sludge tanker drivers' odour education and awareness induction programme and ensure that new drivers are identified and inducted. Carry out periodic observations of tanker discharge operations to ensure compliance with procedures

Seafield WwTW & STC – communication

- Develop an interactive web site for Seafield WwTW for secure public access. Publish a regular newsletter about the site and personnel and celebrate successes and challenges. Provide reasonable access to odour and process-related reports, including data from the boundary monitors and also performance data for processes and OCUs. Publish the minutes of liaison meetings. Conduct annual surveys of public experiences and attitudes through a third-party survey company;
- Consider adding a real-time odour dispersion model display to the web site;
- Develop the complaints response system to be more response-friendly and to provide more positive information;
- Publish anonymised complaint records alongside key on-site performance data and weather patterns, e.g., sludge levels, onshore winds, low wind conditions; and
- Within the future vision for the site, consider plans for educating schools, colleges and HE institutions about waste water treatment, process engineering and pollution control.

Medium-term measures

- Depending upon the outcomes of the feasibility study, identify options for the conversion of storm tanks with scrapers and SwingJets to automate cleaning and enable sequential filling. Eventual covering of tanks may be considered;
- Identify options for re-development of sludge cake/dryer buildings. This would involve clearing-out of the redundant equipment from the former dryer building, establishing an incoming/outgoing sludge transport vehicles airlock system, uprating the air extraction and abatement system, re-organising the sludge cake discharge arrangements, so that sludge discharges directly into covered/enclosed skips (to avoid current practice of double-handling);
- From the outcome of the feasibility study, identify options for provision of additional sludge storage capacity at Seafield WwTW, should this be deemed necessary; and

- Contingent upon the conclusions of the feasibility study, identify firm options for a phased approach to redevelopment of the open PSTs at Seafield with either covered or enclosed, high-rate, small footprint settlement processes, with additional odour abatement plant.

Longer-term measures

- Depending upon the outcomes of the feasibility study, identify options for provision of intermediate wastewater plants in the vicinity of Wallyford and for the coastal towns, taking into account the wider implications of underlying population growth in the region;
- Develop a long-term vision and strategy for the Seafield site, involving re-development of the entire Seafield WwTW site, either with or without accelerated asset replacement, with replacement of each of the preliminary, primary, secondary and tertiary wastewater treatment processes and sludge treatment processes, with state-of-the art high-rate, low footprint, low energy processes. The re-development would proceed based on an architectural competition design brief, incorporating sustainable construction practices and materials and designing-in renewable energy (wind, solar, biogas) generation, with added potential for gas clean-up and grid injection. The site would be compatible with potential future planned land uses in the Port of Leith area and could be a flagship development for Scottish Water, the Scottish Government and the local community including schools and higher education. It is also consistent with the future vision planning of the Leith area; and
- Review the potential relocation of Seafield WwTW and STC to a site remote from population (greenfield/brownfield) and establishment of an entirely new treatment facility.

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Contents

2. Glossary of terms and abbreviations

Term/Abbreviation	Explanation
AD	Anaerobic Digester – closed vessel that anaerobically digests sewage sludge under controlled conditions
ADMS	Atmospheric Dispersion Modelling System – dispersion modelling program supplied by Cambridge Environmental Research Consultants (CERC)
AERMOD	Dispersion modelling program developed by the United States Environmental Protection Agency
ASP	Activated Sludge Plant
BOD_5	Biochemical Oxygen Demand – a measure of the level of polluting matter in wastewater, over a five-day period, that can be broken down by micro-organisms.
CAD	Computer Aided Design
CEC	City of Edinburgh Council
COD	Chemical Oxygen Demand – a measure of the total level organic polluting matter in wastewater, including that which cannot be broken down by micro-organisms (greater than BOD_5)
CoP	The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006
CH_4	Methane, a molecule consisting of one Carbon and four Hydrogen atoms – a gaseous product of anaerobic breakdown of organic matter
CO_2	Carbon Dioxide, a molecule consisting of one Carbon and two Oxygen atoms – a gaseous product of both aerobic and anaerobic breakdown processes.
Detritors	Wastewater treatment process that removes grit from the wastewater flow to protect downstream assets such as valves and pumps
EU	European Union
FSTs	Final Settlement Tanks
H_2S	Hydrogen Sulphide “Rotten Egg Gas” generated by the anaerobic degradation of organic matter containing sulphur

Term/Abbreviation	Explanation
HAZOP	Hazard and Operability Study
ISC	Industrial Source Complex – dispersion modelling program (now superseded) developed by the United States Environmental Protection Agency
km	Kilometre – 1,000 metres
km^2	Square Kilometre – 1,000,000 square metres, 100 hectares
kW	Kilowatts of electrical energy
LRC	Lothian Regional Council
MCC	Midlothian County Council
MEPS	Marine Esplanade Pumping Station
Ml	Megalitres (1,000,000 litres or 1,000 cubic metres)
m^3	Cubic metre (1,000 litres)
m/s	Metres per Second
Nutriox™	A proprietary solution of calcium and magnesium nitrates that can be used to prevent the development of septicity in wastewater
OCU	Odour Control Unit
OdaLog	Instrument used to measure concentrations of hydrogen sulphide in sewer gases
OIP	Odour Improvement Plan
OMP	Odour Management Plan
ORP	Oxidation Reduction Potential, measured in millivolts, is a proxy measure for oxygen-starved and oxygen-devoid wastewater. Measures from +50 mV to +300 mV are indicative of aerated, oxygen-rich water, values from -50 mV to -250 mV are the range in which sulphide formation takes place and values below this range are symptomatic of anaerobic conditions.
ou_E/m^3	European odour units per cubic metre of air
PFI	Private Finance Initiative
PFTs	Picket Fence Thickeners

Term/Abbreviation	Explanation
pH	Measure of the degree of acidity or alkalinity of a liquid
PPC Part A regulation	Regulatory regime for the more complex and potentially polluting industries
PSTs	Primary Settlement Tanks
RBGE	Royal Botanical Gardens Edinburgh
Regulators	CEC and SEPA
SAS	Surplus Activated Sludge
SEPA	Scottish Environment Protection Agency
STC	Sludge Treatment Centre
THP	Thermal Hydrolysis Plant
UKWIR	United Kingdom Water Industry Research
UV	Ultra Violet (light)
VAB	Vent Air Burner – an efficient shrouded flare, powered by natural gas, for the thermal oxidation of odorous gas streams
Wind Rose	A radial diagram showing the distribution of wind speeds and direction around the points of the compass, typically over the period of a calendar year
WML	Waste Management Licence
WRc	Water Research Centre
WwTW	Wastewater Treatment Works

3. Introduction

This section of the report discusses the history and development of the Seafield wastewater treatment works (WwTW) site, its current treatment capacity, population served, the strategic role of the site and the reasons for this review.

3.1 History and Development of Seafield WwTW

"The sanitation of north and west Edinburgh left much to be desired until the Water of Leith Sewers (manholes or inspection hatches can be seen in the valley bottom near Dean Bridge) were laid in 1864 and 1889. Their outfalls of 3 ft 6 in. and 5 ft diameter pass the untreated sewage into the Forth. It was not until the mid-1970s that its first major sewage treatment plant at Seafield was completed costing about £20m. It involved the construction of an 11-mile interceptor sewer up to 10 ft diameter and a 1 3/4 mile 12 ft diameter effluent outfall."[2]

The sewage treatment plant referred to above in the extract from the referenced publication consisted of preliminary and primary settlement only, with settled sewage discharged direct to the Firth of Forth via the outfall pipe. Sludge from the primary settlement tanks was transferred to boats and disposed of at sea.

In the 1990's, with the adoption by the UK of the EU Bathing Waters Directive (76/160/EEC) and the EU Urban Waste Water Treatment Directive (91/271/EEC), secondary and tertiary treatment of wastewaters were required at all sites treating sewage from population numbers in excess of 50,000, together with cessation of disposal of sewage sludge at sea.

At Seafield WwTW, this introduced aerobic secondary biological treatment of settled sewage, using the activated sludge process, followed by final settling. UV disinfection of a proportion of the final effluent flow prior to discharge used to be carried out, in order to comply with the SEPA license. However, subsequent modelling of dispersion from the long sea outfall demonstrated to the satisfaction of SEPA that quality standards could be achieved without UV disinfection which was subsequently discontinued. Treatment of sludges arising from primary and secondary settlement was achieved by thickening and drying, followed by re-use on agricultural land and in land reclamation schemes or disposal to landfill.

3.2 Seafield WwTW Today

The wastewater and sludge treatment plants

Today, Seafield WwTW serves the urban area of Edinburgh and parts of East Lothian, in the Esk Valley catchment, treating 300 megalitres (Ml) of wastewater daily from a population equivalent of approximately 850,000. The current works was constructed under a Private Finance Initiative (PFI) contract in 2000-2001 and is operated on behalf of

[2] R Paxton & J Shipway (2007) 'Civil Engineering Heritage: Scotland - Lowlands and Borders'. Thomas Telford Publications, London.

Scottish Water by the PFI Company Stirling Water Seafield Ltd under the terms of the PFI contract, with Veolia Water Outsourcing Limited being the site operator.

Following preliminary, primary mechanical, secondary biological and final settlement, treated final effluent is discharged to sea. The sludge drying plant that was installed in 2000-2001, in common with others in the UK, was formally taken out of use in 2012. In 2015, a new thermal hydrolysis plant (THP) was commissioned. This produces a treated sludge with a much higher biogas generation potential during subsequent anaerobic digestion and also produces a pasteurised final sludge product. The biogas evolved from the sludge treatment process is used to generate up to 2,300 kilowatts (kW) of electricity in spark-ignition engines. The hot combustion gases from the engines are fed into the site's two boilers (that provide heating for the anaerobic digestion process) to reduce the natural gas demand and usage by the boilers.

The sewerage catchment

A catchment diagram is contained in Figure 1.1 overleaf. From this, the extent of the area served by Seafield WwTW is evident, stretching from Longniddry in the east to Cramond in the west and down to Penicuik[3] and Gorebridge in the south. Discussions with Scottish Water personnel yielded the following information about the development of the sewerage network.

The Esk Valley Trunk Sewer serves the catchment feeding into Wallyford Pumping Station and was developed by Midlothian County Council (MCC) and then Lothian Regional Council (LRC) to deliver flow to what was then Wallyford WwTW. This works provided preliminary and primary treatment of wastewater, with settled sewage discharged to the foreshore near Levenhall Links.

Wallyford WwTW was commissioned in approximately 1972. Further work by LRC expanded the Trunk Sewer into Midlothian, with the incorporation of storm water retention tanks to limit discharges to the rivers North and South Esks.

In a few locations (for example, Dalkeith and Gorebridge) the Burgh treatment plants (which were septic tanks) were "piped through" and connected to the downstream catchments, using gravity to deliver flow to Wallyford WwTW. This rationalisation of assets was all part of the 1960/70s strategy to treat flow at Wallyford. All of this wastewater flow was accounted for in terms of the design at Seafield at that time.

With the introduction of the Urban Waste Water Treatment (Scotland) Regulations 1994, there was a need for the provision of secondary biological treatment for inland and coastal discharges. The site at Wallyford was too small for the provision of secondary treatment and was therefore converted to a pumping station and storm tank facility. The provision of pumps and storm tanks restricted the overall flow being transferred from the Esk Valley into Edinburgh catchments to a maximum of 575 litres/second (l/s), with flows in excess of that (once the storm tank was full) diverted direct to the Firth of Forth.

The coastal communities of Longniddry, Seton Sands, Port Seton, Pondhall, Cockenzie, Prestonpans, Levenhall, Esk, Eastfield and Joppa (shown on the catchment plan in Figure 3.1) had no local sewage treatment and, until these were intercepted and connected to the Seafield network by pumping stations, crude sewage was discharged through local outfalls directly to the foreshore.

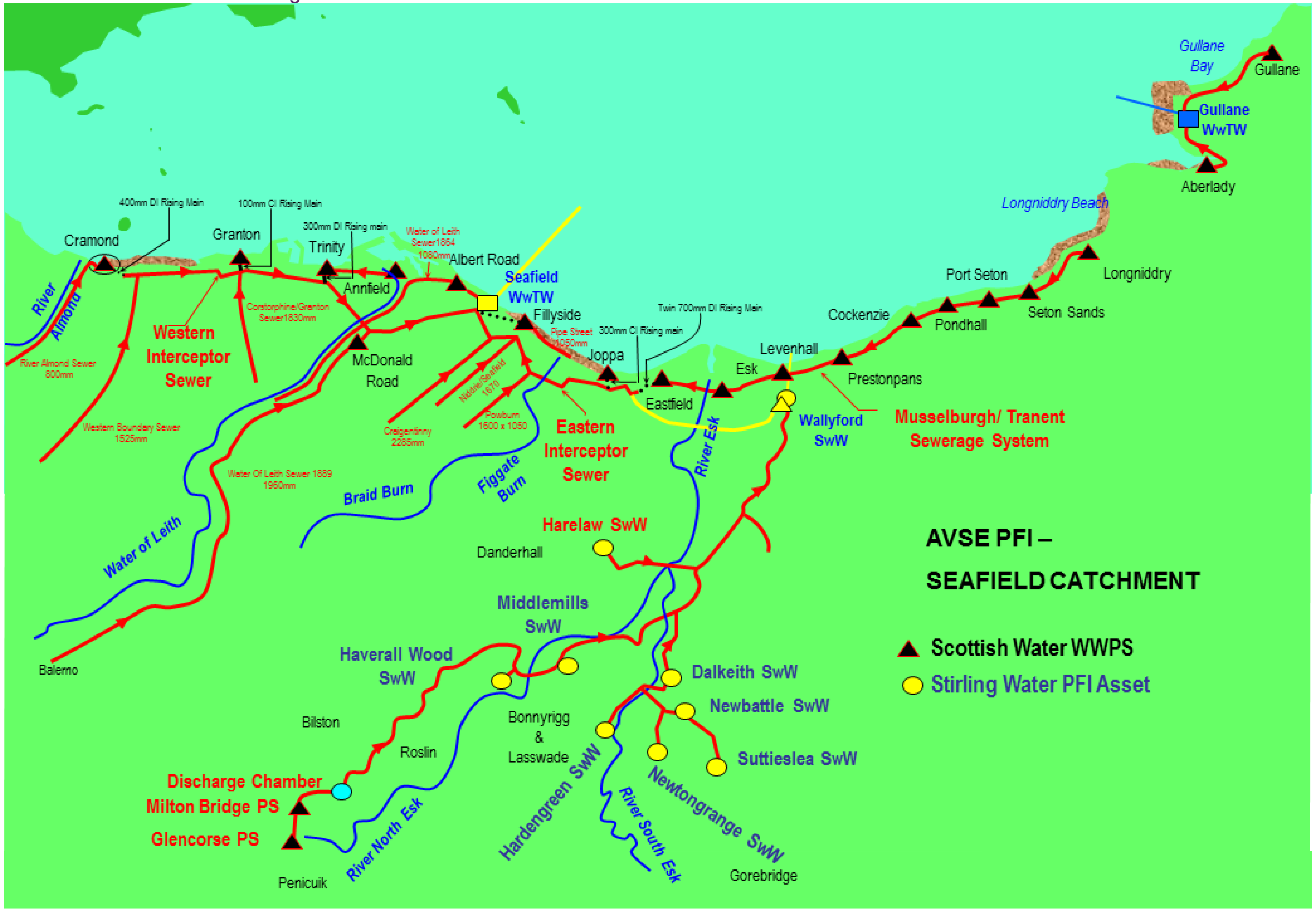
[3] Although Penicuik itself is served by a local treatment plant.

As a result of this, there are intermediate pumping stations at 9 locations to the east of Seafield WwTW, which ultimately feed into the eastern interceptor gravity sewer at Eastfield. In addition, pumping stations at Wallyford, Joppa and Fillyside also discharge into the eastern interceptor. There are a further five pumping stations that feed into the western interceptor sewer. The two interceptor sewers then feed into the Siphon House and thence the inlet to Seafield WwTW.

Flows from the west of Edinburgh, the communities of Cramond, Granton and Trinity, are pumped into the western interceptor sewer and there are gravity inputs also from the western boundary sewer and the Corstorphine/Granton sewer.

The 1889 Water of Leith gravity sewer feeds into McDonald Road pumping station and then onto Seafield WwTW via the Western Interceptor sewer and the Siphon House, with flows greater than 2,600 l/sec overflowing to Albert Road pumping station and then onwards to Seafield via the Marine Esplanade pumping station (MEPS). Flows in the 1864 Water of Leith gravity sewer enter Albert Road pumping station and are pumped from there to MEPS.

Figure 3.1 Seafield WwTW Catchment Diagram



A schematic of the catchment and pumping stations, annotated with flows, is contained in Appendix B and a simplified treatment process diagram of Seafield WwTW is contained in Appendix C.

Wastewater treatment

The WwTW treatment processes consist of:

- Screening;
- Grit removal in four stirred detritors;
- Interim storage of screenings and grit in covered skips;
- Diversion of incoming wastewater flows under storm conditions to four rectangular storm holding tanks;
- Primary settlement of screened and de-gritted wastewater in circular tanks (PSTs);
- Secondary biological treatment in an activated sludge plant (ASP);
- Separation of solids from the final effluent in 9 circular final settling tanks (FSTs); and
- Discharge of the final effluent to the Firth of Forth via the long sea outfall.

Screenings and grit are removed off-site to a licensed landfill facility. The ASP is operated as a “plug flow” carbonaceous plant, with no nitrification or denitrification processes, as there is no ammonia consent for discharge to the Firth of Forth. A proportion of settled activated sludge from the FSTs is recycled into the inlet of the ASP to “seed” the incoming settled sewage from the PSTs with micro-organisms. The remainder is treated on site (see “sludge treatment and handling” below).

Sludge Handling and Treatment

Sludges for treatment at Seafield WwTW arise from 3 sources:

- Primary sludge from the PSTs;
- A proportion of the secondary sludge produced in the FSTs (surplus activated sludge – SAS); and
- Sludge imports by road tanker from outlying WwTW sites.

Primary sludge from the PSTs is fed directly to three picket fence thickeners, where the solids content is increased from ~3% to 6%. From here, the thickened sludge passes to the Thermal Hydrolysis Plant (THP) centrifuge feed tank.

Surplus activated sludge is fed into a belt thickening plant, which increases the solids content to ~6%, and then is pumped also to the THP centrifuge feed tank.

Sludges imported by road tanker are screened and then stored in the imported sludge holding tanks. Then, depending upon their type and consistency, these are transferred either directly to the THP centrifuge feed tank or are thickened further prior to transfer by either drum thickening or belt thickening.

Liquors from picket fence, drum and belt thickening processes are collected in a sump and returned into the incoming wastewater flow just upstream of the PSTs.

From the THP centrifuge feed tank, the combined thickened sludges proceed through a buffer silo and are then further thickened by centrifuging and are fed to the THP (a good description of this sludge treatment process can be found here:

https://www.wateronline.com/doc/thermal-hydrolysis-process-thp-explained-0001).

From the THP, the hydrolysed sludge is fed directly to the anaerobic digesters, the outputs of which are a stabilised liquid sludge and a biogas rich in methane. The digested sludge is then dewatered to approximately 30% solids content by centrifuging and is then stored on site in the sludge cake storage building before being re-used on agricultural land and land reclamation/remediation schemes.

The biogas is cleaned-up to remove siloxane compounds and stored in a gas ball prior to combustion in 3 spark-ignition engines to generate electricity and 2 boilers which generate heat for the THP and digestion processes. The hot exhaust gases from the engines are recycled through the boilers to reduce the boiler fuel demand.

3.3 Strategic Role of the Site

The site sits at the discharge ends of a large sewerage network that has been developed over more than 100 years. The final effluent discharge to the Firth of Forth through the long sea outfall has consistently met its discharge consent limits set and regulated by SEPA. As a result of the combination of the THP and anaerobic digestion plants, coupled with the spark-ignition engines, the site can be self-sufficient in electricity. As such, Seafield WwTW is very much a critical and important part of Scottish Water's long-term strategy for effective and efficient treatment of wastewater and sludges for Edinburgh and East and Mid Lothian.

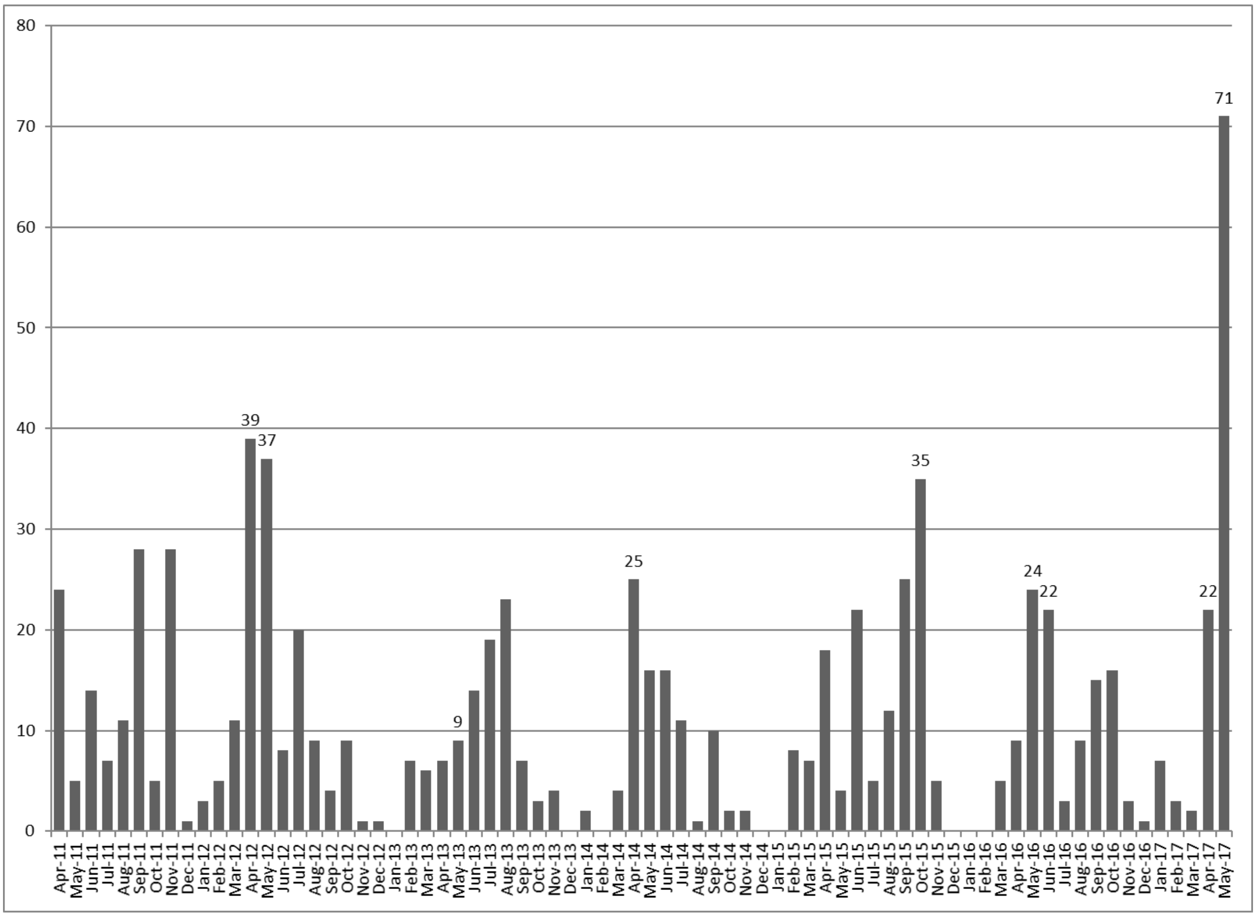
3.4 Reasons for this Strategic Review

From time to time, odours emitted from operations at the Seafield WwTW site have caused annoyance amongst the local communities in the vicinity of the site over many years. Following the serving of an abatement notice in 2003, odour emissions studies and dispersion modelling during 2003 and 2004, to identify a range of options for reducing odour emissions, and following the implementation of the CoP (see below), an OIP was developed and the options identified and approved by CEC in 2008 were implemented with completion taking place in Spring 2011.

As a result of the odour issues in the past at Seafield WwTW, a statutory Code of Practice[4] was introduced by the Scottish Government and came into being in 2006. As noted above this gave rise to an OIP for Seafield WwTW being developed to achieve compliance with the CoP as approved by CEC, such that nuisance would be and would continue to be abated. However, after the completion of the measures approved under the OIP in 2011, although there was a general acknowledgement by the local community that odours were reduced, the numbers of complaints about odour began to increase again and the graph in Figure 3.2 below shows the number of complaints by month from April 2011 to May 2017.

[4] http://www.gov.scot/Publications/2006/04/20140331/0

Figure 3.2 Seafield Odour Complaints April 2011 to May 2017



There are evident peaks in complaint numbers during the 2011 to 2017 period linked to specific operational incidents rather than an ongoing failure to manage odour emissions and these are explored in more in Section 6.

In relation to the events and reactions which triggered the need for this Strategic Review, it was principally the high levels of complaints in response to odour during April and May 2017 that generated the pressure. In summary, a dry April 2017, with only 4 mm of rainfall, created low flow conditions in the sewers and most probably septic sewage entering Seafield WwTW. This, combined with various malfunctions at the plant onwards into May 2017, released malodours which were considered unreasonable by the local community and were witnessed by officers from both CEC and SEPA.

4. Context of Regulation

This section of the report explores the regulatory regimes that are currently in place and applied to control odour emissions from Seafield WwTW, including primary legislation, the statutory Code of Practice and waste management licensing. It also considers available technical and policy guidance.

4.1 Context of Regulation

The Terms of Reference require this report to review,

The effectiveness of and current implementation of the:

1. CoP;
2. Odour Management Plan; and
3. Site controls.

in relation to odour management and monitoring at Seafield WwTW.

Therefore, this section examines the sequence of regulation that defines the regime to control odour from Seafield WwTW. Primary legislation, the statutory Code of Practice and waste management licensing process as well as the implementation of these in the management and monitoring of operational controls at Seafield via the OMP are all relevant. It also considers the use of technical guidance available and the extent to which these are effective.

Rationale for regulating odours

Smell is one of the most primal senses with the most direct connection to the brain. Odorants can stimulate positive as well as negative memories and emotions; they can influence our perception of time, our feeling of health and well-being, as well as our sense of place and purpose. These effects may occur without our direct control. In extreme cases influences to our overall wellbeing can occur including, deterioration and affects to, or loss of our sense of smell, reductions in appetite, and the perception of persistent warnings of danger.

Odours from polluting industries are the highest cause of complaint from environmental issues and are a recognised environmental stressor (Steinheider & Winneke 1993; Sucker et al. 2009; Hayes et al. 2014). The most common impacts from exposure to environmental odours are firstly from the loss of amenity and secondly from reported impacts on wellbeing. Loss of amenity can be recognised in many forms, e.g. not wanting to use a garden or go outside; having to keep windows closed; not being able to invite friends to one’s own house; a shop, restaurant, hotel or trade business losing visitors or customers; etc. Impacts on wellbeing are less direct but still recognised as significant. Whilst direct, physical health effects from exposure to an odorant are normally only recognised for specific chemicals such as Hydrogen Sulphide (H_2S) at high concentrations, physiological health outcomes from the psychological effects of odour annoyance have been reported (Aatamila et al. 2011). In short, annoyance from odour is a direct and intrusive impact on peoples' lives. Therefore, regulation focusses on the sensory impact as opposed to chemical composition already defined in other emission limits.

Regulation of the water industry

Water industry regulation is complex and is no different in Scotland where service quality, service cost and environmental protection are all priorities. Since April 2002 when established, Scottish Water has been regulated in all areas of its clean water and wastewater services for households and businesses. Regulation covers the quality of the services it provides to household and business customers as well as its economic efficiency in providing and maintaining these services.

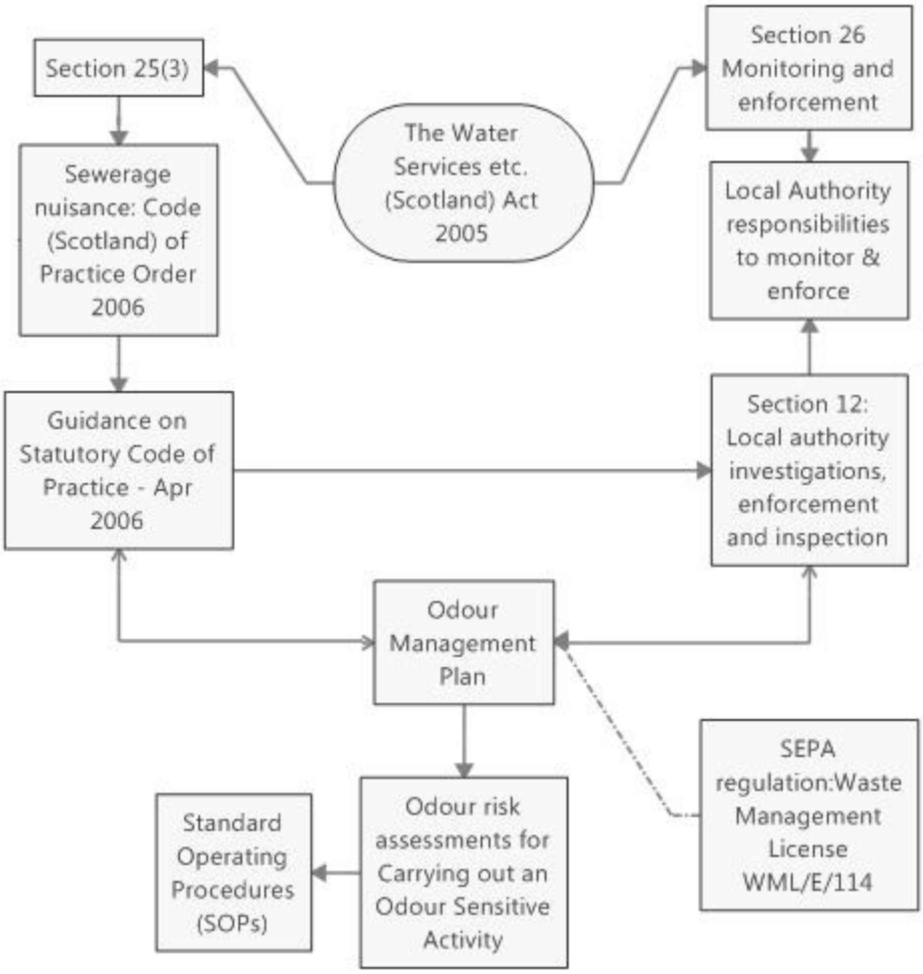
Funding for Scottish Water is largely derived from charges to its customers, i.e., households and businesses, with additional borrowing approved by the Scottish Government. As a public service monopoly, Scottish Water operates within stringent performance indicators and customer service targets specified by the Water Industry Commission for Scotland. These include statutory financial targets designed to significantly reduce its operating costs as well as improve the efficiency of its capital investments. The water sector is one of the most heavily regulated areas of industry and a hierarchical series of legislation and guidance define obligations and requirements for Scottish Water.

European legislation sets the context for key national obligations notably where, equity of access to markets or the risk of harm on a large-scale is a legal concern, e.g. pollution to the wider environment. In applying the principle of subsidiarity, the EU seeks to ensure that ensure that decisions made are as close to citizens as possible. As a result, typically national and local governments are responsible for environmental compliance.

The Council Directive 91/271/EEC concerning urban wastewater treatment, adopted on 21 May 1991 places an obligation on member states to protect the environment from the adverse effects of urban wastewater. This specifies requirements for the collection, treatment and discharge of domestic wastewater, mixed wastewaters and wastewater from specified sectors. The first direct consequence for Seafield WwTW was the prevention of disposal of sewage sludge at sea from 1999. This requires all water authorities including Scottish Water's predecessor authorities, to treat sewage sludge and retain treated products on land for disposal. Immediate improvements in bathing water quality have been evident from this regulation. A further requirement was the provision of secondary WWT for all plants serving a population equivalent above 10,000 in sensitive areas. This remains in place and forms the basis for treatment in all conditions including storm flows. Seafield WwTW makes provision to ensure this compliance. The site includes comprehensive treatment processes. Storm flow provision is also included where screening, settlement in storm tanks and dilution prior to long sea outfall takes place.

Obligations within the Water Services etc. (Scotland) Act 2005

Figure 4.1 Legislative context for odour regulation



The Water Services etc. (Scotland) Act 2005 sets the context for odour regulation from wastewater. Prior to this period, concerns that the legal framework of the UK Environmental Protection Act (1990) did not make adequate provision for nuisance cases led to inclusion of a voluntary code of practice for the control of odours from WwTW. This was issued in April 2005 which in turn was superseded by the Sewerage Nuisance (Code of Practice) (Scotland) Order 2006 and subsequent guidance. Figure 4.1 shows the relationship between these elements of legislation. Separate to this legislation is waste management licensing, shown by a dotted line. This is included as the current Waste Management license also refers to the site OMP (see further).

The Code of Practice - The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006

Section 26 of the CoP states:

> *"…that each local authority must monitor compliance with the CoP and where complaints of Sewerage Nuisance are made to it, to investigate the complaint. If the*

local authority is satisfied that Scottish Water is not complying with (or is not likely to comply with) the CoP, the authority must serve an Enforcement Notice on Scottish Water. The Enforcement Notice may require the execution of such steps necessary for ensuring compliance with the CoP and must specify the date by which the requirements of the notice are to be met." (para.2.1.4, p.6)

The guidance lists a series of requirements in detail, notably in Paragraph 4 of the CoP which defines the stages of WwTW that must ensure compliance. However, the obligation to achieve odour control within 'Best Practicable Means' (BPM) so as not to cause a nuisance is the fundamental requirement. Section 5.3 attempts to define odour nuisance recognising that odour characteristics as well as persistence in the environment and interference with enjoyment of the amenity of a neighbourhood must be taken into account. The CoP also recognises that whilst odours may occur, that the test of best practicable means must be applied when considering the extent of control required. Para 5.4 then sets out the characteristics used to determine odour nuisance.

The CoP guidance explains how BPM can be used to specify a baseline standard designed to assess, control and minimise nuisance, as follows:

The term best practicable means (BPM) is defined in Section 25 of the Water Services etc. (Scotland) Act 2005 as:-

''best practicable means' is to be construed by reference to the following provisions -

a) *"practicable" means reasonably practicable having regard to local conditions and circumstances, the current state of technical knowledge and to the financial implications; and*

b) *"means" includes the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings and other structures; (Section 2.4, p.8)*

The common key in determining BPM is the focus on what is 'practicable', i.e. to what extent should cost be a consideration and therefore decisive factor in determining an acceptable standard of operation.

The guidance offers two pointers to understand the basis for interpreting the significance of cost.

The key issue when determining bpm usually relates to the interpretation of 'practicable'. The definition includes cost consideration but clearly cost is not necessarily the decisive factor. The procedures and controls outlined in this guidance establish a basis against which the term 'best practicable means' (bpm) for control and minimisation of Sewerage Nuisance due to odour from WWTW can be compared. (Section 2.4.2, p.8)

In Section 3.2.1 It then goes on to explain,

There is no simple "one-size fits all" solution to odour problems: often there is a combination of measures that go towards resolution of the problem. These can range from very simple (and often very inexpensive) measures, to very complex *(and often costly) measures. Therefore, it is important that a timely, realistic, cost effective and proportionate approach is taken to resolve odour issues.*

Therefore, in addressing the ToR two considerations are pertinent.

Firstly, is the use of bpm effective in guiding the regulatory basis for specifying odour controls measures that, on the one hand prevent nuisance beyond the site boundary, whilst secondly balance excessive cost for Scottish Water customers, and

Secondly, does the CoP provide an adequate basis for regulators to assess, monitor, review and intervene on wastewater plants to ensure that odour issues are resolved using a proportionate approach?

If the above considerations are effective it is then reasonable to expect that significant nuisance should not persist.

Key to this determination is the CoP Requirement in Paragraph 3

(1) The objective of this Code of Practice is to apply the best practicable means for assessing, controlling and minimising odour nuisance.

(2) Without prejudice to sub-paragraph (1), this Code of Practice applies the best practicable means to control odour emissions from contained and fugitive sources to ensure that emissions do not create an odour nuisance beyond the boundary of the WWTW.

Therefore, confirming odour nuisance beyond the boundary must form the basis of all assessments. This approach is consistent with a wide range of sites across the UK and in other countries.

There is no expectation or requirement for the process of minimising nuisance to be anything other than precautionary, i.e. it is not dependent on causing nuisance in the first instance.

4.2 Effectiveness of and implementation of the CoP

Achievements, limitations and opportunities

To date, the Code of Practice has resulted in a number of major changes being instigated at Seafield WwTW, notably:

- Development of an Odour Improvement Plan (2008-2011) which, following its implementation resulted in a significant reduction in odour;
- Preparation and ongoing updating of the site Odour Management Plan (OMP);
- A series of odour risk assessments for carrying out odour sensitive activities;
- Standard Operating Procedures (SOPs) including reference to odour control measures; and
- Regular reporting of odour monitoring, management procedures and controls including reports of complaints, their investigation and actions taken.

The CoP refers to basic control measures applicable to all works as well as enhanced measures where these are necessary to achieve adequate control, albeit within a limited scope of technology options.

The effectiveness of these control measures has demonstrated a significant reduction in odour emissions, particularly from the implementation of the measures contained in the OIP. The influence of the CoP is clear in that it achieves and continues to influence a reduction in odour emissions.

However, the evaluation between causing odour nuisance and deploying best practicable means (BPM) forms the basis for determining intervention. These are both 'relative benchmarks', i.e. context specific and not 'absolute' metrics which can be used as a point of reference.

Guidance to indicate potential odour nuisance within the CoP uses a formula that includes subjective as well as quantitative values, i.e. frequency, persistence, meteorological conditions, as well as locality & sensitivity. Whilst example calculations are included within the guide, a numeric value for what is an acceptable or unacceptable limit or threshold is not given.

An interpretation of this guidance could result in a site operating until complaints arise and then attempting to determine an acceptable threshold of nuisance. However, the 2008 OIP adopts an odour annoyance criterion from custom and practice within the sector of 5 ou_E/m^3 98%ile of hourly averaged concentrations modelled over a year to define a contour limit for emissions. The 5ou_{E}/m^3 contour was used as a comparative for cost-benefit analysis of the options for odour reduction under consideration at the time.

Whether this exposure threshold is adequately stringent can be debated. In the current context a reasonable emissions monitoring standard would be one that complies with a 3ou_E $/m^3$ – 98-percentile modelled output for the aggregation of all sources. However, use of a fixed value allows an assessment of emissions to be completed on the completion of remedial works, complaints to be evaluated from a knowledge of 'normal emissions' or exceptional incidents, and for bpm to be evaluated against a fixed benchmark of emissions.

To date whilst this 5 ou_E contour was used as a comparative tool for cost benefit analysis, this approach has never been used as a measure or benchmark of ongoing performance. This represents a lost opportunity to learn from the outcome of the OIP design process.

4.3 Odour Management Plan

An odour management plan is used as a method, design, or scheme that is routinely in use to understand all measure on site, prevent and reduce odours. Therefore, if an OMP accurately describes the site and its operations it will prevent the routine release of odours as well as help detect odours exceptional incidents when these arise.

When considering the effectiveness of an OMP a close analogy is possible with the way in which Health & Safety plans operate for a site. Effective site H&S plans in operation will be evident to every person as they arrive. All visitors, contractors, site operators and managers will be exposed to elements of the plan with appropriate levels of detail based on their role. Few, if any, staff will have to know the entire plan. However, all will have to understand and be responsible for the elements of the plan relevant to their role. At the simple level, responsibilities for a visitor may require a site induction, wearing PPE, and being guided on site at all times. In contrast, the plan may place responsibility for controls such as risk assessments, operating procedures, contingencies for emergency, etc. directly on specific individuals. All on site will know their responsibilities, even though few may know the entire H&S plan.

It can be recognised that just like a H&S plan, problems with odour management plans often occur with its adoption. Both H&S and OMP cannot be 'paper-trail' exercises. When an OMP works well this is the most proactive and effective method to prevent odour. However, examples of this method failing do occur, typically when either it is written for the operator rather than by the operator; the OMP is kept off-site, 'in a locked cupboard', is too big; no one knows it exists; or it is not converted to job roles it cannot be adopted. All can be causes of failure of even a good OMP.

Odour management plans need to be designed so that they consider the complete process sequence from all inputs, processes and outputs, as well as make contingencies for equipment failure and emergencies.

The Odour Management Plan is specified as a requirement in Section 6 and Annex 4 of the CoP. The current document in use at Seafield WwTW by Veolia, Issue – 2 Version – 8[5] explains the purpose of the OMP then sets out details of the:

- Site information;
- Site management;
- Odour monitoring and odour control units performance standards;
- Operational practices for odour control; and
- Completion of actions and revision of OMP.

Appendices, tables and figures provide further detail on standard operating procedures (SOPs) and reporting mechanisms.

At Seafield WwTW a monitoring programme is in place around the site reporting process odour controls, liquid and solid flow levels as well as boundary monitoring. Monitoring of H_2S takes place at 4 separate site locations and is consistent with the other PFI sites and best practice. It is evident that the measures specified within the OMP are in place, the roles relevant to odour control are understood, and that the odour controls are managed as specified within the OMP.

However, with monitoring in place and results available to the site, Figure 5.11 shows a high level of H_2S at a 15min average on 26th May, 2017. This coincided with 6 complaints from the community, investigated by the operator. It is normal that where this investigation identifies a process problem remedial actions follow.

H_2S measures are not specified as boundary limits within the OMP. Similarly, odour concentration percentiles are not adopted as a precautionary approach within the OMP. This limits the scope of understanding and overlooks an opportunity to define control. The result is that determination of the need for enhanced controls is left to judgement based on a perception of odour nuisance and whether bpm is being applied, i.e. two qualitative judgements.

[5] Version #9 was issued 22/11/17 after the compilation of this report

Many cases exist where the design and regulation of sites is specified to comply with emission limits. In such circumstances, benchmark levels based on the 98th percentile concentration for sensitive receptors is used to understand the potential for odour annoyance. Data available from previous studies, e.g. the Mott Macdonald (2013) emissions inventory, show the value of these results when modelled, see Figure 5.19.

4.4 Waste Management License

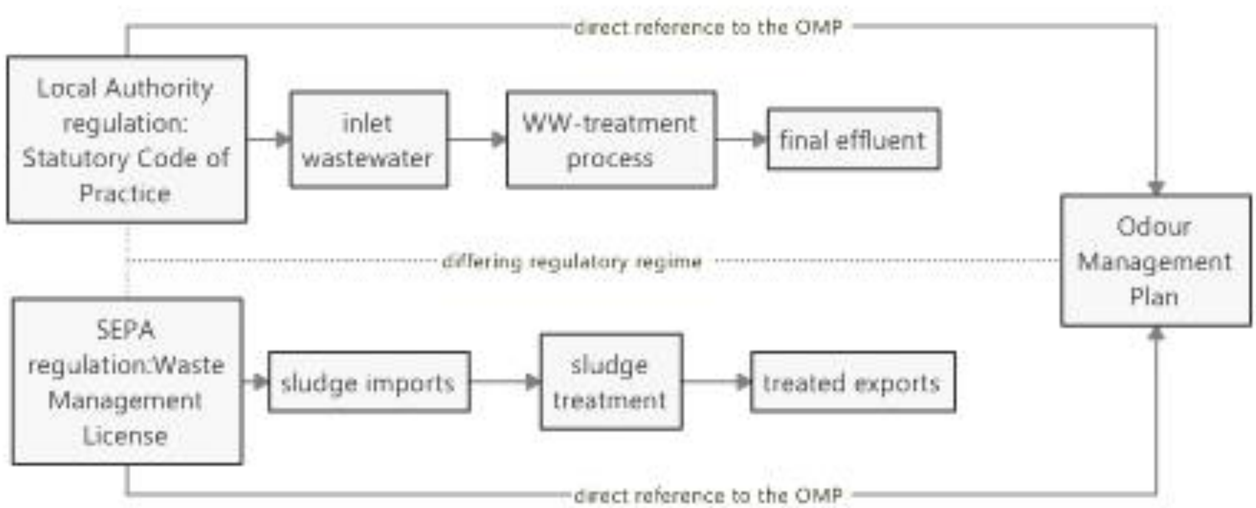
SEPA has sought legal advice to determine the regulatory regime that should apply for the sludge operations on site. The site currently operates within a Waste Management License as opposed to a PPC permit.

A 'holding position' issued by SEPA (August 2012) includes the Seafield WwTW site within what is referred to as the 'UWWTD exclusion'. This has the effect of not requiring the operators at Seafield WwTW to apply for a PPC permit and thus comply with BAT (Best Available Technology). However, Paragraph 6.3 of the CoP (Odour), states:

> *"Sludge reception treatment and storage facilities are designed and operated in such a manner that offensive odours from the site, in the opinion of an authorised SEPA officer, do not become detectable at any point outside the site boundary.*
>
> *The site will be operated in accordance with the Odour Management Plan.*
>
> *Identification of a new source of odour shall prompt a review of both the Odour Management Plan and the Waste Management License Working Plan."*

Both regulators refer to the OMP as the basis for defining and assessing site controls.

Figure 4.2 Dual-regulation both referring to the OMP



To understand the risk of unacceptable emissions, if the OMP specifies a programme of annual measurements for modelling, there is a clear opportunity for regulators to approach regulation of all areas of the site consistently. Open and transparent reporting of results within the OMP is then available for both regulators.

4.5 Site controls

The OMP references a series of site controls including operational procedures for high odour risk activities. The researchers have observed a number of these processes taking place during the review, including storm tank cleaning. It is clear that the training and job roles are well defined and that odour sensitive processes are identified. Understanding of these process impacts comes from investigating complaints.

However, as noted in the previous section, quantitative indicators, i.e. H_2S or odour unit measurements are not used as emission limits. Their use is in retrospectively interpreting and understanding complaint events.

Knowledge of the effect of emissions from specific processes off site can be used proactively by either, setting odour unit emission limits or using H_2S as a proxy measure for odour emissions.

4.6 Influence of the regulatory framework

Local authority responsibilities to monitor and enforce the CoP are undertaken with significant resource commitments by the local authority (CEC). The requirement to demonstrate nuisance to serve a notice for prosecution requires the investigating officer to:

- Substantiate unacceptable odours at sensitive receptors, e.g. households;
- Attribute the odour to the site, i.e. ensure it is from no other source;
- Identify the failure leading to the emission, then;
- Define the outcome required to prevent odour nuisance.

This sequence ensures that notices are served correctly to the process operator and that the remedy required is appropriate. However, the process is 'reactive' and dependent upon completion of the above sequence. The unplanned effect of this approach is to expose the community to odour prior to assessing nuisance. This is not a limitation within the CoP or regulatory framework, but a limitation in deploying quantitative measures and predictive methods to understand the dominant causes of odour release onsite.

4.7 Conclusions

The Code of Practice provides statutory guidance. It outlines the basis for defining operational requirements to control odour emissions. The measures specified address the majority of requirements for a typical WwTW though, since its original drafting there have been a number of technical advances. Selection of these measures is based on an assessment of best practicable means.

The OIP of 2011 used odour modelling at a point in time to evaluate options for abatement efficiency. Guidance within the CoP also refers to the use of modelling as a basis to determine acceptable emission limits. This is useful as a means for strategic review. However, this is not practicable as a method for day-to-day management.

Current H_2S measures taken on site have potential to be used to trigger further investigation at a defined threshold.

Assessing nuisance off site is currently the main basis for determining unacceptable emissions. This approach has the unplanned effect of 'testing' the efficacy of controls on the surrounding community with unacceptable consequences.

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4.8 Summary findings of this report chapter

- The Code of Practice (CoP), "specifies the framework within which Scottish Water and its contractors and local authorities will operate to minimise the impacts of odours from WWTW, and identify steps to tackle nuisance odours;"
- The supporting guidance for the CoP defines a wide range of appropriate measures to assess, monitor and control odour emissions at wastewater treatment processes. The guidance recognises that details of the management measures are not exhaustive. Similarly, the guidance recognises that a simple, 'one size fits all' approach is not effective. The guidance recognises appropriately that it is the responsibility of the operator, working with the local authority to investigate complaints to then prevent nuisance odours:
  - Section 1.7 of the guidance refers to the Scottish Odour Steering Group (SOSG). We have not investigated the work of this group, as SOSG became a regulatory sign-off Group for SR06 and SR10 odour investments. The last meeting was around November 2011.
- There are no restrictions to improvement within the CoP as it recognises that if odour nuisance persists, a review and improvement plan should be developed containing a hierarchy of odour intervention measures linked to cost-benefit analysis. This approach remains effective and meets its objective in setting the framework to prevent odour nuisance;
- The CoP applies a test of best practicable means (bpm) for assessing, controlling and minimising odour nuisance. This has the benefit of prompting operators to ensure that, "…emissions do not create an odour nuisance beyond the boundary of the WWTW" (CoP – Paragraph 4 (c). This sets a framework for operators to seek the best alternatives of odour control that ensure nuisance does not occur but without defining measures that impose excessive cost. The fundamental test is interpreting the combination of odour and nuisance;
- The CoP specifies the requirement for an Odour Management Plan (OMP) to identify all processes with the potential to cause odour, and to monitor and implement measures to prevent emissions with the potential to cause nuisance. Our examination of the control measures in place and the procedures implemented on site show that; where emissions are identified, appropriate procedures and control measures are in place and being used;
- Guidance within the CoP explains the range of methods that are possible to assess odour impact. This includes qualitative data from complaints as well as quantitative data used in odour modelling (Section 7.5). The guidance is correctly cautious on proposing reliance on modelling alone. However, it recognises the importance of using quantitative methods alongside other evidence;

- Similarly, odour incidents caused by new** (see comment below) equipment and processes are dealt with 'reactively' by identifying the cause, defining and implementing mitigating measures that then lead to a reduction in odour. Exceptions to this are 'incidents' such as sludge spills which could have been foreseen;
- The review of current site controls shows that these are understood by managers and operators, in use and appropriate. However, it is evident that there is a lack of awareness of the significance of low-level emissions off-site. These are not addressed specifically within the OMP;
- A 'proactive' approach to both low-level emissions as well as new processes needs to be addressed. Examples could include an annual emission modelling reviews and an odour focussed - hazard and operability study (HAZOP) approach to new equipment would address these limitations within the current OMP; and
    - In summary, the CoP provides an adequate basis to regulate odours from WWTW across Scotland. The bpm test is difficult to apply without exposing communities to a test of nuisance, which can result in a sustained period of exposure to intermittent unpleasant odours. Therefore, a baseline metric is included within the OMP. A suitable baseline could be adopted using emissions modelling at odour sensitive sites. Adoption of a comparable standard such as 5 ou_E/m^3 at the 98 percentile [this was the basis of design for the OIP optioneering] for all treated odours, in use in many parts of Europe including the SEPA Odour Guidance https://www.sepa.org.uk/media/154129/odour_guidance.pdf] would be appropriate. Untreated odours, i.e. raw sewage, could then comply with a more stringent 3 ou_E/m^3 standard or 1.5ou_E/m^3 standard for odour sensitive locations.
- Where new equipment or processes are to be adopted, these need to be assessed for the risk of an increase in both low-level as well as incidental releases. The assessment of bpm remains unaffected as all measures must be reasonably practicable.

5. Concerns about the site and previous investigations

This section of the report explores and analyses key current concerns about the infrastructure in and operation of Seafield WwTW from the points of view of all stakeholders. This includes the local community, residents' groups, the Community Council, City of Edinburgh Council, elected representatives, SEPA, Scottish Water and the site owners and operators.

Introduction

The terms of reference confirm the need to understand the following issues by consulting with stakeholders on:

- Odour complaint data and consult with all relevant stakeholders (i.e. Scottish Water, Stirling Water, City of Edinburgh Council, SEPA, Community Groups), regarding their perspectives [and aspirations] regarding odour management.

(extract from the Terms of Reference)

5.1 Method of stakeholder consultation

Stakeholder groups and the study sample

Scottish Water suggested an initial list of stakeholders to consider with a supporting explanation of their role, see Table 5.1.

Using this list as guidance, the researchers reviewed this to include public and elected officials as well as company representatives for roles linking to: inspection, regulation, investigating and responding to complaints; as well as for those concerned with site operation, management and ownership.

Developing the sample of formal and informal roles, the researchers ensured that invitations were sent to members of the local community not only via CEC but also through community groups such as LLRA and LLCC. Thirty-two individuals across all these groups contributed via meetings, telephone interviews and email exchanges. Response rates were very high when compared to other forms of environmental survey or investigation. Response rates are commonly 5-10%. In this instance, the lowest response rate to an open email invitation to complainants was 50% within the first week indicating that this is an issue on individual's agenda and that they wish to express their views.

In addition to the 32 interviews and meetings attended, the researchers observed an Odour Liaison meeting held at the site, led a joint meeting with councillors and gained information concerning exposure to odours from local organisations and businesses in the area. Information circulated via email and social media amongst the community groups also contributed to a good level of awareness about the study. This further assisted in inviting individuals to express their views. Meeting arrangements included weekdays and evenings in the Leith locality. Where this was impractical for an individual, email or phone interviews were set up to discuss views and then exchange a record of the meeting.

Table 5.1 Suggested Stakeholder Contacts

Organisation	Role
Scottish Water (Client)	Staff including individuals from the PFI team, SW operations team whose networks interface with Seafield WwTW. In addition, representatives from SW Communities and Asset Planning teams were consulted.
Stirling Water	The PFI Company, representatives including management and board members.
Veolia	The Site Operator, individuals at management and operational levels.
City of Edinburgh Council Environmental Health Department	The council are the environmental regulator for the wastewater treatment operations of the site. The council regulate conduct within the COP.
City of Edinburgh Council Councillors	Three councillors, from three different political parties who represent the ward in which Seafield WwTW is based
Scottish Environment Protection Agency (SEPA)	SEPA are the environmental regulator for the sludge treatment operations of the site.
Member of the Scottish Parliament	The local MSP is also the chair of the Seafield Stakeholder Group
Leith Links Residents Association	LLRA is non-statutory body has campaigned to achieve changes to the site having contact with residents in the locality and maintained contact with politicians and the media
Leith Links Community Council	LLCC is a voluntary organisation with democratically elected representatives for the area, which has also complained about odours from Seafield WwTW and campaigned to achieve changes to the site.
Independent consultants	Individuals who have provided advice to either the community, Scottish Water or Veolia

Confidentiality, attribution and internal audit

Applied to all interviews were three working principles:

1. Ensuring confidentiality;

2. Agreeing the information to be noted and not attributing statements to any individual, or in such a way that an individual can be identified; and
3. Ensuring compliance with Data Protection and the Freedom of Information Act

Construction of the survey

Table 5.2 shows the representation of responses by group. Sampling was organised to understand the diversity of views across the stakeholder categories regardless of numbers within the sample. This is in contrast to statistical sampling where identifying dominant views is the main objective.

Table 5.2 Summary of representation from consultee groups

Consultee groups represented	Respondents
Water & PFI company representatives	3
Site operator representatives including operators & contractors	3
National, regional and city elected representatives	5
National and city regulators	4
External advisers / consultants	2
Community representatives via council complaint database	5
Community representatives via community group invitations	10
8x consultee groups. The total number of interviewees =	32

The role of community surveys to investigate odour

Surveys and interviews are common as a means to investigate odour as they often reveal information on the following:

- Collate information and data to explain the characteristics of exposure: the nature, frequency, persistence, meteorological conditions;
- Collate information and data to explain the approaches to and experience of, complaining and investigating complaints; This includes recognising:
  - Knowledge of the complaint system and experience of complaining;
  - Understand concerns and motivations for complaining, e.g. levels of annoyance/loss of amenity,
  - Understand expectations of change, expectations of success,
  - Understand stakeholder’s experience of receiving a response, and
  - Understand sharing of experience, social media, details and encouragement to complain, and heightened local or political awareness.

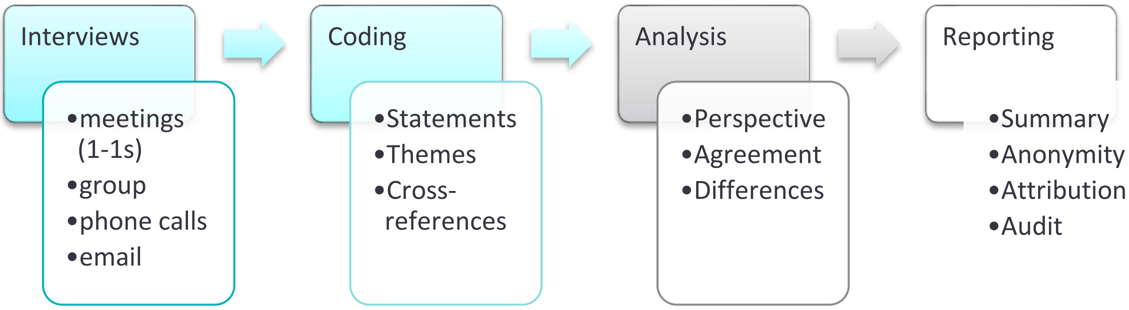
- Provide evidence on the patterns of incidents from an analysis of information from stakeholders; to prioritise site investigation and determine the need for sampling, measurement and further investigation; and
- Provide recommendations for the resolution of odour complaints;

Information from the interviews informed comparisons with complaint data, and modelling results, as well as a set of themes directly targeted to understand the experiences of stakeholders.

5.2 Interview themes & results

The sequence of analysis to achieve this is shown in Figure 5.1:

Figure 5.1 Data process for stakeholder meetings: coding, analysis and reporting



5x themes were addressed in all interviews:

- Residence and or experience of odour issues from the WWTW;
- First detection or problems from Seafield;
- Experience or knowledge of the impact of odours from the WWTW and their description;
- Experience of the complaints system & reporting odours; and
- Experience of improvement and expectations for improvement.

Respondents discussed these in an open-structured interview placing greater emphasis or providing more detail in those areas where they had greatest interest, concern or experience. The grouping of themes and search for common themes then led to recognising areas of common agreement providing those issued presented in the summary.

Below are a series of non-attributed, anonymised quotations for each of the five themes. The table in each section includes a randomised ID reference for the researcher and independent auditor to cross-reference citations with records from respondents. Limited examples are cited, i.e. not all respondents. The presentation of results are in this form as data access is restricted to the Cranfield University internal audit to assure confidentiality.

Residence and or experience of odour issues from the WWTW

Respondents had a wide range of experience of living in the Leith Links and Seafield area with residency spanning from 18months to nearly 50 years, with contributors complaining across a period of only a few occasions in some cases to multiple occasions across many years

On the theme of "residence and or experience of odour issues from the WWTW" examples included the following:

"[I]…have lived in Leith nearly 30 years and been aware of the issue throughout this time. In the last 10 years, there have been significant improvements. However, in the last 3 years there have been major problems…"	**ID 26**
"…Seafield odour has been the No.1 issue…"	**2**

Odour from Seafield has been a significant concern for a long period. The improvements referred to are those from the implementation of the OIP (2008) where many residents identified a notable reduction. However, exposure to odours has persisted.

"…Smells from the site can extend as far as Leith Walk and Edinburgh Road. Areas affected include […], many neighbouring areas."	**ID 21**
"…There have been ongoing noxious smell problems for decades. Smells are inconsistent and unpredictable, but are often worse in good weather, when parks and gardens can't be used…"	**26**
"…Seafield is a long running operational pressure…"	**10**
"…the smell occurs slightly less frequently than years ago, but it still happens far too much…"	**30**

First detection or problems from Seafield

Respondents from all groups described their experience of odour from Seafield, both pre and post the implementation of the OIP.

"…People living in the area have different experiences and expectations, e.g. some get problems when it's bad which causes annoyance on a handful of occasions…"	**ID 14**
"…1st noticed the smell 39 years ago, detected it when I returned to the area. 30 years ago councillors were concerned…Then the smell adhered to clothes…" […] "…5 years ago I had visitors […] who asked, 'can we move inside?' At that time, we often went inside the house because of the smell…"	**22**
"…Odours have always been a problem. I first spent months pouring bleach into the drains until a neighbour told me it was Seafield. […] "It hasn't got worse, but it couldn't have. It continues" […] "When it's bad I close the windows and doors. […] When it's bad you have to be closed off […] indoors to remove the smell."	**24**

"…Throughout [my experience] Seafield has remained an issue. … [...post OIP…] Improvements have been huge…"	**11**

Experience or knowledge of the impact of odours from the WWTW and their description

Respondents described their experiences of exposure to odour from the WWTW, both prior to and following implementation of the improvement plan. Examples referred to both the frequency and pattern of exposure as well as the impact resulting from a change in behaviour or loss of amenity from odour exposure at local facilities. Views of respondents varied greatly on the extent of change and improvement from the site that they had experienced. This was reflected across all stakeholder categories. Improvement was noted in some cases even where residents remained unhappy with current performance. In most cases, the overall view reflected was of a significant reduction since the OIP, yet ongoing incidents due to weather conditions and specific incidents.

"I have an elderly neighbour who has complained. I have been woken at night with choking, cabbage smells…" "We had a terrible burning tyre smell. It was eventually found to be Seafield after two weeks. People were checking their cars…"	**ID 24**
"…I have had three very close friends who moved away from L-Links because of the smell…"	**22**
"…-frequent complainants are known…angst from new residents is [also] recognised…"	**8**
"…The siloxane […] event. …Press reported that the smell was waking people up in their sleep…"	**10**
"…It's disgusting and certainly has an impact on family life. Plans can be cancelled because of it – who wants to play on Leith Links with the kids, or have visitors round when the whole surrounding area stinks of sewage…" "this can affect morale, cause arguments over changed plans, embarrassment to home owners etc."	**30**
"…When it is bad; you cannot sit in gardens, cannot barbecue, people have to leave the town. It is embarrassing when expecting guests – this is our home. Without realising, people sniff the air as they leave their houses to see if there's an odour."	**32**
"…[this smell…] is always a nuisance whenever detected. Humans are 'hard-wired' to be repulsed"	**21**
"The effect is emotionally powerful. …it makes you angry, the response is ineffectual, and the experience is stressful. You don't know when it'll next happen. You can't plan, you have no idea, good weather can be a factor.	**29**
"If you had an abusive neighbour that shouted and prevented you using your garden this would cause an underlying stress… I don't know when I can invite friends… I have no assurance of no smell…"	**23**

Experience of the complaints system & reporting odours

Views on the efficacy of the complaints system again varied greatly. Concerns about complaint fatigue were expressed whilst others felt that they knew how to complain. However, expectations of improvement or changes to process controls occurring from complaining were low, as were the likelihood of regulatory action taking place such as serving an enforcement notice.

“The pattern [of complaints] is cyclical, intense activity then quieter.”… “There is acute community tension some individuals are at the extreme end of concern.”… “A wider part of the community complains when there are specific incidents.”	**10**
“The idea that people, ‘don’t know who to complain to’ doesn’t seem correct. [people have been] complain[ing] for years”	**11**
“The method by which people can complain and protest is not fit for purpose, and feeds into the cynicism and resignation.” “…smell emissions are often transitory/varying with wind etc and by the time the officials come…, there may be nothing to detect.”	**29**
“If the community understand the issue is being taken seriously then this will help. People are despondent about the complaints process. There is a feeling of ‘nobody cares’ that, ‘when it’s a sunny day and the plant is smelling that we can’t use the garden’.”	**19**
[Complaint system] – “they’re very pleasant but by the time they investigate it’s often too late.”	**24**
[Are you satisfied how your complaint(s) have been dealt with?]…”So far, yes, albeit slowly. Ultimately, however, the answer depends on the action taken to resolve the smells.”	**30**
“The process is not easy and the community has the perception of no change arising from complaining.”	**13**
“There is evidence of complaint fatigue.”	**15**
“…someone will come to witness the incident. This has been a problem, i.e. to confirm’ an odour that already exists. If it is not substantiated by attendance this undermines the process.”	**32**
“It is wrong that the situation relies on individuals reporting.”	**29**
“Defining an odour nuisance by intensity, frequency etc., is subject to interpretation. Frequency and the duration of odours from the site is significant.”	**21**
“…the “standard” responses to …complainants appear to be too generic and not incident-specific. […] It would be more appropriate to include an acknowledgement of specific issues and operations & conditions on the particular day.	**3**

“[On some occasions], when odour complaints are received and an investigation is initiated, there is no obvious source or cause identified on the WwTW site… feedback on the complaint along the lines of “no odour source identified”,… can be regarded by the complainant as an unsatisfactory response.”	**4**
“They’ve made it as hard as possible to complain…”	**23**
“It is always the community alerting the council…”	**21**
“Complaint fatigue is happening from the lack of expectation of a resolution. The community want a significant reduction.”	**33**

Experience of improvement and expectations for improvement

Views differed on recognising whether improvement had taken place or not. A pattern emerged of recognised improvement since the OIP with a notable reduction in persistent high concentrations of odour. However, this cannot be equated to satisfaction. Recent significant events in 2016 and this year have highlighted a perception of lack of control. In addition, lower level concentrations of odour persist for householders in specific locations around Leith Links.

“My personal experience is that there has been a significant reduction in odour emissions from the site over the past 15 years”	**1**
“The CoP requires minimisation … […] It is not achieving a baseline performance…”	**4**
“perhaps the smell occurs slightly less frequently than years ago, but it still happens far too much”. “My expectation is that there should be no smell whatsoever”	**30**
“Real improvement would be where the odour does not exceed the boundary wall alongside the works.”	**22**
“It is important to recognise the interpretation of ‘minimisation’… ‘minimisation’ as ‘best in class’ across Scotland, England & Wales, which is known as ‘minimisation’ differs greatly from the community perception of ‘do the minimum’	**19**
“Transparency is an issue. In other regulated sectors, e.g. construction sites regulated on [operating hours] …if limits are breached ….this places a level of control [of evidence] for householders.	**11**
“Residents are in ‘complete disbelief’ and cannot understand how this problem continues, i.e. how can they not get it fixed?”	**9**
“Whilst elimination may not be possible, it must be possible to ensure that the smell is minimised…”	**32**

“The ‘rubber’ and Apr/May incidents demonstrate a lack of honesty and resulting in loss of confidence in the company and future operations.”	**29**
“Future development [near the site] incurs a risk of encroachment… benchmarking against others is important.”	**1**
“The community has an expectation of investment (supported by management).”	**21**
“A holistic approach is essential that recognises the role of scientists and engineers to address problems that are inherent within the network.”	**33**
The future ‘story of the site’ needs to consider the contribution that Seafield makes to the city by reducing pollution, saving energy and ensuring that wastewater-discharges are compliant.	**14**

The summary of reviewing all interviews, collating themes and comparing these is presented in a series of summary blocks in the following pages. It is important to note that the objective is to reflect the range of views and to use this to inform other evidence within the review.

5.3 Summary findings of this report chapter

- Meetings with stakeholders broadly covered 8 categories of consultees including:
    - Scottish Water & PFI company representatives;
    - Site operator representatives including operators & contractors;
    - National, regional and city elected representatives;
    - National and city regulators;
    - External advisers / consultants;
    - Community representatives via council complaint database; and
    - Community representatives via community group invitations and the researcher following up recommendations.

Contact with the community was elicited in 4 ways. Firstly, the City Council invited individuals within the area who had complained to contribute. This included new as well as frequent complainants. Residents were invited to contact the researcher by the Community Council. Similarly, residents were also invited to contribute by the Residents Association. A small number of individuals who had learnt of the study contacted the researcher. In addition, the researcher followed up recommendations to speak to businesses and neighbours who may have had concerns. This included businesses in close proximity to Seafield. 38 individuals were contacted and 32 meetings with representatives were recorded. All who were contacted were happy to discuss the issue and valued the opportunity to contribute.

- Interviews with stakeholders were based on questioning 5x themes as follows:
    - Residence and or experience of odour issues from the WWTW;
    - First detection or problems from Seafield;
    - Experience or knowledge of the impact of odours from the WWTW and their description;
    - Experience of the complaints system & reporting odours; and
    - Experience of improvement and expectations for improvement.
- Interviewees discussed the above issues but were not restricted to these alone. All discussions were recorded confidentially and agreed with respondents;

- Leith is held in high regard by its residents and businesses, and valued as a historic and attractive place to live and visit;
- Outside of the City, Leith is in the top 5 employment locations with 5% of all jobs located here. 2,200 children attend school in Leith and amongst all areas in Edinburgh, Leith has seen very substantial growth;
- The 2011 census reported the location with the highest population density in Edinburgh as the Leith Walk area. With a peak of nearly 26,000 people resident within an 800 metre radius. This is equivalent to a density of 12,900 persons per km^2. This local population density is higher than anywhere else in Scotland, including Glasgow. Scotland averages $67.2/km^2$. The Leith Links area is immediately adjacent.

  2004 plans for major redevelopment were postponed following the 2008 financial crash. However, growth in housing and business has increased with a recent resurgence of housing expansion around the Ocean Terminal area. No evidence of development restriction from the impact of Seafield was identified. Similarly, no examples of reduction in investor confidence were found. However, this is likely to be due to demand for industrial land being low compared to that of housing. Property price comparisons are considered inaccurate as there are a limited number of equivalent neighbouring areas to Seafield;
- Many positive characteristics of the neighbourhood were cited; the historical significance of Leith as an industrial area and working port; its strong connection with the history of social movements and the heritage of its industrial architecture. The sporting legacy and the history of Leith Links in establishing the rules for golf, plus in more modern times the role of the ports and hosting the Royal Yacht Britannia;
- Many residents spoke of their enjoyment of the local area, the presence of a local community and the qualities and strengths of being part of the community. This included newcomers as well as long-term residents;
- The Leith Links area, park and allotments are valued greatly as they provide opportunities for individual sport and teams, recreation, community and social events as well as educational activities within a densely populated area;
- Individuals expressed many differing views. However, there was clear agreement that the Seafield WWTW had a history of causing significant odour;
- There was general agreement that implementation of the OIP (2008) had made a significant reduction to odours. Prior to this, Leith had a notorious reputation for sewage odours from Seafield, which many described as horrendous. Reports of impacts prior to the implementation of the OIP included experiences of watering and stinging eyes, having to close windows, unable to hang out washing, not using gardens, not inviting neighbours, visiting friends away from the area and householders leaving the area. Householders described the land and housing area affected extending beyond Leith Links;

- For all the householders interviewed in the Leith Links area, Seafield WwTW continues to cause problems. However, there was general agreement that problems were less intense, with the worst instances caused by either, specific site instances, or aggravated by local weather or prevailing wind conditions, notably the haar or sea fret, i.e. a cold sea fog where dispersion is significantly reduced and odours remain close to source;
- Despite improvements from the OIP, descriptions of both ‘low-level’ odours as well as significant ‘incidents’ show an independent pattern of reporting across the Links area from all interviewees referred by each of the different sources. Those residents describing low-level odours used a range of descriptions, at the lesser end as; annoying’, ‘embarrassing’, ‘unpleasant’, ‘bad for the neighbourhood’, to being like, ‘an anti-social neighbour’ where the unpredictability is a constant source of stress and intrusion. In these examples, the lack of control on site perceived by the householder meant that residents could never predict when conditions would be good and there would be no odour. This unpredictability makes it difficult for some to plan events, invite friends and use their gardens or the Links;
- Where residents cited examples of specific incidents during interviews, notably; sludge spills, the siloxane event, and the Apr/May low flows, reports of the impact were consistent in their increased intensity. Impacts included, ‘being woken up in the night’, having to close windows at all times’, ‘hosting events for families and friends away from the house’, not being able to ‘hang out washing’. It is likely that the interviewees responding to the invitation to contribute were those most directly affected. However, it is important to note that the location of residents citing these experiences was across a large area of the Links. It is also relevant to note that the breadth of examples given including, cancelling barbecues & social events, personal reputation, use of gardens & gardening, children noticing odours, and the effect on visitors showed independence and variation between respondents;
- An ongoing concern expressed by many individuals in the stakeholder interviews was the extent to which there appeared to be a poor demonstration of control over operations to prevent odour emissions. Confidence in the reliability of odour control was poor, despite in some instances there being a good knowledge of the operational procedures reported to control odour. This perception was based on experience of repeated failures leading to major incidents, albeit for differing reasons. Examples of this perception cited the failure to disclose problems, such as the sludge spill; and an apparent lack of knowledge concerning new processes, such as the siloxane emissions;
- No concerns were expressed that directly related to the visibility of the site. Currently there is no housing encroachment anticipated but the land to the west of the site at Marine Esplanade is defined for use as industrial / commercial and therefore may house offices;

- Experience of the complaints system reflected concerns about the split responsibility differing between ownership and operation as well as dual-regulation;
- Many interviewees expressed confidence in the attention given to attending complaints and the professionalism given to complaint investigation. However, few expressed confidence in any improvement or there being a likelihood of enforcement resulting from complaining. It was evident that specific locations had notably high levels of complaints. These were suspected by many to match the exposure pattern and dispersion corridors of site emissions;
- Many reported frustration that 'an authorised officer' was required to attend in order to substantiate that an odour was present and causing a nuisance. This was recognised by some as an unavoidable requirement for a legal process, whereas others felt this conveyed a lack of trust of a resident's experience. Overall, a strong common view was that the community had to endure and report complaints before action, if any, would take place, i.e. a 'reactive' system of odour regulation, despite the CoP being in place;
- Some respondents amongst the household groups were aware of the dual-regulation by the local authority and SEPA. All those aware of this expressed concern about the consistency of approach and information sharing. These concerns were also expressed by many non-resident respondents. Amongst some members of the community there was concern about the lack of transparency over decisions to serve a notice or prosecute;
- The current complaint system was often reported as time consuming and slow, in particular, when compared to the transient nature of odour emissions during 'low-level' incidents. A number of examples were given where individuals had not bothered to complain where they had in the past. The reasons cited were the time taken and low expectation of change, i.e. complaint fatigue. Feedback on the final outcomes of complaints were often reported as 'limited'. Other respondents explained how they had been encouraged to complain, particularly recently to ensure there was a record of impact. The majority expressed an increased likelihood of complaining again if odours persisted; and
- When asked about what would be recognised as improvement, 'no odour' was the common statement. However, a number also explained that a marked difference from low-level persistent odours and control over major incidents would be noticed.

6. Analysis and results

This section of the report contains the results of the technical investigations carried out as part of this Strategic Review. This includes an analysis of complaints in relation to odour emissions and WwTW site operational characteristics, the influence of weather and location. Modelling of measured odour emissions from processes at the site is used to assess the likely current levels of odour impact and the role of the sewerage network in giving rise to odour emissions at Seafield is discussed. The individual treatment processes at Seafield are assessed for their potential to cause odour annoyance.

6.1 Summary of methods

The methodology that underpins this section of the report includes an analysis of recent complaints and establishing relationships between complaints and WwTW operational parameters, including:

- Raw wastewater flows;
- Raw wastewater quality;
- Sewer network characteristics;
- Trade effluent discharges;
- Odour emissions from unit processes;
- Prevailing weather conditions;
- Dispersion modelling to assess the impacts of odour emissions;
- Boundary odour monitoring of hydrogen sulphide; and
- Sludge management & handling.

6.2 Technical Assessments

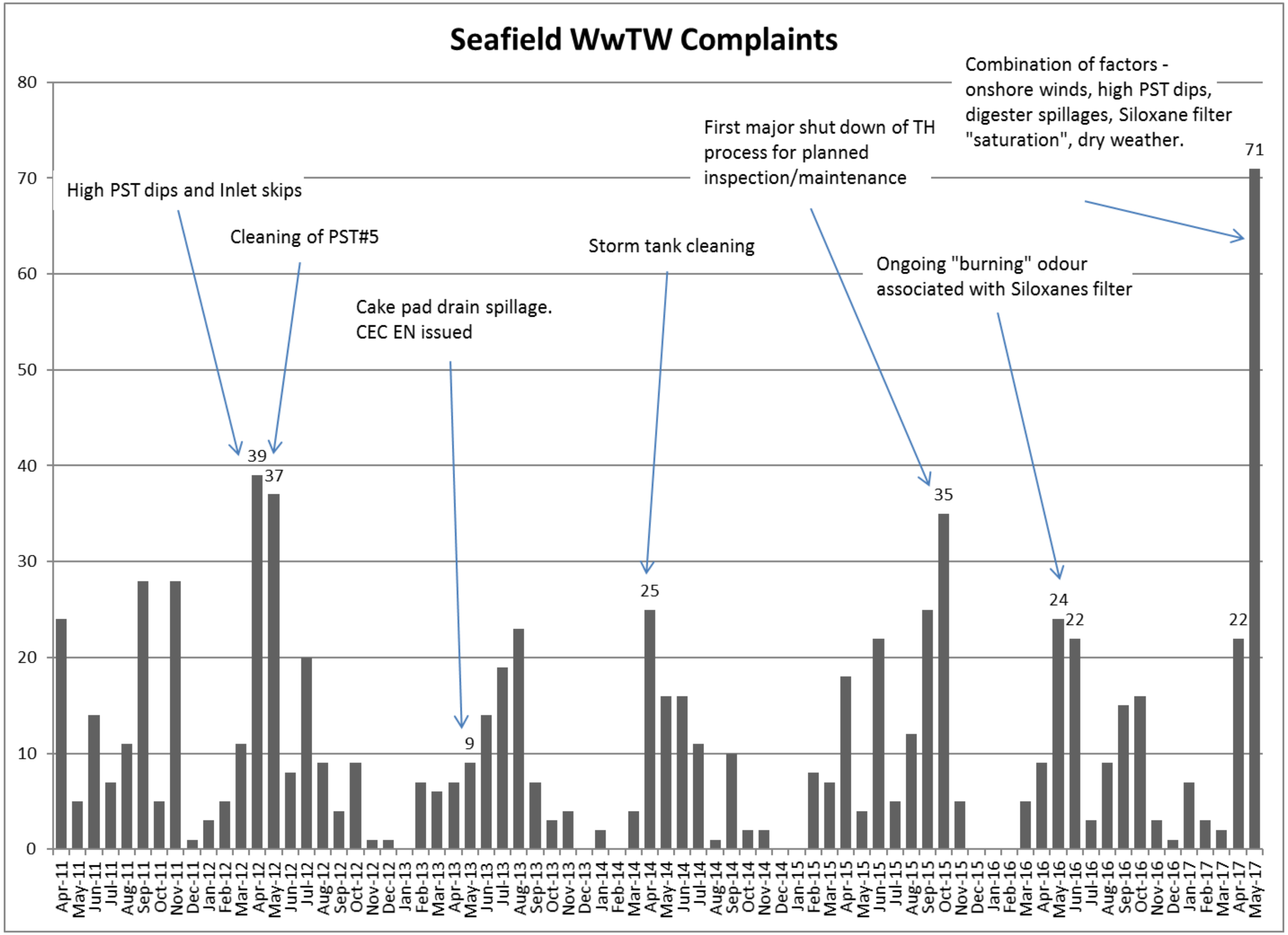
Complaints Analysis

A plot of complaints received by month from April 2011 up to the end of May 2017 is included overleaf as Figure 6.1. The plot is annotated with suspected reasons for the complaints, in terms of what activities were taking place on the Seafield site at the time the complaints were received. In the greater majority of the periods when complaints have been received over this time, the wind direction, measured at the Seafield site, has been recorded as “onshore”. There are only a very small number of complaint records where the wind direction has been classified as “offshore” and this relates to periods of light and variable winds. Common descriptors of the odours experienced by the local community include the following:

- Sewage;
- Burning;
- Burnt gravy;
- Burning rubber;
- Burning chemical;
- Burning fæcal matter; and
- Excrement.

Combinations of the above odours have also been reported by members of the local community.

Figure 6.1 Annotated complaints log April 2011 to May 2017



Our experience of dealing with odours from sewage and sludge treatment processes, combined with the information available on wind directions, other meteorological parameters, wastewater flow and quality data for Seafield, allows us to carry out an analysis and interpretation of the received complaints.

April and May 2017 period

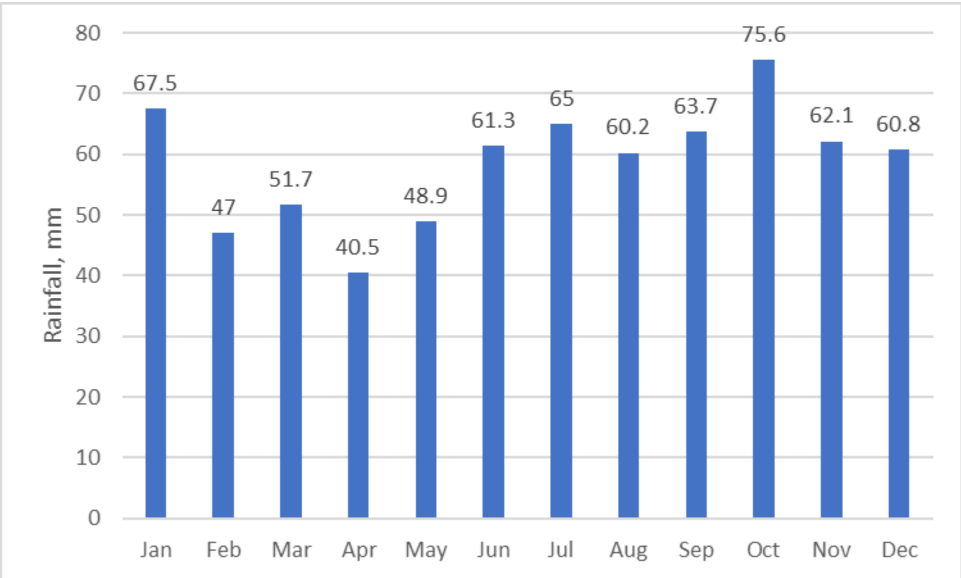
Low rainfall and wastewater flows

The month of April 2017 was exceptional, in that only 4 mm of rainfall was recorded at the Royal Botanic Gardens Edinburgh (RBGE) weather station[6]. Whilst this was certainly extremely unusual, it was not entirely unprecedented. Examination of historic climate data held by the UK Meteorological Office for a recording station at Leuchars, over the 60-year period 1957 to 2017, shows that there were 15 months when rainfall amounts were less than 10 mm. In very simple terms, the frequency of occurrence can be expressed as a probability of approximately 2%. These were:

- 7 months of February (1959, 1965, 1973, 1979, 1985, 1983, 1998);
- 1 month of March (1973);
- 5 months of April (1980, 1997, 2006, 2017); and
- 2 months of September (1971, 1972).

Data held on the UK Meteorological Office web site for the RBGE station shows that, historically over the period 1981-2010, the months of April and May do have the lowest recorded rainfall amounts (Figure 6.2) but that these are, on average, well into double figures (40.5 and 48.9 mm respectively).

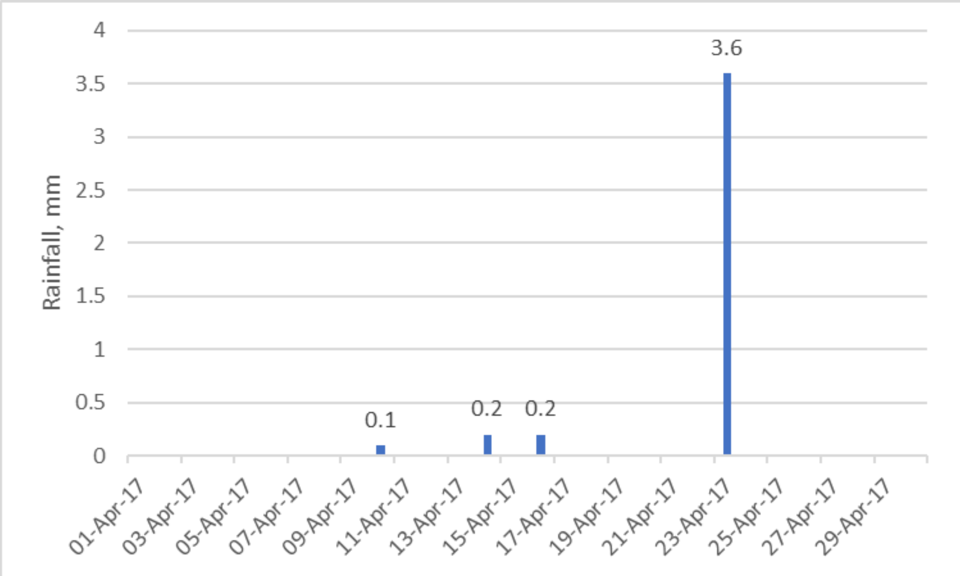
Figure 6.2 Average monthly rainfall at RBGE 1981-2010 (Annual average total 704.3 mm)



[6] http://www.rbge.org.uk/assets/files/science/Weather/2017/04_2017.pdf

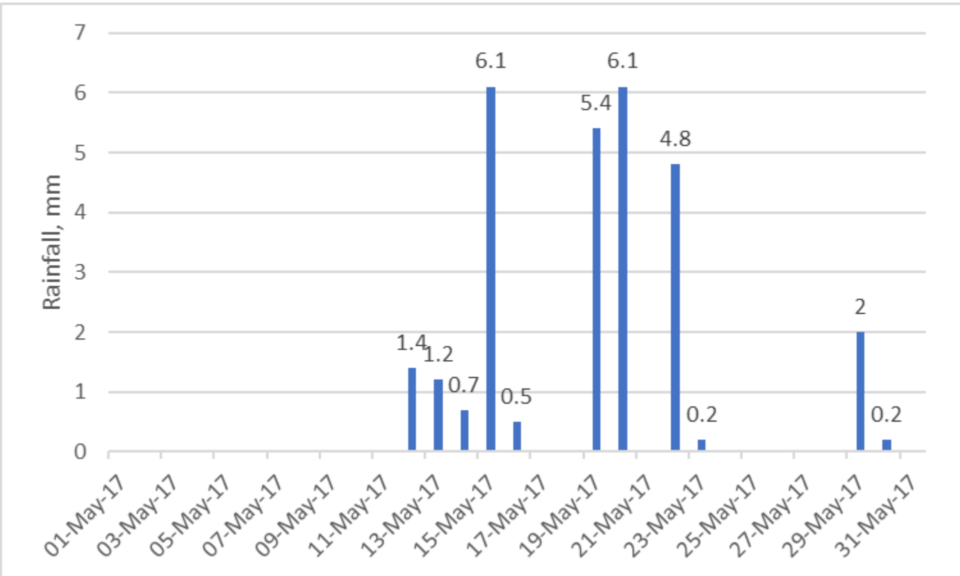
The actual daily rainfall amounts for April 2017 can be seen in Figure 6.3 below, extracted from data on the RBGE web site. Rainfall occurred on only 4 days in the month, with the greater majority falling on 23rd April.

Figure 6.3 Daily rainfall amounts at RBGE during April 2017 (Total rainfall 4.1 mm)



In May 2017, there was 28.6 mm rainfall, below the normal average, and most of this fell around the middle of the month, with a dry start to the month and little rain after the 22nd May. (Figure 6.4).

Figure 6.4 Daily rainfall amounts at RBGE in May 2017 (Total rainfall 28.6 mm)



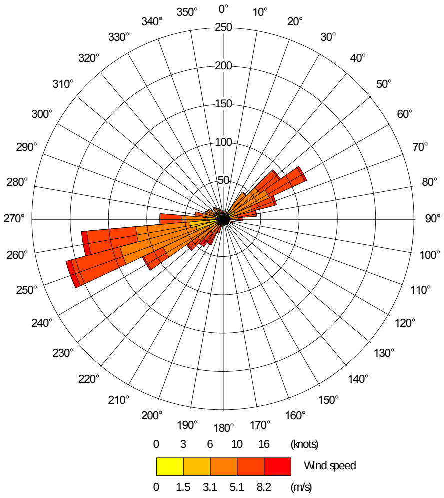
Looking back at the complaints log in Figure 6.1, there are months in other years with complaints in double figures and where there were a significant number of days with no or little rainfall, for example:

- April 2013 – no rain from 5th to 21st;

- June 2013 – no rain on 21 days of the month;
- August 2013 – 12 days with no or little rain;
- April 2015 – 19 days with no or little rain; and
- June 2015 – 11 days with no or little rainfall.

The frequency of occurrence and distribution of wind speeds and direction during April and May 2017 are illustrated in Figure 6.5 below.

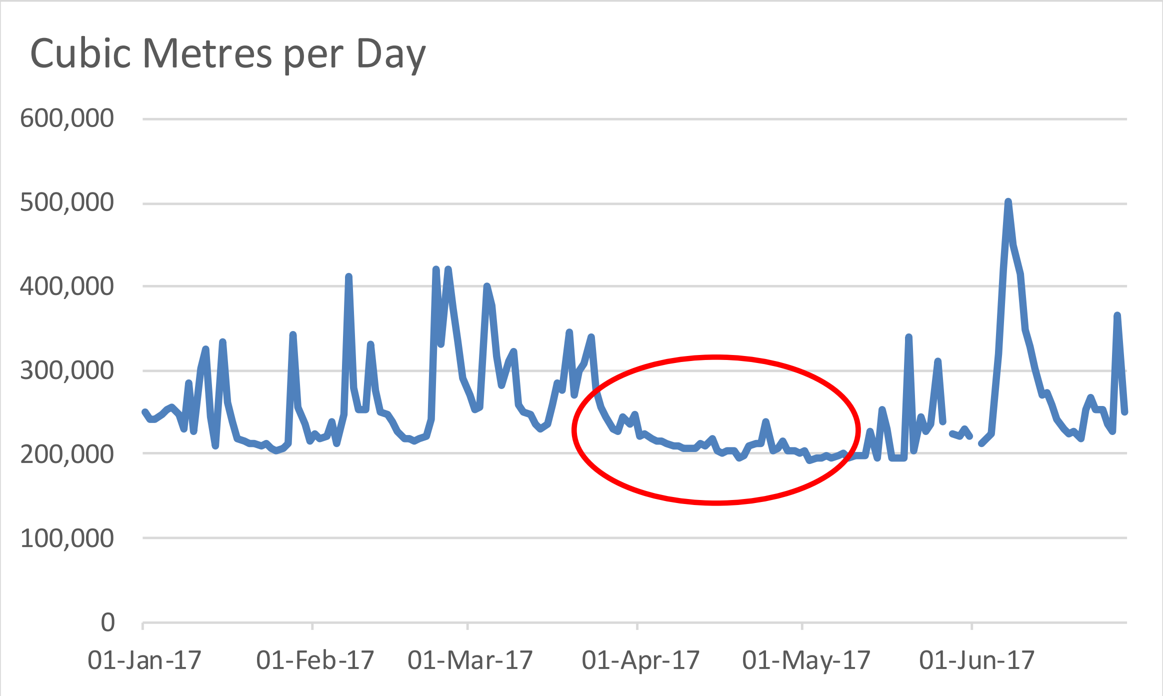
Figure 6.5 Wind speed and direction during April and May 2017



During this period, there were 279 hours (almost 12 days) of onshore winds, of which 174 hours (~7 days) were relatively low wind speed (< 5 m/s – 10 mph, a gentle breeze at most).

The obvious effect of this dry period was that wastewater flows into Seafield WwTW were significantly reduced, since the combined sewerage system delivers large quantities of rainfall runoff into the site during periods of rainfall. Figure 6.6 below shows a plot of the daily wastewater flow into Seafield WwTW over the period January to June 2017.

Figure 6.6 Raw wastewater flow into Seafield WwTW January to June 2017



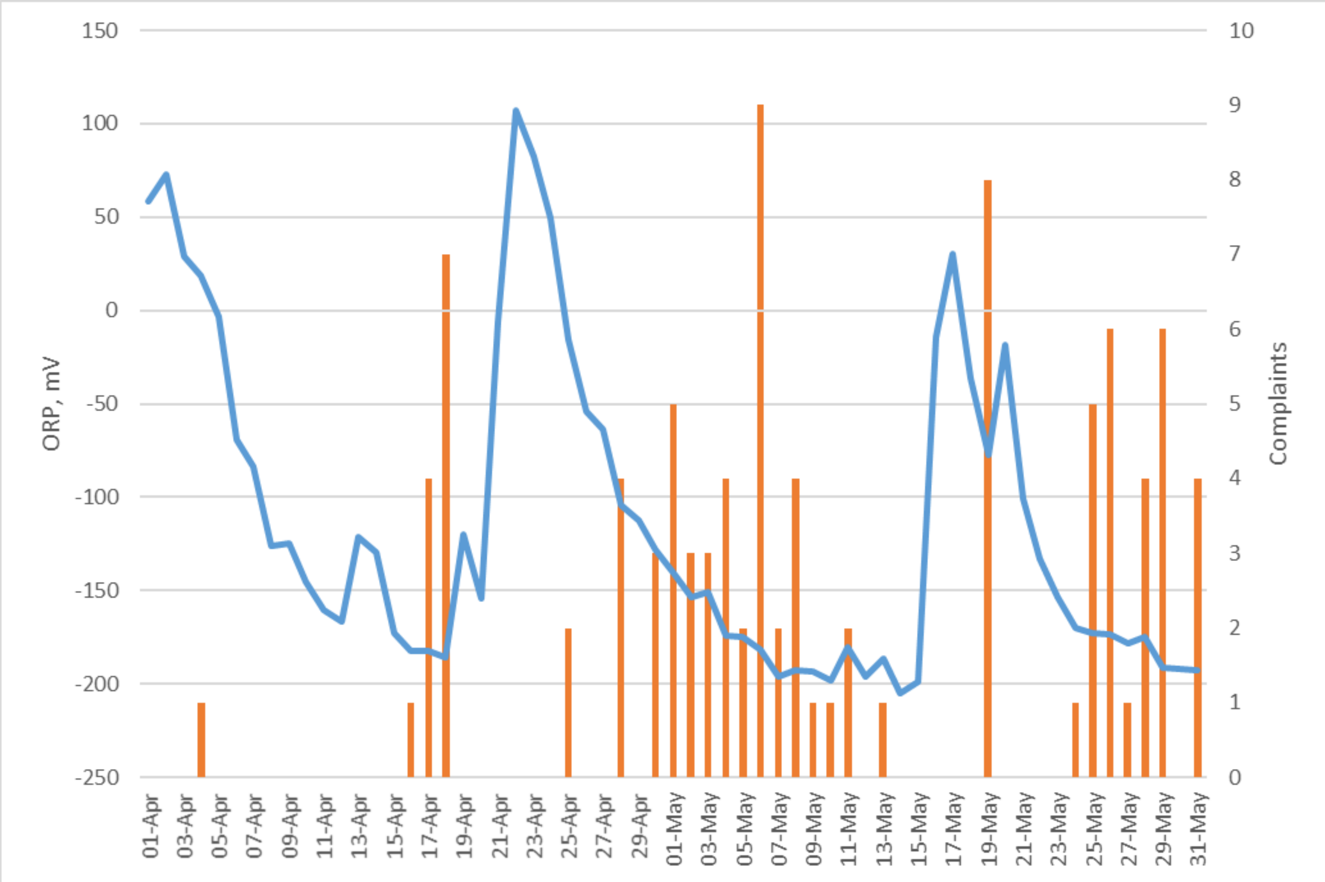
This shows that the flow into the site was at or around 200,000 cubic metres per day (m^3/d) for April and May, two-thirds of the normal average flow. Under these conditions, the waste water entering the remotest parts of the sewer network (at, say, Penicuik and Longniddry) would take approximately 6 hours to reach Seafield, assuming a flow at the minimum self-cleansing sewer velocity of 0.75 m/s. Add to this the detention times for the wastewater in the wet wells of pumping stations along the route and the travel time could double. For the other parts of the network that feed into the Water of Leith gravity sewers, the development of septicity is less likely, since the travel times are shorter (from Cramond, Granton and Trinity).

Such conditions would encourage the development of septicity in the waste water, with subsequent release of hydrogen sulphide and other odorous gases generated by anaerobic microbial activity in sewers. It is, therefore, likely that, during the April-May period, odour emissions from the detritors and PSTs at Seafield would have been elevated and responsible for complaint generation.

Figure 6.7 contains a plot of average daily measured ORP (oxidation reduction potential)[7] levels in the raw wastewater entering Seafield WwTW during the period April to the end of May 2017, overlain with complaint data for the same period. It is clear that periods of low ORP values, indicative of septic sewage and likely emission of gaseous hydrogen sulphide and other reduced sulphur-containing odorous compounds coincided with the receipt of complaints.

[7] ORP (or REDOX), measured in millivolts, is a proxy measure for oxygen-starved and oxygen-devoid wastewater. Measures from +50 mV to +300 mV are indicative of aerated, oxygen-rich water, values from -50 mV to -250 mV are the range in which sulphide formation takes place and values below this range are symptomatic of anaerobic conditions.

Figure 6.7 Measured ORP (blue line) in Seafield raw wastewater and complaint numbers (orange lines) during April and May 2017



Figures 6.8 and 6.9 below show the recorded hydrogen sulphide (H_2S) 15-minute average concentrations measured by the continuous monitors at the Seafield inlet and PST monitoring stations, respectively, during April and May 2017.

Figure 6.8 H_2S concentrations for the inlet monitor

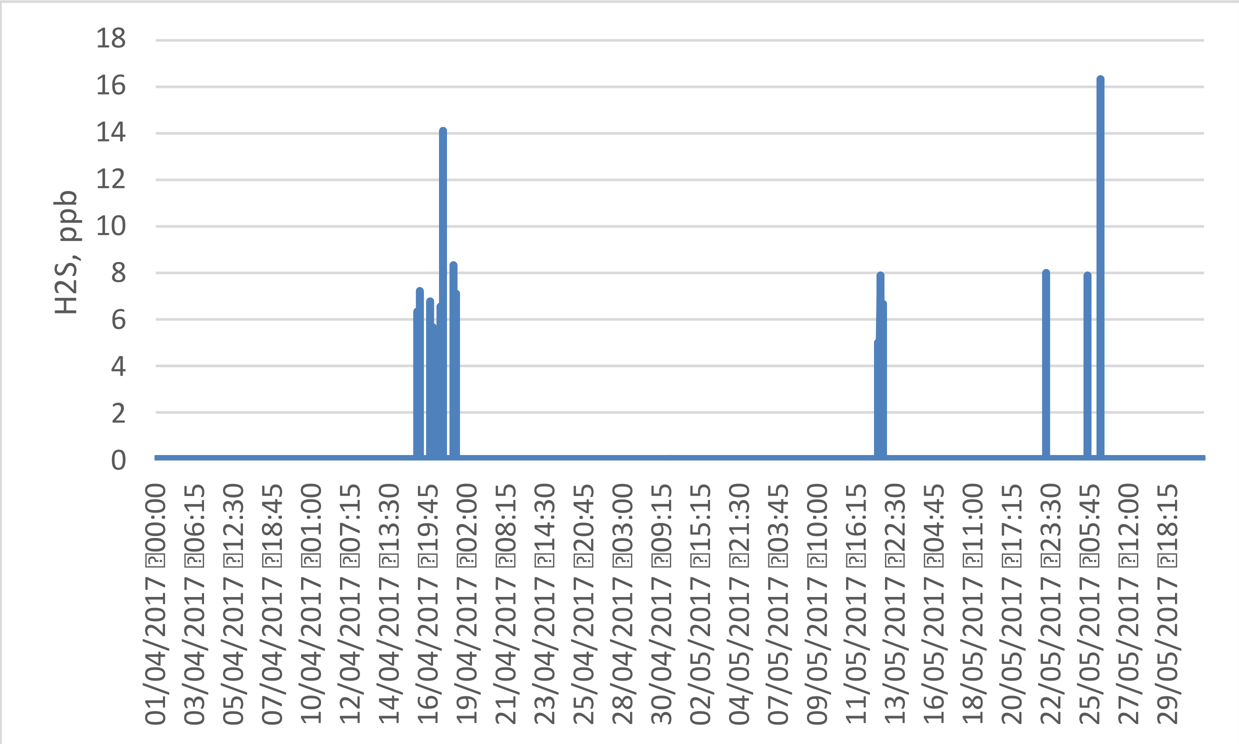
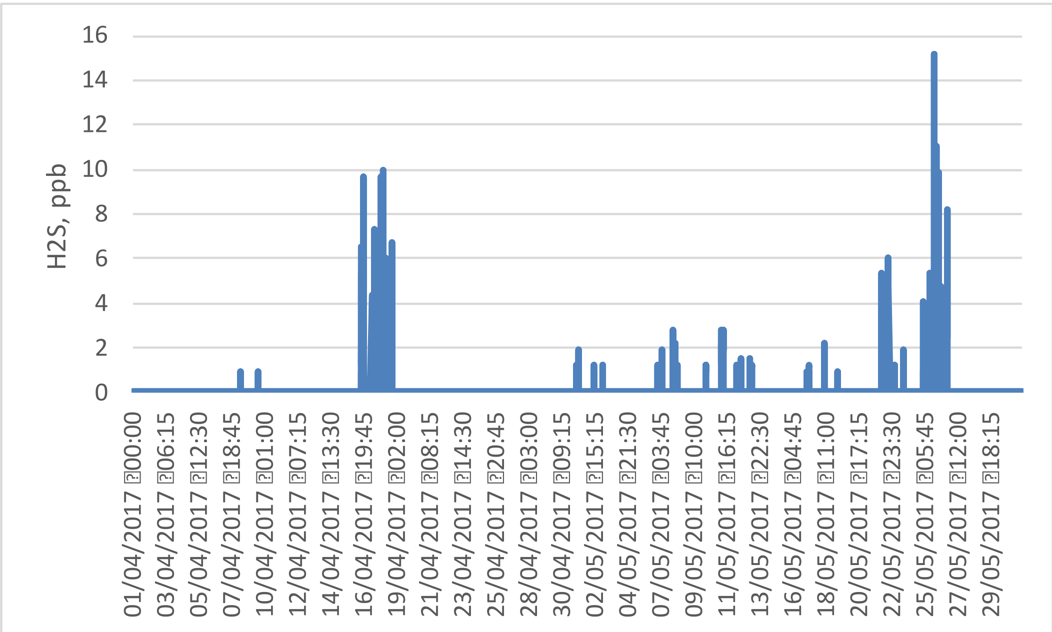


Figure 6.9 H_2S concentrations at the PST monitor



Again, there are clear relationships between the complaints, ORP levels, inlet wastewater flow and measured H_2S levels on the site during this period. Both of these monitors are located on the western boundary of the Seafield site, so the recorded levels are consistent with an onshore wind direction.

It should be noted that these measured H_2S concentrations are averages over a 15-minute period of monitoring. Within this period, concentrations will fluctuate about this average. A human being would actually experience peak levels of H_2S (and, of course, odour) over periods from 10 seconds up to 1-2 minutes up to 10 times greater than the levels recorded by the monitor.

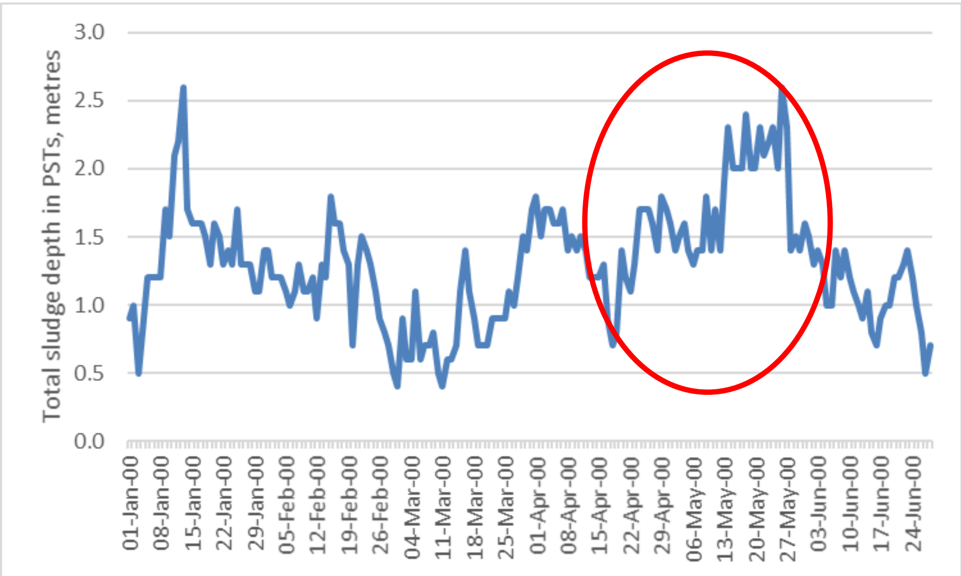
Other factors

However, following an analysis of the available data and information, it is considered that the increased levels of complaints during this period were not solely initiated as a result of low wastewater flows and potential partial sewer septicity. Additional causes, including high levels of sludge retained in the PSTs, emissions from the siloxane filter re-generation, sludge and biogas spillages from the digesters and sludge cake spillages also made a contribution to odour emissions from the Seafield site during this period.

Sludge blanket levels in PSTs

From daily data which provide measures of sludge depths in the PSTs, it is evident that there was an increasing trend of sludge depth over the April to May 2017 period (Figure 6.10 below).

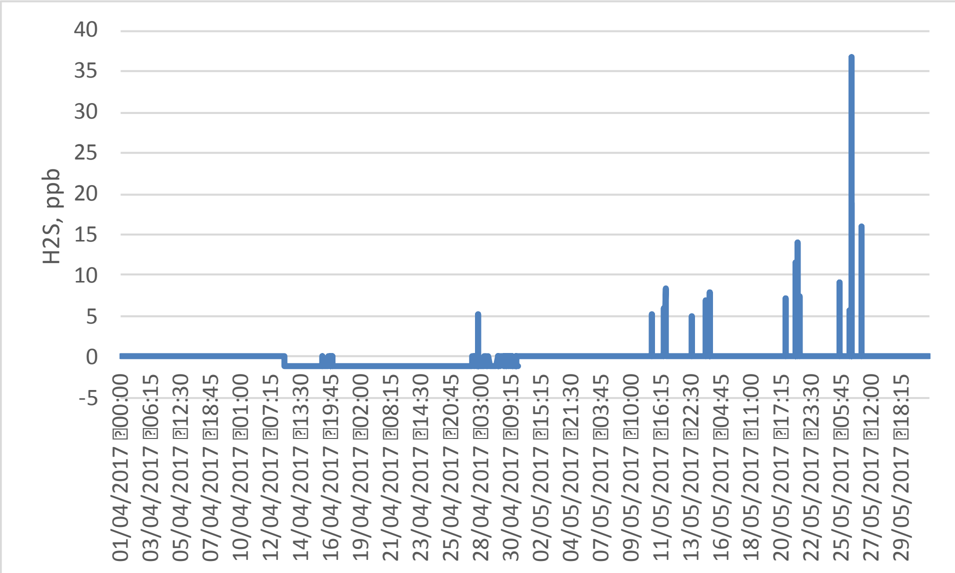
Figure 6.10 Trend of total sludge depth in PSTs to end June 2017 (April/May period highlighted)



Emissions from sludge treatment area

In addition to this, the concentrations of H_2S recorded by the monitor in the digester area (which is in the extreme north-west corner of the site), showed a number of peaks during May, from 10th to 27th (Figure 6.11).

Figure 6.11 H_2S concentrations recorded by digester area monitor April – May 2017



The concentrations recorded were higher than those recorded by both the inlet and PST monitor and cannot, therefore, be accounted for by inlet or PST odour emissions, since the wind direction would not have blown emissions from the inlet or PSTs towards this monitor. It is most likely that the source of the high H_2S readings is much closer to the monitor and originates from sludge spillage, siloxane filter regeneration emissions and losses of biogas from the digesters.

2016 - Emissions from siloxane filter regeneration

Biogas generated by anaerobic digestion of sewage sludges contains typically between 60% and 75% methane (CH_4), 19% – 33% carbon dioxide (CO_2) and ~ 6% moisture by volume[8]. It also contains a range of trace components, other hydrocarbon compounds, H_2S and a range of organic silicon compounds. When biogas is combusted in spark-ignition engines (such as those at Seafield), the organo-silicon compounds are oxidised to form siloxanes, which are refractory and are deposited in the combustion cylinders of the engines, causing physical damage and requiring much more frequent oil changes and additional maintenance[9].

To remove the silicon compounds prior to biogas combustion, the raw biogas is passed through a filtration unit, which preferentially removes organo-silicon and other high molecular weight compounds. As the removed contaminants accumulate within this filter, it needs to be regenerated. The siloxane filter regeneration is an intermittent operation that occurs once per day. The siloxane filter is first purged for 4 - 8 hours with heated air, before it is purged for a further 30 minutes as the system cools. The unit is then back-purged with biogas for approximately 10-15 minutes. The air and biogas used during purging was originally, until late July 2017, released direct to atmosphere through an emission stack located close to the digesters on the Seafield STW site.

During mid-April 2016, complaints were received from the local community, citing “burnt gravy, meaty, rubber like smell” odours. Further investigations by CEC, SEPA, Veolia and

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[8] http://www.biogas-renewable-energy.info/biogas_composition.html
[9] https://www.omicsonline.org/open-access/presence-of-siloxanes-in-the-biogas-of-a-wastewater-treatment-plantseparation-in-condensates-and-influence-of-the-dose-of-iron-chl-2252-5211-1000192.php?aid=65109

Scottish Water were initiated over the period May to September 2016 and, at the Stakeholder meeting on 30th September, Veolia identified the cause as emissions from siloxane filter regeneration.

In October 2016, Veolia commissioned OdourNet to conduct an odour assessment of emissions from regeneration of the siloxane filter. The first stage of this involved sampling and quantification of the odours emitted during the regeneration process. Table 6.1 below summarises the results of this stage of the assessment.

Table 6.1 Odour emissions during the siloxane filter regeneration cycle*

Stage in cycle	Temperature, ˚C	Odour concentration, ou_E/m^3	Gas flow, m^3/s	Odour emission rate, ou_E/s	Operational time (h/day)
Heated purge - start	140	1,358,916	0.139	928,936	1.7
Heated purge – middle	140	1,010,069	0.139	19,103	1.7
Heated purge - end	140	279,546	0.139	8,902	1.7
Cooling purge	70	88,266	0.139	8,617	0.5
Biogas purge	40	107,426	0.139	5,087	0.25

*Extracted from Table 2 of OdourNet report number VWST16H_09, dated 21 December 2016.

Considering the odour measured odour concentrations in column 3 of the above table, to place these into perspective:

- 1 ou_E/m^3 is the odour threshold;
- 5 ou_E/m^3 is acknowledged as a faint odour; and
- 10 ou_E/m^3 is a distinct odour.

Subsequent characterisation of the odour samples taken during the different stages of the regeneration cycle revealed the following results (Table 6.2).

Table 6.2 Characterisation of odours from the siloxane filter regeneration cycle

Stage in cycle	Odour concentration, ou_E/m^3	Odour Character Low dilution	Odour Character High Dilution
Heated purge - start	1,358,916	Biogas, sulphurous, cabbage	Gravy, savoury, meaty
Heated purge – middle	1,010,069	Biogas, sulphurous, cabbage	Gravy, savoury, meaty
Heated purge - end	279,546	Biogas, sulphurous, cabbage	Gravy, savoury, meaty
Cooling purge	88,266	Biogas, sulphurous, cabbage	Slightly meaty, gravy
Biogas purge	107,426	Biogas, sulphurous, cabbage	Meaty, biogas, gravy

*Extracted from Table 2 of OdourNet report number VWST16H_09, dated 21 December 2016.

The odour character descriptions for the high dilution samples in the table above match well with the descriptions offered by the complainants during 2016. It is common for the character to be different at high and low dilutions and it is at the higher dilutions that the local community would have experienced the odour.

A further analysis revealed that, in order to avoid malodour impact among the local community, emission concentrations in the discharge from the siloxane filter stack would have to be reduced to below 41,000 ou_E/m^3. With reference to the measured odour concentrations listed above in column 2 of Table 6.2, it is clear that abatement is required at all stages of the regeneration cycle to achieve this target.

OdourNet also conducted a detailed compositional analysis of the discharged gases from the regeneration cycle and identified a number of individual organic compounds that could be harmful to health, if present in air at sufficient concentrations. Detailed dispersion modelling of these components indicated that the ambient concentrations likely to occur outside the site boundary of Seafield WwTW would be well below established limits set to protect human health and that there was no cause for concern.

The conclusions of the health impact assessment were confirmed by Health Protection Scotland, following review of the OdourNet study, in their report dated December 2016[10].

Following the outputs of these studies, Veolia, Stirling Water and Scottish Water resolved to tackle this issue by installing a vent air burner (VAB – essentially an efficient shrouded flare) which would capture the emissions from the siloxane filter regeneration cycle and incinerate them. Typically, with this form of abatement, reductions in odour levels of at

[10] Health Protection Scotland (2016) Interpretation of Odournet Health Impact Assessment Reports from Seafield Sewage Treatment Works, Edinburgh.

least 99% will be achieved. Assuming that this level of abatement will be achieved in practice, odour annoyance from these emissions should not be a problem in the future.

The VAB was commissioned in late July 2017, some 10 months after identification of the source of the odour. OdourNet was commissioned to repeat the odour assessment in August 2017. The results of this re-assessment are awaited and are anticipated to be positive.

Emissions from sludge treatment

During an initial walkover survey of the Seafield WwTW site at the end of June 2017, moderately strong odours of dewatered sludge were detected on the north side of the sludge cake pad building. It was surmised that these were fugitive odour emissions, being drawn out of the building through louvres and imperfections in the building fabric by the wind pressure.

On a subsequent site walkover during week commencing 24th July 2017, with light winds blowing from the east-north-east onshore, the same character of odour was detected at the site boundary immediately to the west of the sludge cake pad building, with and without the roller-shutter door open as vehicles accessed and egressed the building. During the early evening of the same day (25th July), an identical faint odour was detected intermittently on Leith Links, close to St. Mary's Roman Catholic Primary School. Complaints from residents about a sludge odour on Leith Links were also received on 19th July 2017.

There is also anecdotal evidence that problems with sludge handling and treatment have caused odour complaints in the past, notably during commissioning of the THP unit in 2013 and in 2015, during a partial maintenance shut-down of the THP.

6.3 Process and network investigations

An evaluation of the design and operation of the wastewater and sludge treatment processes at Seafield WwTW has been carried out to identify the sources of odour that are giving rise to continuing complaints from the local community. The elements of these investigations include:

- An investigation of potential fugitive odour emissions from the sewer network;
- An evaluation of consented trade effluent discharges and recorded check-analyses;
- Review of the original WRc odour emissions;
- Review of the results of a 2013 set of odour emission surveys carried out by Mott MacDonald;
- A septicity survey of the sewerage network in September 2017;
- An odour emissions survey of Seafield WwTW in September 2017;
- Discussions with the operating partners (Veolia Water Outsourcing Ltd, Stirling Water Limited and Scottish Water);
- Site walkover surveys of the WwTW; and

- Dispersion modelling of odour emissions from Seafield WwTW, using historical and current odour emission estimates, to identify the past and current spatial “odour footprint” generated by the site.

Network investigations

Fugitive odour emissions

In any large sewerage network, there will be the potential for fugitive emissions of odour from manhole chambers/covers, pumping station buildings (if not odour-controlled) and from sewer vent pipes, where these are installed to prevent air locks developing and for pressure relief purposes. Vent pipes have been identified on the Water of Leith 1889 gravity sewer and on the outlet sewer from Albert Road pumping station. The latter vent pipe is some 1.5 metres above ground level within the Albert Road pumping station compound and is remote from residential areas.

The vent pipe on the Water of Leith 1889 gravity sewer is located over the sewer in the south-west corner of a grassed area close to St Mary’s Roman Catholic Primary School at grid reference 327764, 676032. From a Technical Note prepared by Harley Haddow Consulting Engineers in 2007:

“*the vent is an octagonal brick chimney on a square stone base. The lower section of the chimney is largely covered in ivy and has a locked steel doorway in the stone section which appears to give access down to internal ladders and platforms. Access through this door is not available. The upper brickwork is generally in reasonable structural condition but pointing is in poor repair. The original cope has been replaced at some time with an in situ concrete cope*. *The sewer originally had an outfall at the shoreline to the north of Salamander Street. It was therefore tidal and the chimney may have been built to vent the sewer during high tides. The sewer now connects to an interceptor sewer which takes the waste to Seafield sewage works and this venting may now not be necessary.*”

The sewer downstream of the vent pipe enters the Albert Road pumping station. It is approximately 10 metres in height above ground level and is of internal diameter approximately 1 metre. If the vent pipe is still connected to the gravity sewer, even though there is now no direct discharge to the Firth of Forth and, hence, no flood tide back pressure which could push foul air out of the vent pipe, it is still possible that the action of the wind across the open top of the pipe could draw air out of the pipe.

On the worst-case assumption that a 3 m/s wind velocity across the mouth of the vent pipe would generate a 3 m/s exit velocity for air out of the vent pipe, the volumetric flow rate is equal to the surface area of the outlet of the vent pipe multiplied by the wind velocity. In this case, that would be 2.35 m^3/s. The potential effect of an emission of sewer odour from this source is addressed below in the section on dispersion modelling of odours.

Trade effluent consents – flows and polluting loads

As discussed earlier (section 3.2 of this report) the catchment serving Seafield WwTW is large, extending to some 300 square kilometres (km^2), with the remotest parts of the network lying some 16 km (as the crow flies) from Seafield itself. Within this catchment, there are a number of industrial and commercial premises that generate wastewater flows which are discharged, with or without pre-treatment, into the sewer network. The following information was sourced from Scottish Water in relation to trade effluent discharges:

- Nature of commercial/industrial premises and location;
- Volume and quality parameters of aqueous discharge consented; and
- Details of any check sampling and analysis carried out.

It transpires that there are 84 consented trade effluent discharges into the Seafield sewer network, of which 30 relate to vehicle washing, 11 to hospitals and patient care, 7 to laboratory effluents, 7 to laundries and laundrettes, 5 to breweries and a distillery, 3 to pharmaceuticals and laboratory discharges, 7 to various industrial processes (printing, metal fabrication & finishing, a bakery and paint stripping), 2 fish processors and 13 waste-related discharges (landfill leachate, gully cleaning residues, septic tank and chemical toilet discharges, water treatment works sludge and dewatering effluents).

In terms of the flows and polluting loads consented under the Trade Effluent Agreements, the "top twenty" dischargers in terms of flow account for 88% of the total trade effluent flows permitted in a 24-hour period. These cover activities such as distilling, water and wastewater treatment discharges, vehicle washing, brewing, pharmaceuticals manufacture, patient care, fish processing and landfill leachate. The consented daily flows for this group of 20 dischargers total some 10,000 m^3, approximately 3.3% of the daily flow of wastewater into Seafield WwTW and the totality of all trade effluent consented flows constitutes 3.8% of the daily Seafield flow. Even under the low-flow conditions of April-May 2017, these percentages would only increase to 5% and 5.7%.

With regard to polluting loads in the trade effluent discharges, the highest consented loads of biochemical oxygen demand (BOD_5)[11] arise from brewing and distilling, pharmaceutical manufacture, bus washing, patient care and fish processing, with the top twenty dischargers accounting for 91% of the daily consented trade effluent BOD_5 load. In total, the consented trade effluent daily BOD_5 load makes up approximately 6.7% of the total load entering Seafield WwTW on a daily basis.

Trade effluents – specific contaminants

Within the trade effluent consents, a variety of parameters can be included, some general, such as BOD_5, COD and suspended solids, and some more specific to the actual processes being conducted by the discharger that can influence the quality and content of the discharge. Whilst some of these substances can affect wastewater and sludge treatment, if present at sufficient concentrations, through inhibition of biological processes arising from spillages or illegal discharges to the sewer network, the purpose of the trade effluent consents is to ensure that concentrations of such inhibitors are controlled. The main concerns in respect of odour generation from Seafield WwTW is with the presence in the incoming wastewater of chemicals that are odorous in themselves or have the ability to contribute to septicity.

Septicity arises when the dissolved oxygen in the wastewater has all been consumed by the actions of micro-organisms, which then turn their attention to chemically-bound oxygen, such as that contained in sulphate ions (SO_4^{--}), which are omnipresent in wastewaters. The reduction of sulphate by bacteria results in the production of sulphides (S^{--}) in the wastewater. At neutral pH levels (7) 50% of the sulphide in wastewaters is present in the gaseous form and, if there is a degree of septicity in the incoming

[11] BOD_5 – a laboratory measure of the amount of oxygen consumed by bacteriological oxidation of polluting matter in a trade effluent sample under controlled conditions over a 5-day period.

wastewater, then it will be odorous, the level of which will depend upon the degree of septicity and the sulphate content and pH of the wastewater flow.

With specific regard to the trade effluents discharged to Seafield, any excessive quantities of sulphate in the effluents, contained within, for example, in discharges of sulphuric acid used to regenerate ion exchange resins in de-mineralisation plants, could contribute to odour emissions at times of septicity development. Whilst the general level of polluting load, characterised by BOD_5, is also a contributing factor in septicity development, there would not appear, based upon the information discussed in the previous report section above, to be any significant effect exerted by trade effluent derived BOD_5 loads.

In the listing of 84 trade effluent consents, there are only 4 discharges in which concentrations and daily loads of sulphate are specified. The total daily consented load of sulphate from the four sources is 826 kg; this equates to an incremental concentration in the inflow to Seafield of approximately 3 mg/l (parts per million - ppm) or 4 mg/l under low flow conditions. Even if all of this consented load were to be discharged over an 8-hour working shift, the increment to concentrations arriving at Seafield would only be 8 mg/l. The baseline sulphate concentration in domestic wastewater typically mirrors the concentration in potable water supplies, which is limited to 250 mg/l. This places into perspective the likely concentration increments arising from trade effluent discharges considered above. On this basis, it is considered highly unlikely that there are specific trade effluents discharged into the network that could create or exacerbate odour emissions from Seafield WwTW.

Check sampling of trade effluents

Within the body of information supplied to us by Scottish Water, some results of check analyses of trade effluents emerged. A selection of these, relating to three major dischargers of volume and polluting load, is discussed below.

- Consent A – discharge of landfill leachate into the sewerage system. Check samples taken on five occasions during 2016 and 2017 demonstrated full compliance with concentration limits set for BOD_5, COD, pH, suspended solids, sulphate and heavy metals, all by a significant margin;
- Consent B – pharmaceuticals research wastewater discharge into the sewerage system. Check sample analyses on four occasions during 2016 and 2017 revealed full compliance with concentration limits set for BOD_5, COD, suspended solids, pH, sulphate and formaldehyde, again by a good margin; and
- Consent C – Fine Chemicals manufacture wastewater discharge into the sewerage system. The results from check sample analysis on 46 samples taken during 2016 and 2017 revealed full compliance with consented concentrations for 19 quality parameters, with one exception in 2016, when a failure on pH only was recorded. Limits set for all other parameters were complied with by a significant margin.

Other inputs to the network

We are aware, from discussions with Scottish Water, Stirling Water and Veolia operations personnel, that sludges from primary and secondary treatment of wastewater enter the network at certain locations:

- Primary sludge from outlying works at Prestonpans; and
- Surplus activated sludges (SAS) from Penicuik WwTW.

Network septicity survey

During the week commencing Tuesday 19th September 2017, remote high-level logging H_2S detectors were installed in four manhole chambers on the sewer network serving Seafield WwTW in the following locations:

- Inlet to the Siphon House upstream of Seafield WwTW (confluence of the eastern and western interceptor sewers – see Appendix C);
- Inlet to the Marine Esplanade Pumping Station (MEPS) on the Seafield site (feed from Albert Road pumping station (Water of Leith sewers – Appendix C);
- Inlet to Wallyford pumping station (receives flows from the southern and south-eastern parts of the network (Appendix C); and
- Discharge manhole downstream of the Wallyford PS Rising Main discharge point upstream of the eastern interceptor sewer in Portobello (Appendix C).

An indicative location map is provided as Figure 6.12. The loggers were set to record H_2S concentrations every 5 minutes over the course of a nine-day period. The results of the survey are summarised below in Table 6.3 and Figures 6.13 to 6.16.

Figure 6.12 Network septicity survey monitoring locations (identified in red)

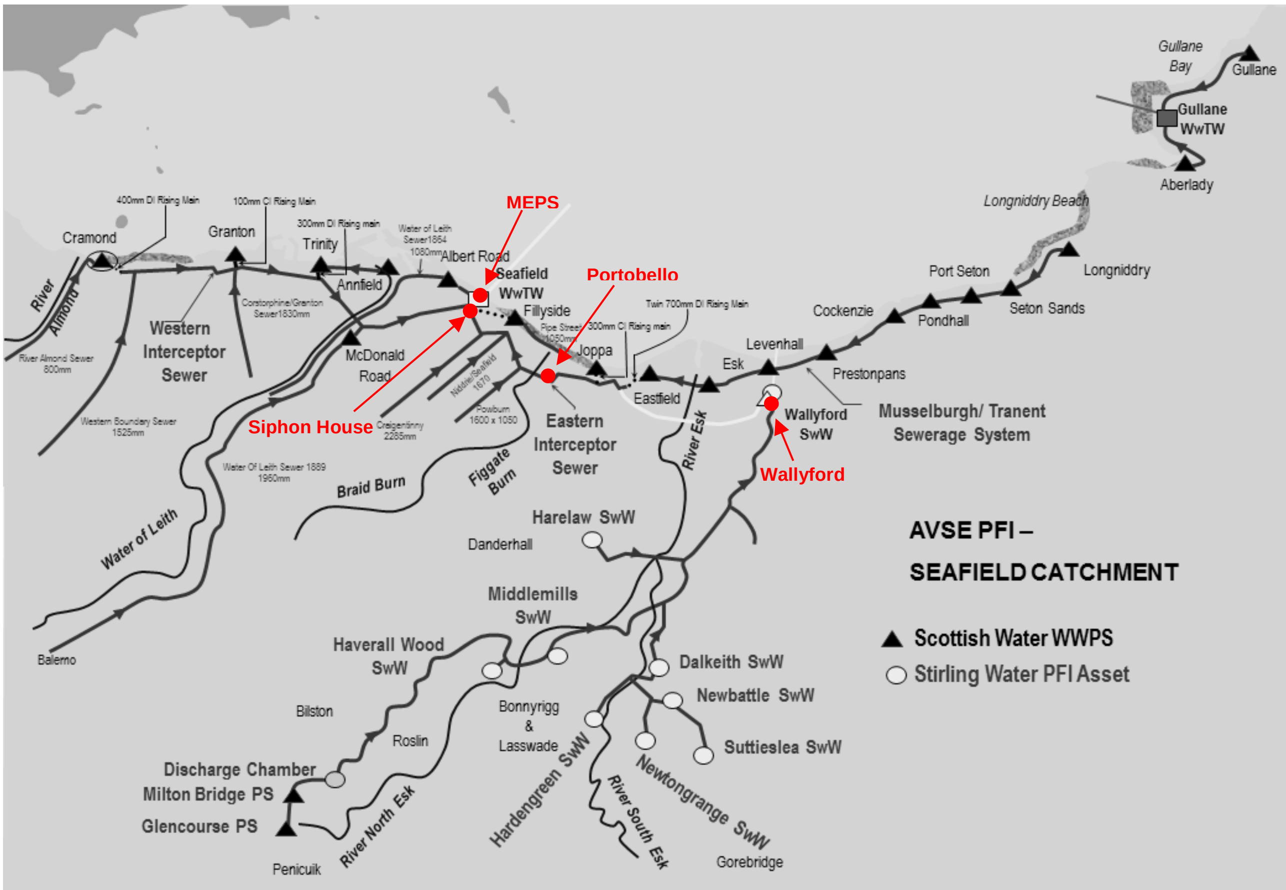


Figure 6.13 Results from the H_2S monitoring at the Siphon House

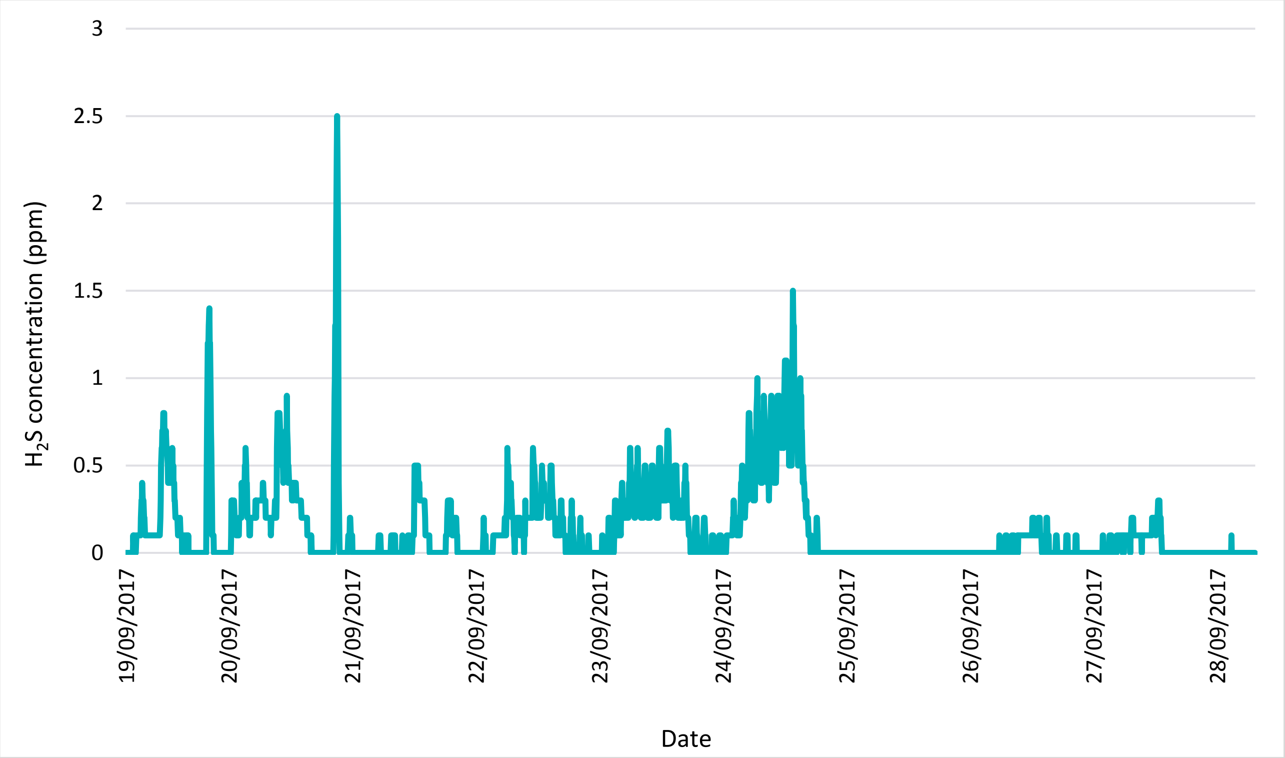


Figure 6.14 Results from the H_2S monitoring at the MEPS

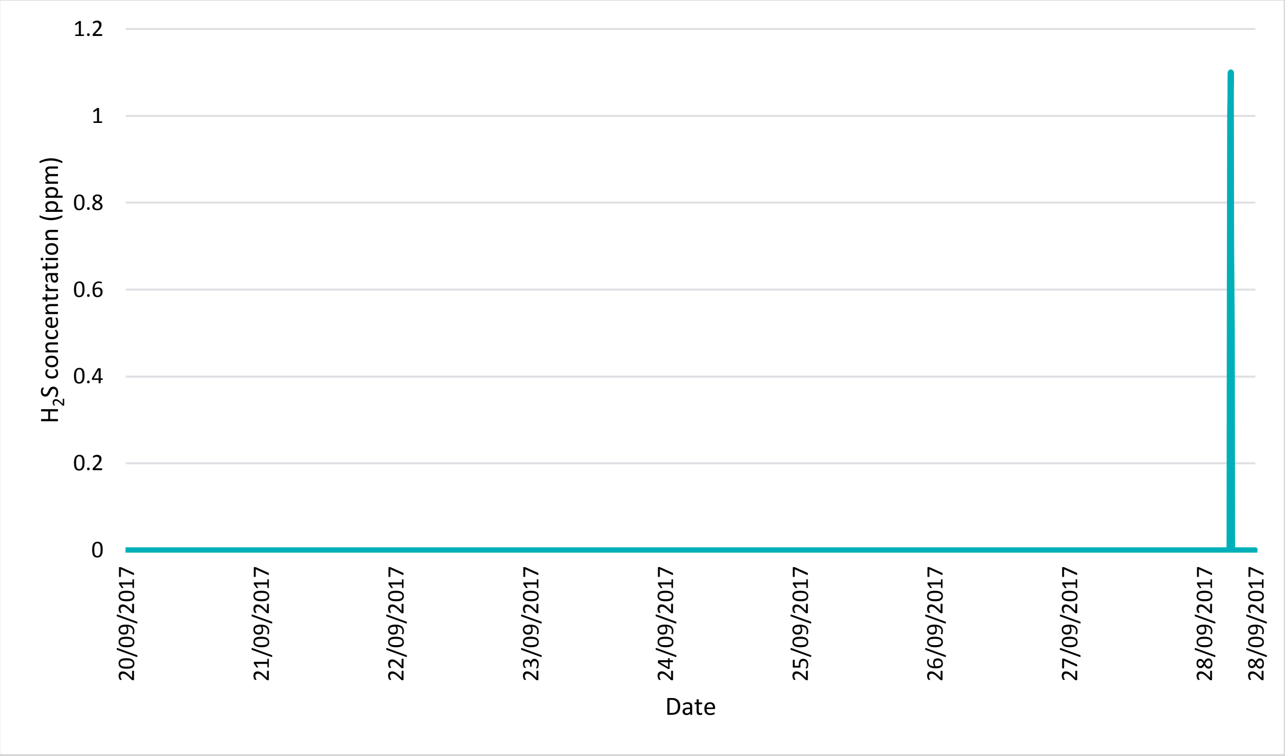


Figure 6.15 Results from the H_2S monitoring at Wallyford

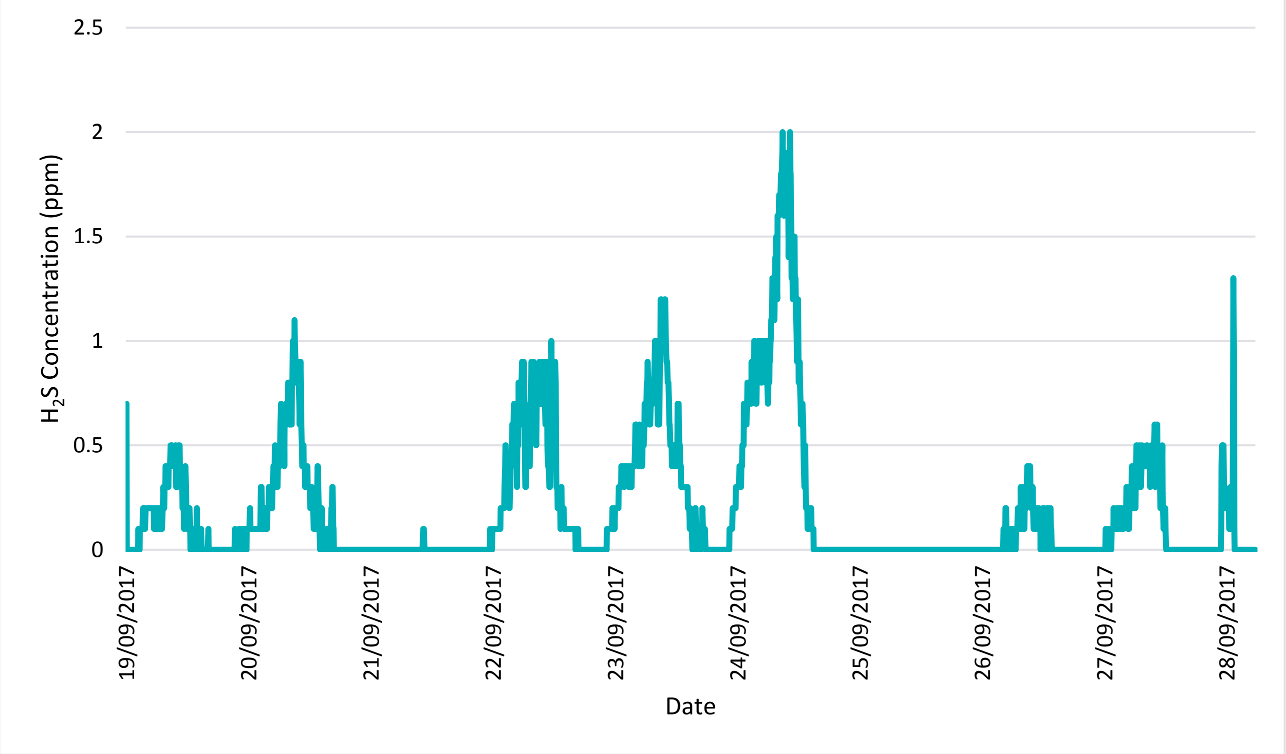


Figure 6.16 Results from the H_2S monitoring at Portobello

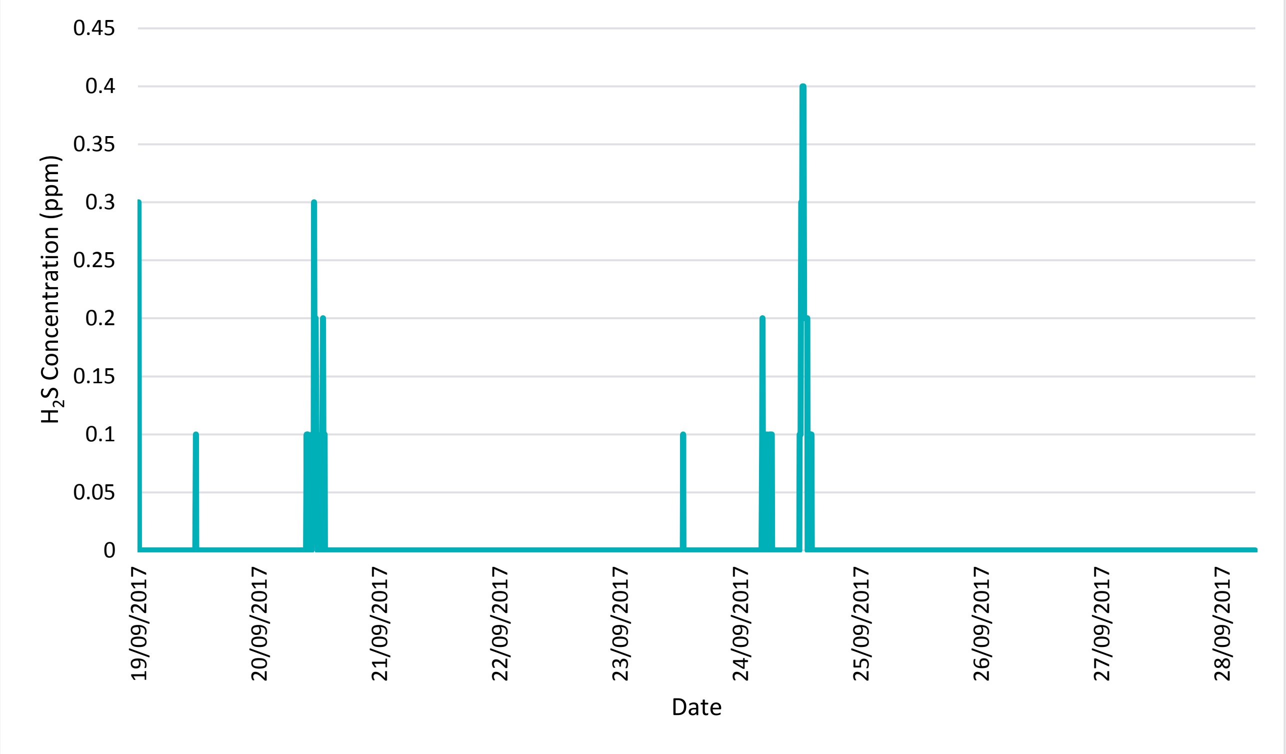


Table 6.3 Summary data from the network H_2S monitoring

Site	Maximum H_2S concentration over survey period, ppm	Average H_2S concentration over survey period, ppm
Siphon House	2.5	0.134
MEPS	1.1	0.002
Wallyford	2.0	0.195
Portobello	0.4	0.004

Figure 6.17 below shows a plot of the daily average H_2S concentrations measured at the Siphon House with daily rainfall from RBGE. It is surmised that this apparent relationship arises from either the flushing of deposits from the sewers under the action of rainfall, or increased turbulent flow in the wastewater, or a combination of both.

Figure 6.17 Results from the H_2S monitoring at the Siphon House versus rainfall from RBGE

Process investigations

Odour emissions measurements at Seafield

The original emissions surveys of odour from process units at Seafield WwTW were undertaken during 2003 by WRc. Whilst we do not have the original survey reports, the emissions of odour from each unit process were documented in a joint Scottish Water/Stirling Water report dated April 2008[12]. Odour emission rates (in ou_E/s) were tabulated for each of the unit processes in toto. Using the surface area of the unit processes (detritors, PSTs, ASP, FSTs), calculated from scaled CAD drawings of the processes on the Seafield site, we have been able to derive odour emissions per unit area per unit time ($ou_E/m^2/s$). These emission rates have then been used in a dispersion modelling assessment.

In 2013, Silsoe Odours Limited was instructed by Mott MacDonald, acting on behalf of Scottish Water, to carry out comprehensive odour emissions measurement surveys at Seafield WwTW, five times over the period June to September 2013. The surveys were requested by CEC, in its role as the regulator for odour emissions from the WwTW site and the report can be found on the CEC web site as Item 7.15, attached to a report to the CEC Transport and Environment Committee dated 26th August 2014[13]. The stated purpose of the surveys in the CEC report (at paragraph 3.9, page 7) was:

"*Following discussions with Scottish Water, Mott MacDonald were appointed as independent odour consultants, undertaking studies and odour modelling during the period May to September 2013 with a final report being submitted to the Council in November 2013."*

The final report submitted by Mott MacDonald included an odour emissions inventory for Seafield WwTW. There is no comparison of the measured odour emissions with typical best practice benchmarks or, indeed, the original post-OIP WRc emission rates. Neither is there any evidence of dispersion modelling having been carried out to identify the extent of the impact of the measured odour emissions.

This appears to be at odds with the initial stated purpose of the surveys, in line with the duty of CEC to monitor ongoing compliance with the objectives of the OIP. This, in our view, represents a missed opportunity to critically assess the performance of Seafield WwTW and STC in relation to odours.

These surveys involved 5 sampling campaigns in summer 2013 of all post-OIP odour control units and all open-to-atmosphere tanks, including detritors, PSTs, ASP, FSTs, digested sludge storage tank, storm tanks, MEPS, the Siphon chamber inlet, SAS tank, sludge cake building, sludge import area, inlet screens building and FST distribution chamber.

It should be noted that the above 2013 surveys were carried out at a time when the containment and operation of the WwTW were different to those of today, in particular:

- The digested sludge storage tank, SAS tank and FST distribution chambers were uncovered;

[12] Scottish Water/Stirling Water (2008) Odour Improvement Plan – Seafield Wastewater Treatment Works. April 2008.
[13] http://www.edinburgh.gov.uk/meetings/meeting/3481/transport_and_environment_committee

- The THP plant was not commissioned;
- The THP OCU was not commissioned; and
- Sludge return liquors were routed into the inlets of the ASP, rather than, as today, into preliminary treated wastewater channels upstream of the PSTs.

A comparison has been drawn between the odour emission rates measured in the two above (2003 and 2013) surveys and two reference sources:

- A compilation of odour measurements taken by Amec Foster Wheeler (and its former antecedent companies) over the period 2003 to 2016 at wastewater treatment plants across the UK, together with results harvested from other publicly-available emissions survey reports in the UK; and
- Referenced "best practice" unit process odour emission rates compiled by WRc in a 2002 UKWIR report[14].

In addition, because the current configuration, operation and containment of process units at Seafield WwTW has changed from the 2003 and 2013 dates, Silsoe Odours Limited was commissioned to carry out a repeat of its 2013 surveys and this was conducted during the week commencing 18th September 2017.

A comparison of the 2003, 2013 and 2017 measured process odour emission rates with each other and the two above reference sources is contained in Table 6.4 overleaf.

[14] UKWIR (2002) Odour Control in Wastewater Treatment - A Technical Reference Document. UKWIR Reference:- 01/WW/13/3. ISBN:- 1 84057 246 9.

Table 6.4 Comparison of measured Seafield WwTW unit process odour emission rates with reference sources

Unit Process	**Odour emission rates, $ou_E/m^2/s$ (ou_E/s for OCUs)**				
	WRc, 2003	**Mott MacDonald, 2013**	**Amec Foster Wheeler database**	**UKWIR, 2003 (“Typical”)[@]**	**Silsoe Odours, 2017**
Detritors	4.17	13.4	6.99	53	3.71
PSTs	2.53	5.6	7.03	1.9	0.84
ASP	1.39	3.5 – 30.3*	1.96	4.0	0.46
FSTs	0.42	0.44	1.16	0.7	0.25
Storm tanks	2.16	2.66 – 6.9	2.64	-#	1.99
OCU 1	-	3,095	#	#	-
OCU 2	-	1,428	#	#	15,543
Main OCU	-	919	#	#	546
Digester OCU	-	6	#	#	11
THP OCU	-	-			14,412
PST airlift carbon filters	-	-			565

* Range of values from inlet lane (highest) to middle lane (lowest) – sludge return liquors entering ASP inlet.
- not measured or process not commissioned at time of survey.
Values for process not included in databases.
[@] The UKWIR report provides 4 categories of odour emissions – “Low”, “Typical”, “High” and “Very High”

Dispersion modelling of odours from Seafield WwTW

Previous studies

Odour dispersion modelling of emissions from Seafield WwTW was first carried out by WRc in 2004, to establish the odour "baseline" and to test the effects of incremental future odour-abated scenarios. This modelling was updated in 2008, to incorporate a revised odour baseline emission, in 2010 to reflect the potential addition of the THP plant and changes to the odour control units and, finally, in 2012, to determine the effects of covering the sludge cake store and digested sludge holding tank.

The dispersion model used in the WRc assessments was the USEPA Industrial Source Complex-Short Term dispersion code (ISC), together with meteorological data from Edinburgh Airport, although the exact years of data were not specified. The ISC model is no longer the USEPA's recommended regulatory dispersion model and has been replaced by AERMOD[15].

In the UK, the accepted dispersion model code for regulatory applications is ADMS, developed by CERC[16]. Unlike ISC, which uses the Pasquill-Gifford classification of atmospheric stability/turbulence into discrete idealised categories, both AERMOD and ADMS use a continuously varying system of defining atmospheric turbulence, which leads to a more precise simulation of the behaviour of gaseous materials dispersing and diluting in the atmosphere.

Modelling using past, recent and database odour emissions

The ADMS dispersion model has been used in our current modelling of odour emissions from Seafield WwTW, incorporating the following scenarios:

- Scenario 1: The original WRc Option A abatement scenario emissions;
- Scenario 2: The emissions measured during the 2013 Mott MacDonald odour surveys;
- Scenario 3: Average emissions from the Amec Foster Wheeler in-house odour emission database; and
- Scenario 4: Emissions derived from the 2017 Silsoe Odours Limited survey.

All the above were run with 5 individual years (2012-2016) of hourly sequential meteorological data from the Edinburgh Airport (Turnhouse) recording station and the results for the year returning the highest odour concentrations are reported here.[17]

The odour emission sources included in the model are those that are still open to the atmosphere on the current site. Emissions from the odour control units are not included, as these appear to perform well and the residual odours after treatment will not be offensive in nature. The sources in the model include:

- Detritors;

[15] https://www3.epa.gov/scram001/dispersion_prefrec.htm
[16] http://www.cerc.co.uk/environmental-software/ADMS-model.html
[17] The possibility of using more site-specific met data was explored, as there is a weather station on the Seafield site and also one at the RBGE in Leith. However, measurements at the site were not in a suitable form for use in modelling and wind speed and direction is not measured continuously at RBGE.

- PSTs;
- Storm tanks and storm return channels (these are configured in the model to simulate the actual storm tank usage for 2016, with the odour emission rate set to zero at times when the tanks are not in use);
- ASP; and
- FSTs.

The contours represent 98th percentile hourly average concentrations, those concentrations only exceeded for 2% of the hours in a year. This 98th percentile approach to identifying thresholds for odour annoyance has been established since the early 1990's and is a widely applied metric for determining odour annoyance, on the basis that it is not considered unreasonable for communities to experience some detectable levels of ambient odour for a small proportion of the time in a year. Studies in the Netherlands have shown a good relationship between this 98th percentile metric and odour annoyance in communities.

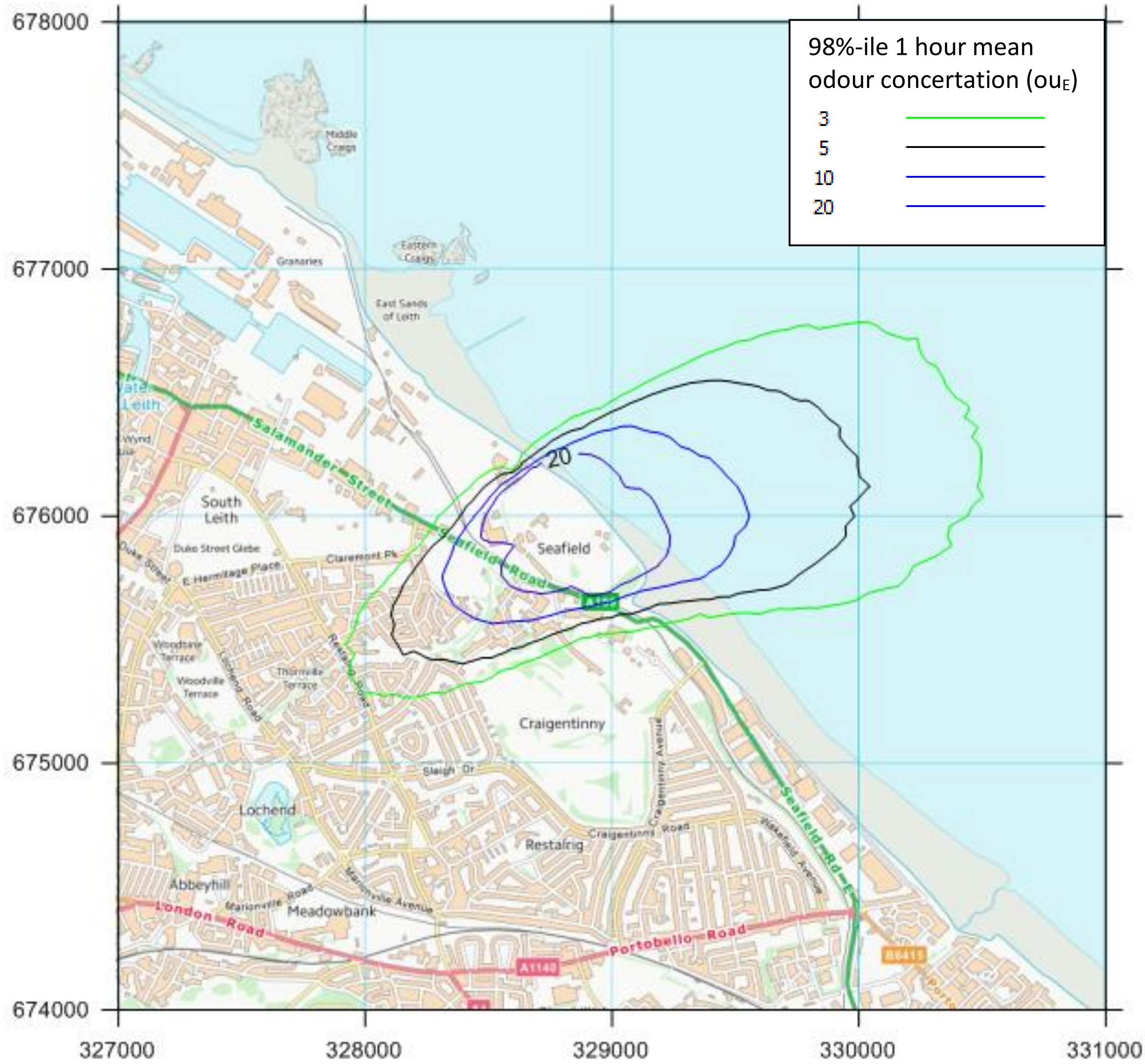
The modelling results for Scenario 1 are contained in the form of an odour contour plot, overlain on a base map of the Leith area, in Figure 6.18.

How do I interpret these modelling results?

The odour contour lines on Figure 6.18 are just the same principle as height contour lines on an Ordinance Survey map but they join together points of equal odour concentration, as opposed to points of equal ground heights above sea level.

The black contour line in Figure 6.18, labelled "5", represents the points where a concentration of 5 odour units (a faint odour) is exceeded for only 175 hours in a year (2% of the year). So, if someone was standing at a point on that line for the entire year, they would experience faint or greater than faint odours for no more than175 hours. For the rest of the year, they would experience no more than a very faint odour.

Figure 6.18 Odour dispersion contours for Scenario 1



The minimum value contour on the plot is 3 ou_E/m^3 as a 98th percentile (green line). This level is currently accepted as that odour concentration below which there should be no complaints[18]. 5 ou_E/m^3 has been used as the benchmark for wastewater treatment works and this is included in the above plot as the black line. Essentially, what this shows is that, using the original emission rates from the Option A WRc abatement study, and incorporating a varying emission rate for the storm tanks and return channels, based upon recorded 2016 usage, there is still the potential for emissions to generate complaints within the local community, as demonstrated by the extent of the odour contours.

When the Scenario 2 model is run as for Scenario 1 but using the Mott MacDonald measured emission rates from the 2013 on-site survey, the results illustrated in Figure 6.19 are obtained.

[18] http://www.ciwem.org/wp-content/uploads/2016/04/Control-of-odour.pdf

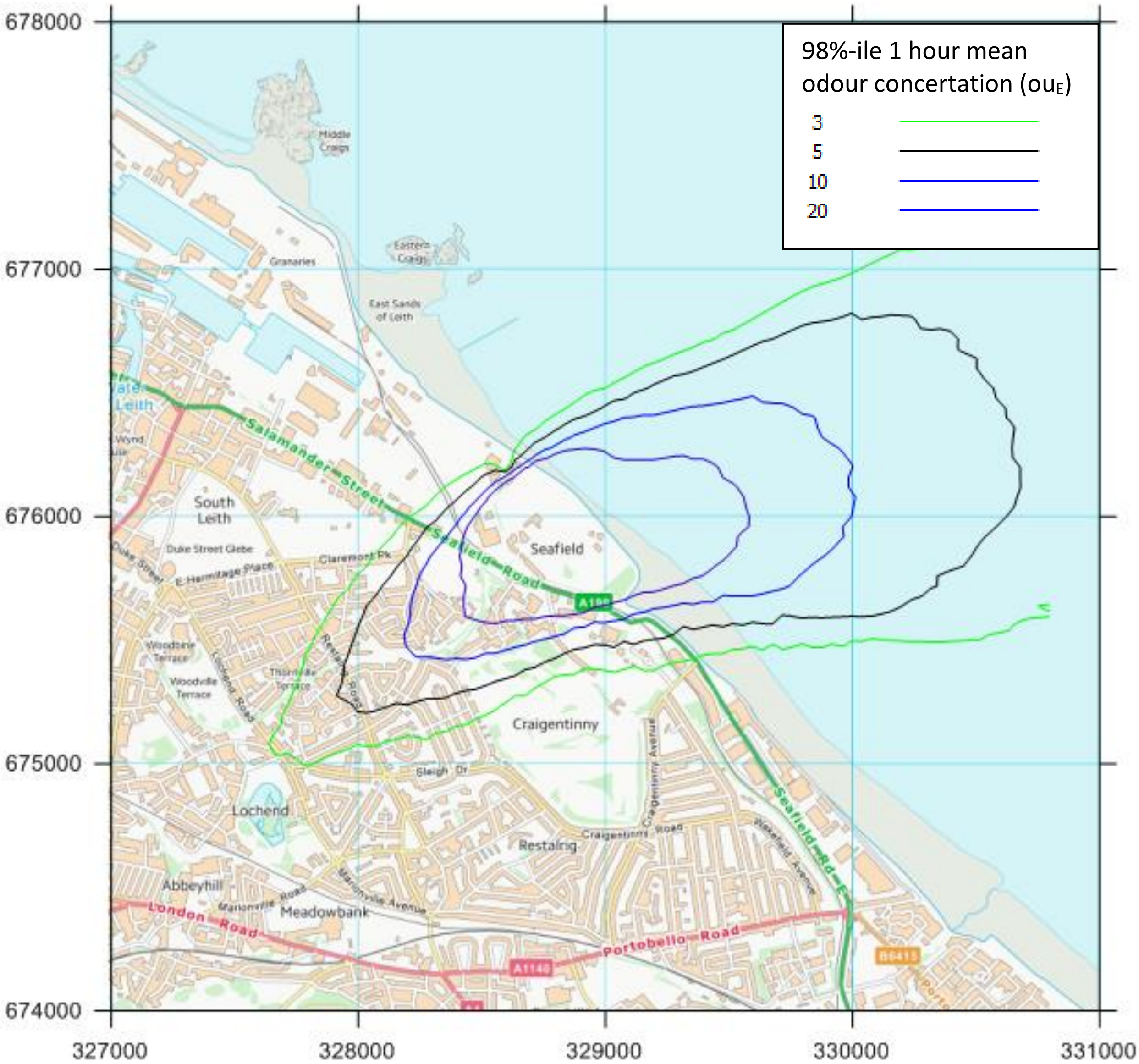
Figure 6.19 Odour dispersion contours for Scenario 2

As for Figure 6.12, the green and black contour lines represent, respectively, the 98th percentile 3 ou_E/m^3 and 5 ou_E/m^3 contours. The extent of the contours is greater than those of Scenario 1 because the measured emission rates from the detritors, PSTs and ASP are all higher than those determined in the WRc assessment of 2003. It is considered that the higher emissions from the ASP result from the sludge dewatering return liquors that were directed to the inlet of the ASP and the bulking growths at the time of the survey.

The modelling results for Scenario 3, using the overall average odour emission rates from the Amec Foster Wheeler database, are presented in Figure 6.20. This shows a position somewhere between those of Scenario 1 and 2, in terms of the extent of the odour contours and the propensity to generate complaints within the local community[19].

[19] It is possible that the average figures in the database are slightly skewed to the high end, as some of the base data is derived from investigations of problem WwTW sites, where odour emission rates would be expected to be higher than "normal".

Figure 6.20 Odour dispersion contours for Scenario 3



It should be noted that the odour emission factors used in the above 3 model scenarios have been derived from a limited number of measurements that represent "snapshots" at discrete times of the year and it is an implicit assumption in the modelling that the emission rates persist for the entire year.

However, what is evident is that, irrespective of which set of odour emission factors are applied in the modelling, levels of odour with the potential to generate annoyance do disperse westwards and west-south-westwards into Leith from Seafield WwTW, when the winds are onshore, which, in 2016, occurred for approximately 28% of the hours in that year.

It should also be noted that these concentration contour plots are based upon hourly average odour concentrations. Within that hour period, concentrations will fluctuate above the hourly average (of course, they will also fluctuate below the average but it is only the fluctuations <u>above</u> the average that concern us here). Human beings experience and react to odours over periods of 10 seconds to 1-2 minutes and, over these time scales, the peak odour concentrations can be as high as 10 – 20 times the hourly average[20].

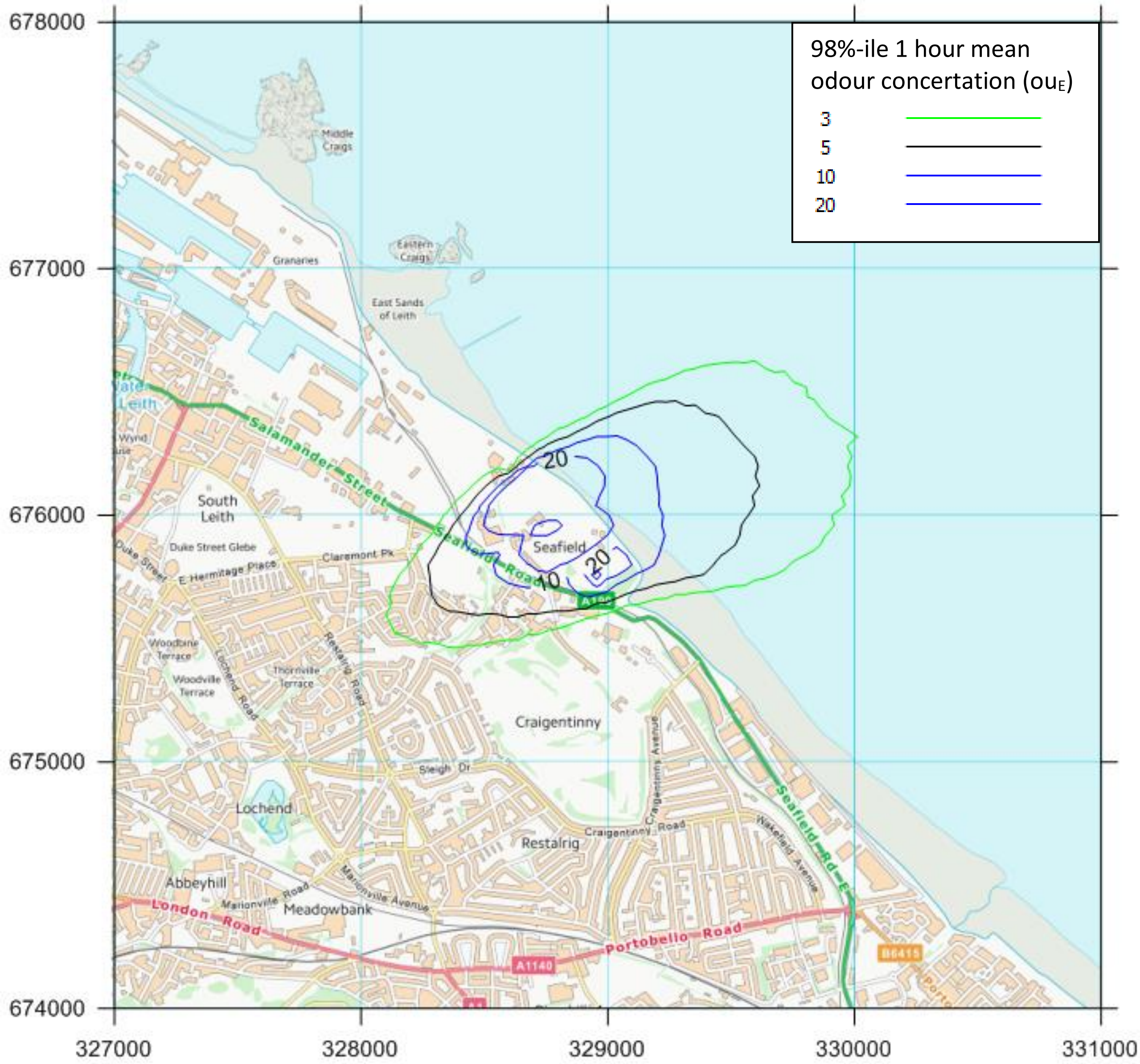
Modelling using 2017 measured odour emissions

The results of the 2017 Silsoe Odours Limited odour emissions survey detailed in Appendix D of this report, include total odour concentrations for each emission source, odour emission rates (in $ou_E/m^2/s$ for open tank sources and ou_E/s for point sources such as OCUs) and H_2S concentrations for each source.

The source emission rates were incorporated into the model that has been established for Scenarios 1-3 above, thus creating a Scenario 4 model. The results of this, again based upon the worst-case year of 2016 meteorology, are contained in Figure 6.21 below. This model contains identical sources to the Scenario 1, 2 & 3 models but also incorporates emissions from the carbon filter units located in the hubs of the PST scraper bridges at the centre of the four operational PSTs, as these were found during the measurement survey to have high levels of odour emissions.

[20] Warren Spring Laboratory (1980) Odour Control – A Concise Guide. ISBN 0856242144.

Figure 6.21 Odour dispersion contours for Scenario 4

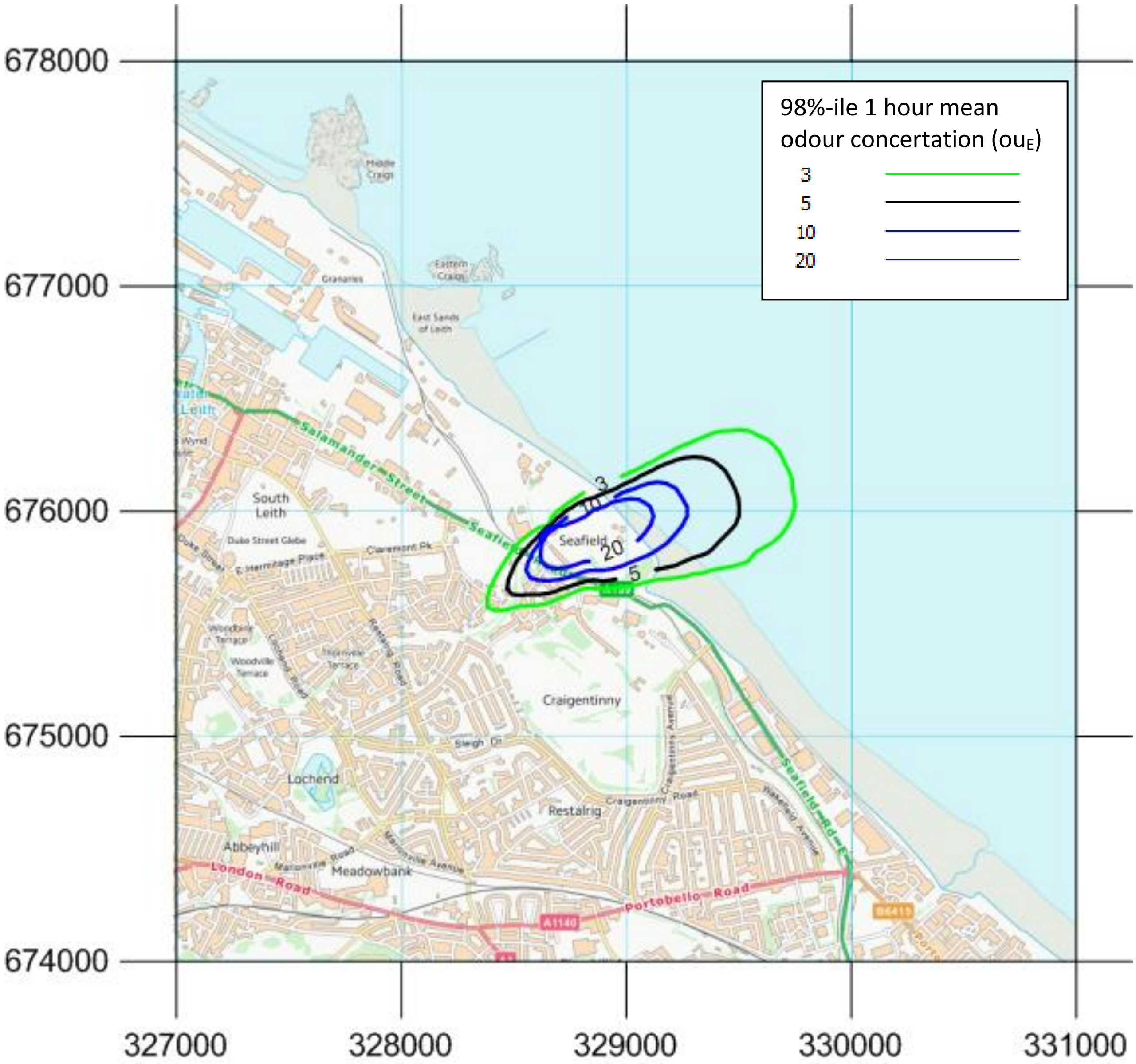


Source apportionment of odour concentrations

In order to identify the WwTW site sources that contribute most to off-site odour concentrations, the above Scenario 1-3 model results were re-processed to extract the contributions of individual sources. The results of this exercise for the PSTs using Scenario 1 emission factors (the lowest of the 3 Scenarios) are shown in Figure 6.22 below.

It can be seen that, even with the PSTs alone in the odour model, emitting odour at the lowest rate of the 4 Scenarios (0.84 $ou_E/m^2/s$, which is less than 50% of the emission measured during the 2013 site survey, less than the geometric mean of PST emission rates in the Amec Foster Wheeler database and lower than the UKWIR "Typical" level) the 3 and 5 ou_E/m^3 98th percentile odour contours extend out into the Leith community.

Figure 6.22 Odour dispersion from PSTs – Scenario 1 emission levels



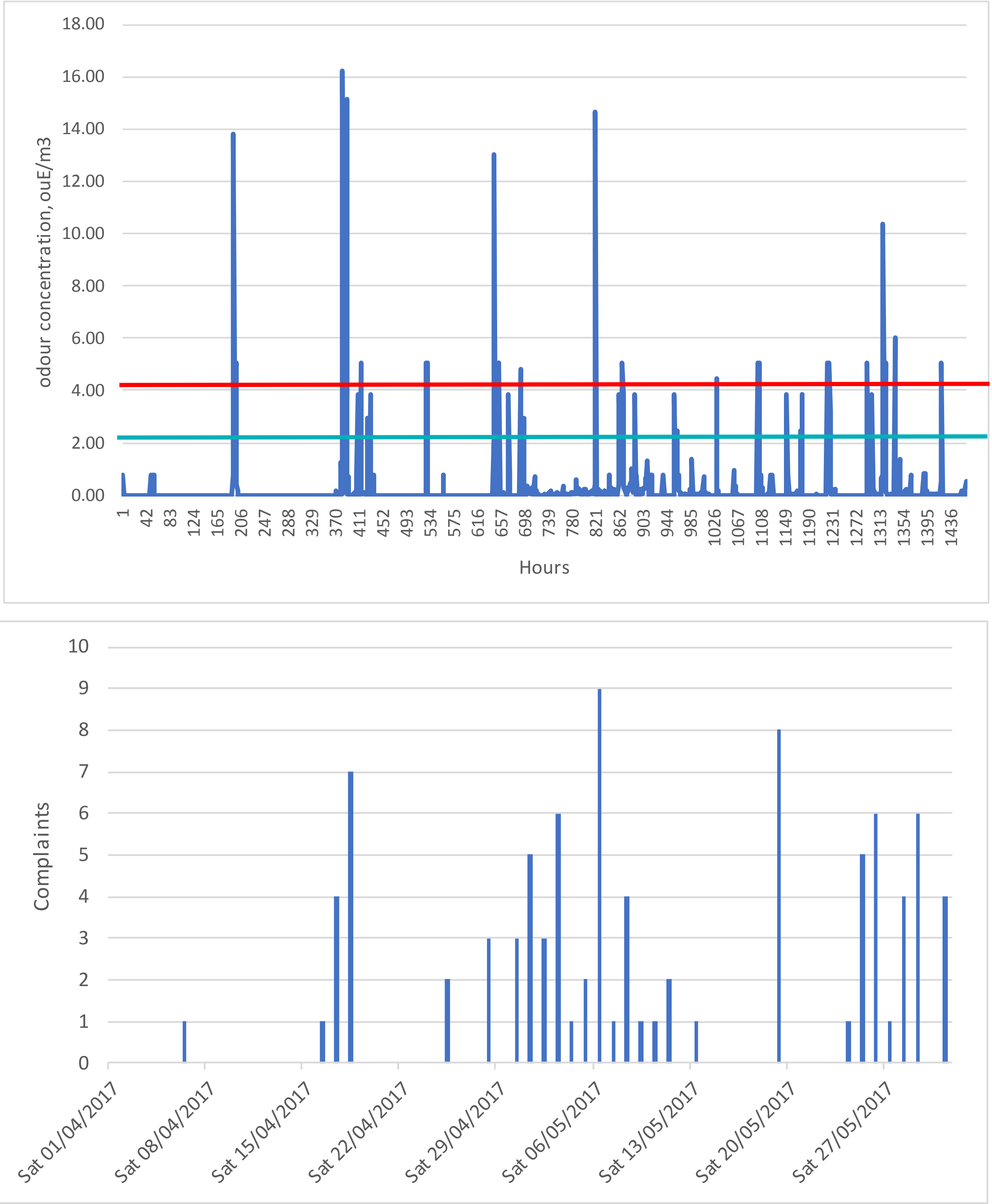
Short-term modelling for April – May 2017

More detailed analysis has been conducted in respect of odour levels likely to have been experienced within the local community during April and May 2017. Hourly sequential measured meteorological data for the period January to June 2017 has been obtained from the UK Met Office and this has been used in a short-term dispersion model which concentrates upon a specific period (months of April and May 2017) and specific receptor points in the residential area to the west and west-south-west of Seafield WwTW.

The odour emission rates used in the model were identical to Scenario 4 above and the model was run on an hour-by-hour basis to yield a time series plot of odour concentrations at the specific receptor points.

Figure 6.23 below shows the output from the model as an hourly time series of odour concentrations at a selected point on Leith Links over the period 1st April 2017 to 31st May 2017. Also included below is a time series of received odour complaints over the same period.

Figure 6.23 Time series of odour concentrations at Leith Links during April and May 2017 and complaints



In summary, there were 27 hours when odour concentrations above 5 ou_E/m^3 were recorded, 59 hours above 3 ou_E/m^3 and the maximum recorded hourly concentration was over 16 ou_E/m^3. There were 92 complaints received over the period.

This shows that during May, there was a more or less continuous low level of odour experienced, superimposed upon by higher level events. This model, again, as for Scenarios 1-3, assumes a continuous level of odour emission from the sources at Seafield WwTW and does not reflect the diurnal or day-to-day variation in emissions that will occur in practice. Neither does it re-create the actual events of April and May 2017, when specific occurrences at the WwTW site created emission “events”. The variation in odour concentrations in the graph above are, therefore determined by the wind direction, speed and other atmospheric conditions. The actual record of concentrations at this location during this period is very likely to be higher than these depicted in Figure 6.23.

The conclusion to be drawn from this modelling exercise is that, under normal continuous low-level emission of odour from Seafield WwTW, onshore winds will give rise to odour concentrations within the local community in Leith that are of sufficient magnitude to cause annoyance and give rise to complaints. In addition, a source apportionment analysis has shown that normal emissions from individual sources (the PSTs) have the potential to cause annoyance. If particular events at the WwTW occur that serve to increase the level of odour emission (such as, for example, septic incoming wastewater, increases in sludge blanket depths in the PSTs, unplanned sludge spillages and/or releases of digester gas), this will significantly increase off-site odour concentrations and intensify annoyance and complaints over and above normal background levels.

Modelling of emissions from sewer vent on Ropeworks Site

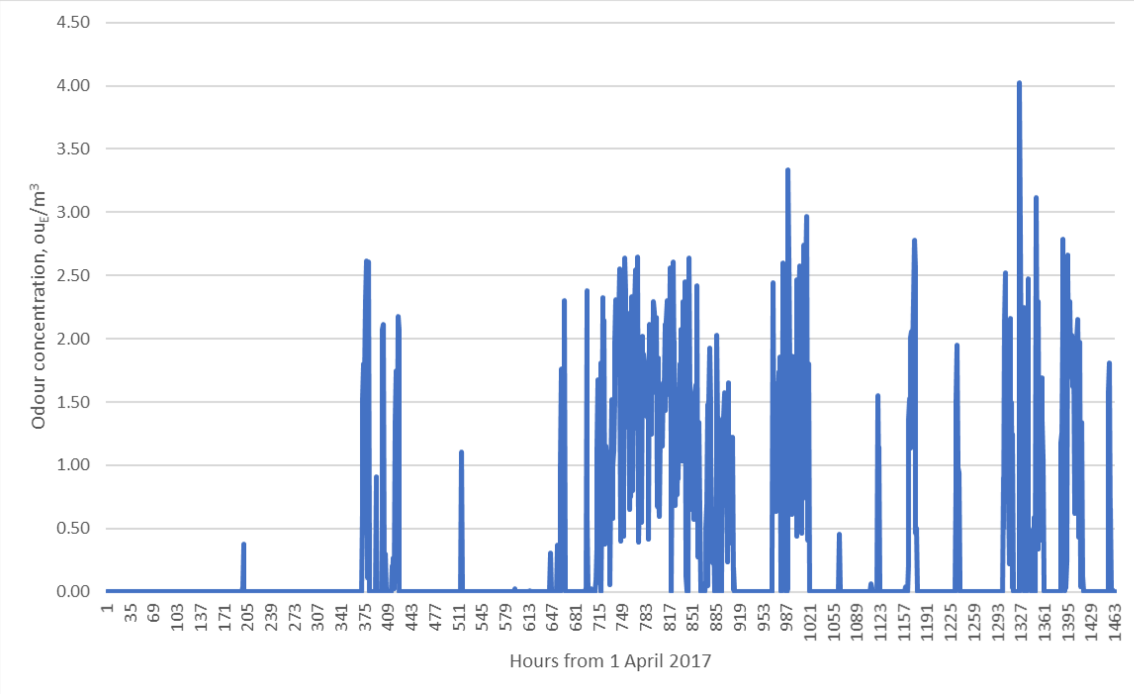
As referred to in Section 6.3 of this report, if the vent pipe is still connected to the Water of Leith sewer, then there is the potential for odours to be drawn out of the pipe by wind action across the orifice. To simulate the potential effect of this upon ambient odour concentrations, a dispersion model was set-up, with the vent pipe represented as a chimney of 10 metre height above ground level, 1 metre in diameter at the top.

On the assumption that air would be drawn out of the vent at the same velocity as the ambient wind speed (3 m/s), this results in an emitted air volume of 2.35 m^3/s. In terms of what odour concentration would exist in the sewer atmosphere, looking at the OdaLog results for the Siphon House (Figure 5.13), an H_2S concentration of 0.5 ppm was selected. To convert this H_2S level to an odour concentration, the relationship between H_2S and odour derived by the Mott MacDonald survey results from 2013 was used (Appendix C of the 2013 Mott MacDonald report). This gave an odour concentration equivalent of 6,318 ou_E/m^3, yielding an odour emission rate form the vent pipe of 14,847 ou_E/s.

This data was input to the model, together with the height, diameter and location of the vent pipe. A single receptor point, to the west-south-west of the vent pipe, on Leith Links, was selected, taking into account the prevailing wind directions. The model was then run for the April and May 2017 period, producing an output odour concentration at the selected receptor point for each hour of that 2-month period (1,464 hours).

The results are presented graphically in Figure 6.24 below as a time series of odour concentrations at the receptor point on Leith Links.

Figure 6.24 Time series of hourly average odour concentrations from the vent pipe at Leith Links



The maximum forecast odour concentration arising from this potential source over this period was 4 ou_E/m^3, just below a faint odour. Within this hourly period, over periods of seconds and minutes, there would be fluctuations in the odour concentration below and above that average level, to the extent of 10-20 times the hourly concentration. It is possible, therefore, that detectable odours could be emitted from the vent pipe. Further engineering investigations will be required to determine if the vent is still connected to the Water of Leith 1889 sewer.

Review of unit process performance

This sub-section of the report considers the sequential and related stages in the Seafield WwTW treatment of wastewaters and sludges and evaluates their effectiveness in odour control terms. It draws upon the results of odour emission surveys on the Seafield WwTW site and information acquired/observations made during the 2017 walkovers.

Preliminary treatment

Incoming wastewater receives coarse and fine screening to 6 mm and then grit removal in four stirred detritors. The inlet MEPS screw pumping station and the inlet channels are all enclosed and covered and air within the enclosures and beneath the covers is extracted and treated in the Main Site OCU prior to release to atmosphere. The detritors are open to the atmosphere and there is little turbulence, the inlet baffles and outlets are enclosed within plastic strip curtains. The odour emission rates measured during the three surveys conducted in 2003, 2013 and 2017 are 4.17 $ou_E/m^2/s$, 13.4 $ou_E/m^2/s$ and 2.97 – 4.64 $ou_E/m^2/s$, respectively. The detritors, with a combined surface area of approximately 1,000 m^2, are a relatively small source with a medium emission rate and are not considered to contribute significantly to off-site odour concentrations, apart from when odorous and potentially septic wastewater arises, such as during April and May 2017.

The outputs from the screening process are washed, compressed and discharged into skips which are enclosed with tarpaulins. Grit is also washed and stored in covered skips. These are not considered, on the basis of their surface area and covering, to be significant odour sources.

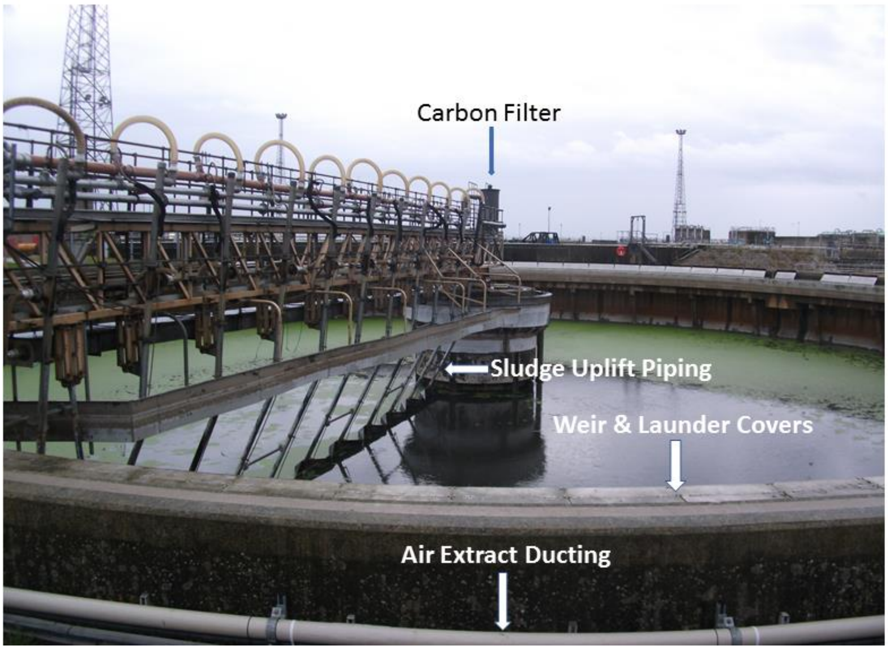
In overall terms, therefore, given the enclosure and odour-controlled nature of the preliminary treatment processes, they are considered to be medium risk.

Primary settlement

The feeder channels from the preliminary treatment stages to the PSTs are all covered and air is extracted from here and treated in the main Site OCU. The sludge return liquors from the PFTs, centrifuges, drum thickener and belt thickeners are fed into these channels by pipeline at a point upstream of the bifurcation point for the two sets of four PSTs. The distribution chambers for each set of four PSTs are covered and extracted to the Main Site OCU.

The PSTs (four are currently in service) are flat-bottomed and the primary sludge that settles on the tank floors is effectively sucked off the floor by flattened nozzles that are suspended from the rotating scraper bridge as it rotates around the tank (Figure 6.25).

Figure 6.25 Primary settlement tank



The weirs and launders of the PSTs are enclosed by moveable covers and the air is extracted to and treated by the Main Site OCU. Whilst there is scope for some fugitive emissions to escape from the brush seals around the scraper bridge mechanism, this is considered to be limited. There is a scum and grease removal system on each PST, which appears, upon observation, to be operating well, with minimal surface scum noticeable on the liquid surfaces of the tanks.

There remain, however, two sources of odour emission here: emissions from the liquid surface in the tank, which is quiescent, and emissions from the carbon filter located on the centre hub of the scraper bridge, which treats the air expelled from the sludge uplift system on each individual tank.

In terms of odour emission values for the PSTs, those measured in the 2003, 2013 and 2017 site surveys were, respectively, 2.53, 5.6 and 0.46 – 1.53 $ou_E/m^2/s$, which, in the round, are not excessive. However, the large exposed surface area of liquid settled wastewater (~9,500 m^2) means that the total odour emission is relatively high (between 16,340 ou_E/s and 212,800 ou_E/s, a large range. From our internal database of results for PSTs, this gives an average of 7.3 $ou_E/m^2/s$, with a range of 0.3 to >35,000 $ou_E/m^2/s$, based upon 126 measurements at plants in the UK.

During the 2017 survey, it was identified that odour concentrations in the outlet air flow from the carbon filters on PSTs 3 and 5 were, respectively, 41,868 ou_E/m^3 and 48,900 ou_E/m^3, with corresponding H_2S concentrations of 5.1 ppm and 7.8 ppm. The associated odour emissions, taking into account the air flow rates, were 330 ou_E/s and 967 ou_E/s.

On this basis, the total emission rates from the four operational PSTs would be between 16,670 and 213,767 ou_E/s.

In addition, at times of low wastewater flow of potentially septic sewage into the WwTW or when sludge blanket levels increase, the emission rate from the surface of the tanks will also increase. Given that the dispersion modelling of PST emissions has indicated that odours from this source will be detectable in the local community under onshore wind conditions and “normal” odour emission rates, it is considered that the PSTs pose an ongoing significant odour risk.

Liquors from sludge thickening and dewatering are returned to the flow into the site just upstream of the PSTs and arise from the following sources:

- Picket fence thickeners for primary sludge;
- Imported sludge drum thickener;
- Surplus activated sludge (SAS) belt thickeners;
- THP thickening centrifuges; and
- Digested sludge dewatering centrifuges.

These liquors have typically high BOD_5 and COD concentrations and are very odorous and, thus, can add to the odour emissions generated by the PSTs. At times of low rainfall and reduced wastewater flow into Seafield WwTW, the sludge removed from the PSTs will have an increased odour potential and this will develop through the thickening processes, generating liquors with an increased odour potential. When returned into the flow immediately upstream of the PSTs, this will further exacerbate odour emissions from this source.

Secondary aerobic treatment (ASP)

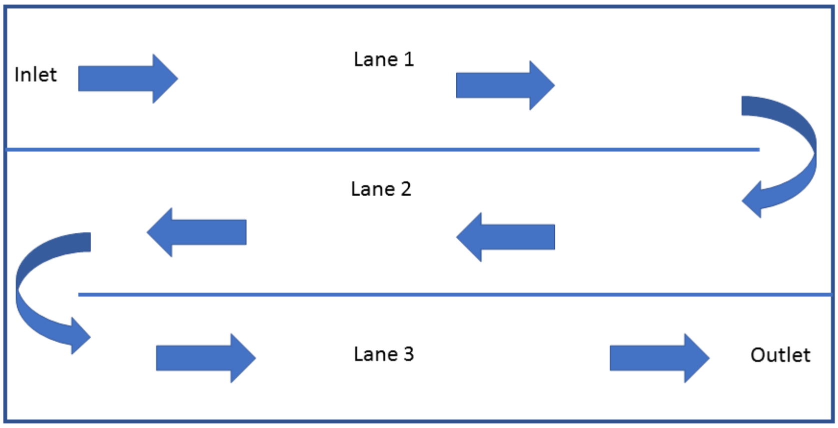
The feeder channels from the PSTs are covered and air extracted from beneath the covers is routed to the Main Site OCU for treatment. Likewise, the return activated sludge, used to “seed” the incoming settled sewage with micro-organisms, is contained and the mixing chambers are enclosed. The ASP is a plug-flow, “carbonaceous”[21] oxidation plant and the sludge age is limited to approximately 2 days, to prevent “bulking”, which is when

[21] This is effectively a “straight-through” process that aims to reduce the BOD5 and COD polluting load in the wastewater. There is no need to ensure oxidation of ammonia to nitrate, or subsequent denitrification, because there is no ammonia or nitrate consent on the discharge from Seafield WwTW to the Firth of Forth.

excessive growths of filamentous organisms produce foaming in the aeration tanks and a sludge that is difficult to settle.

The total area of the aeration lanes is approximately 9,100 m^2, split between 6 sets of three-lane units. Currently, four of the three-lane units are in service and, occasionally, five sets are used, depending upon flows and loads. The arrangement of one of the sets of lanes is illustrated in Figure 6.26 below.

Figure 6.26 Schematic arrangement of aeration lane sets



Because of the operational characteristics, referred to above, the odours emitted from this typical ASP are of an earthy, sweet, detergent-like nature, which are not offensive. During the 2013 Mott MacDonald odour emission survey, when sludge dewatering liquors were routed into the inlet of the ASP and there was bulking, odour emission levels for the first and second halves of Lane 1 were 30.3 $ou_E/m^2/s$ and 14.9 $ou_E/m^2/s$ respectively. Emission rates had declined to a more normal 3.5 $ou_E/m^2/s$ by the middle of Lane 2. From our experience of odour measurements on ASPs, emission rates average 1.96 $ou_E/m^2/s$, with a range of 0.29 to 31.0 $ou_E/m^2/s$ (based upon a sample size of 86 at plants in the UK).

The results obtained during the 2017 Silsoe Odours Ltd survey returned odour emission rates of between 0.44 and 0.49 $ou_E/m^2/s$, which is relatively low. In addition, the odour quality of the samples from the ASP were characterised by the odour panellists as generally “refuse, compost, onions, earthy, damp”, with one sample categorised as “sewage” by one panellist and another sample characterised as “fish” by three panellists.

On this basis, whilst the total odour emission from the ASP would appear to be relatively modest in numerical terms (~ 4,459 ou_E/s), the nature of the odours is such that it is unlikely that these would give rise to annoyance under normal operational circumstances. In addition, there is no evidence from the detailed complaints log of odour descriptions fitting emissions from the ASP. On this basis, assuming that normal operation of the ASP can be achieved on an ongoing basis, it would appear that this can be categorised as low to medium risk. A rating of low risk has been assigned.

Final settlement tanks

In our experience, FSTs do not contribute significantly to overall odour emissions from WwTW sites, unless there is a problem with the upstream ASP which affects the solid-liquid separation process in the FST, or if sludge is held for over-long periods in the tanks. An additional occasional odour problem can occur if foam accumulates at the surface of the stilling drum at the centre of the tank and then decays biologically, releasing odour. In the case of Seafield, final effluent sprays are installed to break-up any such foam accumulations. The typical nature of the odours is sweet and earthy.

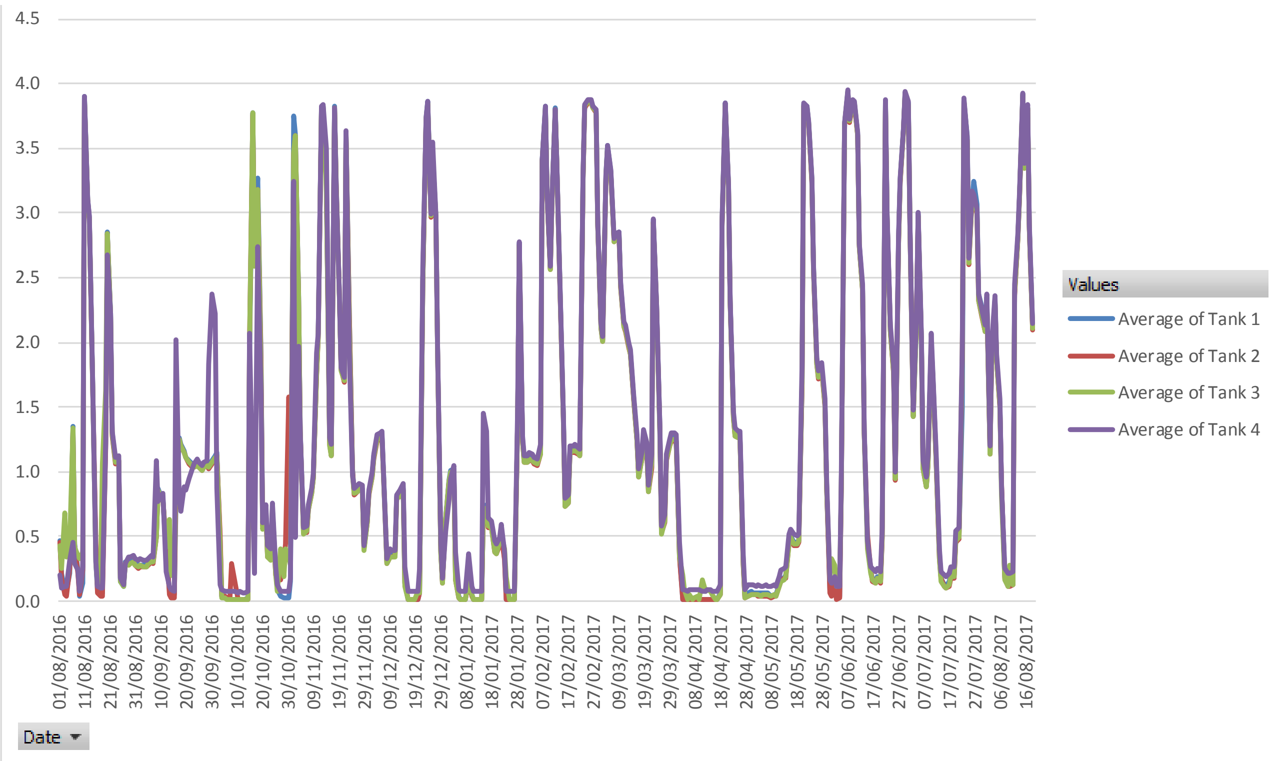
Measured odour emission rates in the 2003, 2013 and 2017 site surveys returned numbers of 0.42, 0.44 and 0.25 $ou_E/m^2/s$ and the odour character in the 2017 survey was predominantly described as “compost, refuse”. These compare with an average emission rate from our internal database of 1.16 $ou_E/m^2/s$, with a range of 0.08 to 14.5 $ou_E/m^2/s$, based upon analysis of 110 samples from UK plants.

On this basis, given the low odour emission rates and the characteristics of the odour, this source is rated as low risk.

Storm tanks and storm sewage return channels

There are four open rectangular storm tanks on the Seafield site, some 12,000 m^2 in area. The feed channels to and from the storm tanks are open to the atmosphere. Usage records obtained from Scottish Water for the period 1st August 2016 to 31st July 2017 indicate that the storm tanks were clean and empty for 63 days and, therefore, held storm sewage and were “in use” for 302 days, either filling, holding, emptying or cleaning. Given the area of the liquid surfaces in the tanks, the potential significance of this odour source cannot be immediately dismissed. Figure 6.27 shows the variation in liquid levels in the storm tanks over this 12-month period.

Figure 6.27 Variation in storm tank content levels 1st August 2016 to 31st July 2017



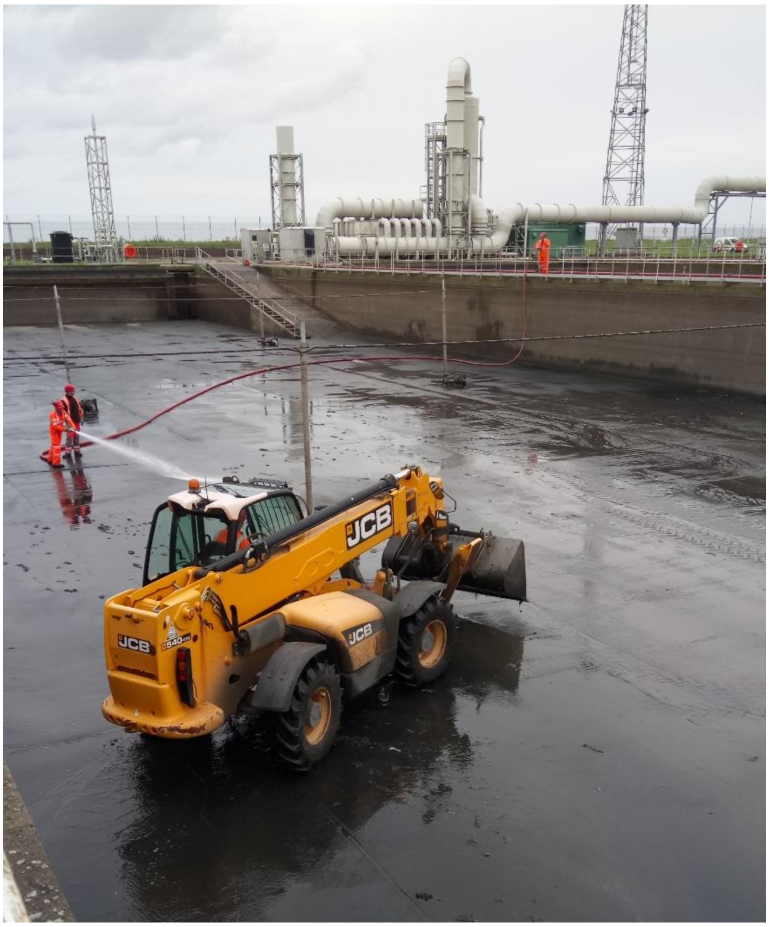
Storm sewage, overall, will be more dilute and, therefore, potentially less odorous than normal dry-weather flow wastewater. However, the “first flush” of storm sewage following a period of dry weather may be particularly odorous, as deposits are purged from the sewerage system and this has been a noted issue at other WwTW sites with extensive catchments (such as, for example, Mogden in West London and Davyhulme in Manchester).

Determining odour emission rates for the contents of storm tanks is, accordingly, problematic. The original WRc surveys in 2004 assumed that the storm tanks would be empty and no emission rates are included in the schedule of rates for consideration in the OIP. The Mott MacDonald report on the 2013 survey recorded the emission rate for empty, clean storm tanks as 0.44 $ou_E/m^2/s$, equal to that measured from the FSTs. However, subsequent odour sampling of a storm tank that had been drained and was awaiting cleaning returned a measurement result of 6.9 $ou_E/m^2/s$.

The odour emission rate recorded in the 2017 Silsoe survey was 2.0 $ou_E/m^2/s$. The average odour emission factor contained in our internal database is 2.64 $ou_E/m^2/s$, with a range of 0.36 to 26.0 $ou_E/m^2/s$; interestingly, a figure referred to in the 2013 Mott MacDonald report as an average for storm water is 2.66 $ou_E/m^2/s$. The measured results would give a total odour emission of between 24,000 and 82,800 ou_E/s, which would likely generate detectable odour concentrations off-site. On this basis, the storm tanks are assigned a rating of high risk.

Because of the particular design of the storm tanks, cleaning has to be a manual operation, as shown in Figure 6.28 below. However, before emptying, the tank contents are mixed using the floor-standing Amajets.

Figure 6.28 Storm tank cleaning operations 5th September 2017



Sludge treatment processes

As described in section 3.2 of this report and Appendix C, sludge treated at Seafield WwTW is both indigenous and imported by road tanker[22]. The sludges are thickened, thermally hydrolysed, anaerobically digested and dewatered to form a cake product of ~ 30% solids content. The biogas evolved during digestion is combusted in spark-ignition engines to generate electricity for site use[23]. All parts of the sludge handling and treatment process take place in covered and ventilated tanks, from tankered sludge reception, picket fence thickening, drum thickening, belt thickening, centrifugation, THP processing and anaerobic digestion. The picket fence thickeners are enclosed and extracted air is treated in a calcified seaweed biofilter prior to discharge to atmosphere.

The buildings in which the sludge treatment is carried out are all connected into an air extraction system which maintains a small negative pressure. The extracted air is routed to an odour control unit (the THP OCU), which consists of a biofilter followed by an activated carbon polishing unit. Air from the digested sludge holding tank and the THP process are routed to the biofilter and then the carbon polishing unit, whilst air extracted from the sludge cake pad building is routed directly to the carbon polishing filter.

From our walkover site inspections, there are occasional fugitive emissions from the sludge cake pad building and these odours have been detected off-site. There is evidence of an ongoing issue with elevated ammonia concentrations in the sludge cake pad building, which has necessitated the installation of booster fans to make working conditions inside the building more acceptable.

Odour control units (OCU)

There are 5 odour control units on the Seafield site:

- **The main OCU**, treating air extracted from:
  - Inlet works:
    - Marine Esplanade Pumping Station (MEPS);
    - Diversion structure;
    - The 5 coarse screens, 5 fine screens and associated channels;
    - Screenhouse building; and
    - Screenings drainage pumping station.
  - 2 PST distribution chambers;
  - 6 PST perimeter weirs;
  - PST outlet channels;
  - Secondary pumping station;
  - ASP main distribution chamber; and
  - 2 ASP sub-distribution chambers.

[22] In addition, sludge is also injected into the sewers at Prestonpans, to minimise tanker traffic into Seafield.
[23] The site is self-sufficient in electricity.

- **The AD OCU**, treating air extracted from the 6 anaerobic digester spill chambers;
- **OCU 1**, treating air extracted from:
  - Picket fence thickeners;
  - Main sludge pumping station; and
  - Tankered sludge import tanks.
- **OCU 2**, treating air extracted from the belt thickener building, the digester feed tank and return liquors sump; and
- **The THP OCU**, treating air extracted from the sludge cake pad building, thickening centrifuges, buffer silo, digested sludge holding tank, and THP itself.

Main OCU

The flow through this OCU is 13.6 m^3/s (48,960 m^3/h). During the odour emissions survey in September 2017, the measured flow was 9.5 m^3/s (34,200 m^3/h). The survey results are shown in Table 6.5 below.

Table 6.5 Odour and H_2S sampling results for the Main OCU (September 2017)

Position	H_2S concentration, ppm	Odour concentration, ou_E/m^3	H_2S abatement efficiency, %	Odour abatement efficiency, %
Scrubber inlet	0.485	2,769	-	-
Carbon filter outlet	0.011	58	98	98

At the time of sampling, this OCU was significantly underloaded, in both flow and odour terms but the removal efficiencies for both H_2S and odour were good (98%).

AD OCU

This OCU treats air extracted from the digester spill chambers with a carbon filter unit and is rated at a flow of 0.18 m^3/s (648 m^3/h). During the survey in September 2017, the measured flow rate was 0.16 m^3/s (576 m^3/h). The results of the sampling for H_2S and odour are contained in Table 6.6.

Table 6.6 Odour and H_2S sampling results for the AD OCU (September 2017)

Position	H_2S concentration, ppm	Odour concentration, ou_E/m^3	H_2S abatement efficiency, %	Odour abatement efficiency, %
Carbon filter inlet	0.675	8,376	-	-
Carbon filter outlet	0.270	37	60	99

OCU 1

At the time of the survey, the calcified seaweed in this OCU was undergoing regeneration and the fans were switched-off. No significant odours were detected in the area around the unit, picket fence thickeners or sludge import tanks.

OCU 2

The measured flow through this unit during the survey was 4.05 m^3/s at the inlet but only 1.67 m_3/s at the outlet point, indicative of leakage from the unit. Measured odour and H_2S concentrations and abatement efficiencies are included in Table 6.7.

Table 6.7 Odour and H_2S sampling results for OCU 2 (September 2017)

Position	H_2S concentration, ppm	Odour concentration, ou_E/m^3	H_2S abatement efficiency, %	Odour abatement efficiency, %
Biofilter inlet	1.7	14,676	-	-
Biofilter outlet	0.745	9,282	56	37

THP OCU

The total air flow through this OCU is ~7.84 m^3/s (28,224 m^3/h). During the 2017 site odour emissions survey, the outlet air from the carbon polishing unit had an average odour concentration of 573 ou_E/m^3, with H_2S present at 0.18 ppm. The full sampling results are shown in Table 6.8 below.

Table 6.8 Odour and H_2S sampling results for the THP OCU (September 2017)

Position	H_2S concentration, ppm	Odour concentration, ou_E/m^3	H_2S abatement efficiency, %	Odour abatement efficiency, %
Biofilter inlet	1.30	14,730		
Biofilter outlet	0.035	1,832	97	88
Carbon unit inlet	0.20	567		
Carbon unit outlet	0.18	573	86	96

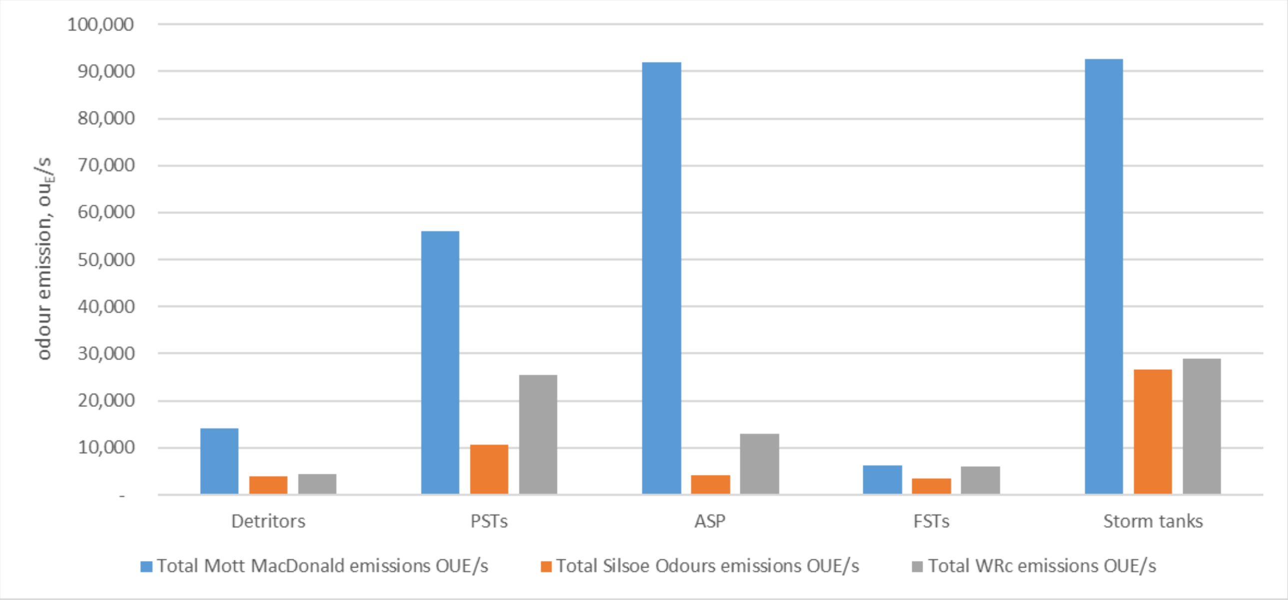
In general, the odour control units were found to be operating well, with the following exceptions:

- The main OCU was underloaded, in terms of flow rate and odour/H_2S loading and clearly has spare capacity;
- Odour removal performance of the AD OCU was good (99%) but the abatement efficiency for H_2S was only 60%. This is indicative either of "blinding" of the carbon active sites by VOC or the wrong selection of carbon type, thus inhibiting H_2S removal;
- OCU 2 was performing poorly, achieving only 56% removal of H_2S and 37% odour abatement; and
- The THP OCU was performing well, overall, achieving 86% H_2S removal and 96% odour removal. However, it appears that the second stage carbon filter unit is not effective at polishing the residual H_2S concentrations and there is no significant difference in the inlet and outlet odour concentrations. This leads to the conclusion that the carbon is exhausted.

Total odour emissions from Seafield WwTW

Based upon the measured odour emissions at Seafield from the 2004 WRc, 2013 Mott MacDonald and 2017 site survey reports, Figure 6.29 depicts these as a bar chart.

Figure 6.29 Bar chart of odour emissions measured from Seafield WwTW



This shows the significant variation in overall site emissions from open processes at the site.

6.4 Summary findings of this chapter of the report

- There are strong links between odour complaints, onshore winds, periods of low raw wastewater flow in April-May 2017, raw wastewater ORP levels, readings from the boundary H_2S monitors and sludge blanket levels in the primary settlement tanks;
- During the exceptionally dry April-May 2017 period, there were elevated baseline odour emissions from the open processes (detritors, PSTs, ASP, storm tanks), owing to low wastewater flows and septicity in the incoming wastewater. However, this cause of odour was compounded by increasing sludge blanket depths in the PSTs, sludge spillages and unplanned digester gas releases. This does not represent best practice operation of Seafield WwTW during this period;
- Emissions of odour from regeneration of the resin filter of the PpTek biogas siloxane removal unit have, in the recent past, contributed strong and noticeable odours in the Leith residential areas. These were first reported in March/April 2016 and the source of the odours was confirmed in September 2016. Following a period of sampling and impact assessment from September 2016 through to February 2017. A health impact assessment of chemicals contained in the emissions found that ambient concentrations in the Leith Links area were well within established public health protection limits. These findings were endorsed by Public Health Scotland and the NHS. A vent air burner has now been commissioned (July 2017) and this thermally oxidises the emissions from the siloxane filter regeneration in a high-temperature flare;
- Fugitive emissions of wastewater odours from manhole chambers and pumping stations in the sewerage network serving Seafield WwTW are a possibility but there is no firm evidence that these could be the source of complaints from the community. The vent pipe on the Water of Leith sewer on the Ropeworks development site could be a source of odour but it has not yet been determined if it is still connected to the sewer;
- An examination of Scottish Water's trade effluent discharge consent records for industries revealed that trade discharges make up approximately 3.8% of the total daily wastewater flow into Seafield WwTW and approximately 6.7% of the polluting load, expressed as BOD5. There are four consented discharges of sulphate into the network, which could contribute to septicity development but the quantities discharged are very small in relation to the large dilution available in the wastewater flows. There are no evident discharges of particularly odorous chemicals that could significantly influence odour emissions from Seafield WwTW. The results of check monitoring on samples of trade effluent indicated a very high level of compliance with the consented discharge limits, with few minor exceptions;

- A survey of H_2S levels in manhole chambers at four locations in the sewer network during September 2017 identified relatively modest concentrations over this period, notably at Wallyford, the Siphon House and Portobello, where similar-timed peaks in H_2S levels were observed, coinciding with rainfall events and increased flow turbulence in the sewers. H_2S levels at MEPS, the main lift pumping station at Seafield WwTW inlet, were negligible over the same period, indicating there is sufficient dilution, under normal conditions, to negate this septicity as a significant cause of odour emissions from Seafield WwTW;
- Examination of measured odour emissions from unit processes at the Seafield WwTW site identified two past surveys (WRc in 2003/4 and Mott MacDonald in 2013). Neither of these is representative of how the site is operated today. A further emissions survey was conducted in September 2017. The results of the surveys were compared against each other and with typical values contained in UKWIR and our own in-house odour emissions database for WwTW sites in the UK. The lowest odour emission rates were found in the 2017 survey, the highest in the 2013 survey *[*with the 2003/4 survey results between these former two. Given the range and scale of the emissions measured in 2013, we find it surprising that these were not used in a modelling exercise to determine the odour “footprint” at that time, as the express reason for the sampling was to assess compliance with the OIP. We consider that this was a missed opportunity to identify the extent of effects at that time from Seafield WwTW;
- An updated odour dispersion model for the Seafield WwTW site has been compiled and has been used to assess the impact upon residential areas in Leith of the different sets of emissions referred to above. This shows that, for the residual “Option A” abatement scenario WRc emissions (Figure 6.18 above), there would still likely be sufficient levels of odour in the community to prompt complaints. Turning to the emission levels measured in 2013, these produce an odour “footprint” (Figure 6.19 above) larger than the 2003/4 emissions. Use of averaged emissions from our in-house database produces a footprint somewhere between the two (Figure 6.20 above). However, it should be noted that these two “scenarios” are not representative of the site as it is today. When the model is run using the measured emissions from the September 2017 survey, a much smaller footprint is derived (Figure 6.21 above);
- The results of this modelling show, in essence, that odour concentrations in the Leith residential areas at times have been at levels that would generate annoyance and complaints, even taking into account the low level of emissions measured in September 2017. This is not a continuous circumstance – these odour concentrations would only arise when the wind is in an onshore direction, which occurs for approximately 25% of the hours in a typical year and then, only when the wind speed is relatively low and emissions are sufficient. In addition, the modelling assumes that the emissions remain constant throughout the year. In reality, these will vary from day-to-day, depending upon weather, wastewater flow and operating conditions;

- A model simulation of conditions during April and May 2017, using real meteorological data for each hour of the 61 days in that period, identified periods when, at a location on Leith Links, odour concentrations arising from Seafield WwTW emissions would be at detectable levels likely to cause annoyance. These were compared with complaints received during that period (Figure 6.23 above) and there is a clear relationship;
- A further simulation of potential emissions from the Water of Leith sewer vent pipe (assuming it is still connected to the sewer and odours can be drawn out of it by wind action) indicates that there is the potential for detectable odours to arise on Leith Links;
- A review of the proportional contribution of the individual unit process to off-site odour concentrations has identified that the PSTs and storm tanks are high-risk in terms of the potential for triggering off-site odour complaints. For the PSTs, this is because of the large surface area of exposed wastewater and emissions from the sludge uplift carbon filters and their sensitivity to the quality of the incoming wastewater and the sludge blanket levels in the tanks. For the storm tanks, although the procedures now adopted by the site operator for emptying and cleaning will minimise the risk of odour annoyance, there is still the risk of this occurring, given the time-in-use of the storm tanks over last year (Figure 6.27 above) and the scale of the likely odour emission rates. The detritors, although a relatively small area source, could also be a moderate risk, at times of incoming odorous and potentially septic wastewater under onshore wind conditions;
- The ASP and FSTs, under normal operational circumstances, are not considered to present a significant risk of causing annoying odours off-site, given the relative inoffensiveness of odours from these sources. This observation is consistent with our experience of such unit processes elsewhere in the UK;
- It is considered, from observations made during the course of this review, that there is definite potential for fugitive odours to escape from the sludge cake pad building, based upon odours experienced at the adjacent site boundary and odours noticed on Leith Links under light onshore wind conditions in July 2017;
- The odour control units on the site have been found, in general, to be operating efficiently, with a number of small exceptions, and are not considered to present a significant risk of causing annoying odours off-site; and
- In summary, therefore, there exists the potential, under onshore winds and varying odour emission rates from the unit processes (particularly the PSTs, storm tanks and, to a lesser extent, the detritors), for odours at annoying levels to occur in Leith from time to time. Earlier this year, this was exacerbated by a long dry period and other, uncontrolled releases of odour. These latter emissions should be controllable, moving forward. However, the risk of odour arising from the remaining uncovered sources remains.

7. Operation of sewer network and Seafield WwTW

7.1 The sewer network

A schematic flow chart of the sewer network that contributes wastewater flows to Seafield WwTW is contained in Appendix B. Operation of elements of this network is split between Scottish Water (dark blue boxes) and Stirling Water/Veolia (light blue boxes).

There are a total of 19 wastewater pumping stations and one discharge chamber (at Milton Bridge) managed and maintained by Scottish Water. These include wastewater flows from the coastal towns of Longniddry along to Joppa in the east, Penicuik, Glencorse and Milton Bridge in the south and flows from central and western Edinburgh through Cramond, McDonald Road, Granton, Trinity and Albert Road pumping stations.

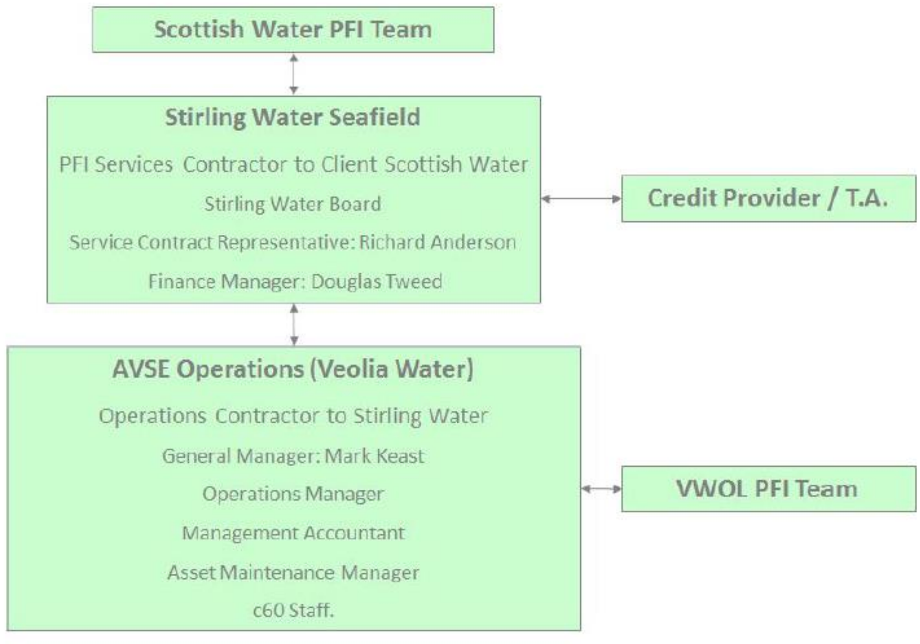
Stirling Water/Veolia are responsible for the operation and maintenance of pumping and storm water facilities at Mayshade, Haverall Wood, Middlemills, Newton grange, Suttieslea, Newbattle, Hardengreen, Dalkeith and Harelaw, which all feed in to Wallyford pumping station and storm water facility. There is also an off-line storm water detention facility at Portobello Golf Course, but we understand this is rarely used. Stirling Water/Veolia also manage and maintain the Siphon House and Marine Esplanade pumping station (MEPS).

7.2 Seafield WwTW

Introduction

Seafield WwTW and sludge treatment centre (STC) is operated by Stirling Water Seafield Limited and Veolia under a PFI agreement with Scottish Water. The relationship between these three parties is summarised in Figure 7.1 below.

Figure 7.1 PFI contractual arrangement between Scottish Water, Stirling Water and Veolia



From our site walkovers and discussions with Stirling Water, Veolia and Scottish Water personnel over the review period, it is evident that on a day-to-day basis under normal circumstances, the WwTW and STC are operated to a high standard and in accordance with the OMP, which is designed to achieve compliance with the OIP, WML and Working Plan. There is a good system of "odour relevant" procedures in place, including:

- The daily site inspection check list;
- The odour assessment check sheet;
- The odour site investigation procedure;
- The odour complaint investigation report; and
- The operational procedure for odour sensitive tasks.

There is a designated Odour Technician present on the site 24 hours per day, 7 days per week and this person is responsible for carrying out the above bullet-pointed tasks, together with ensuring that the OCUs are operating effectively.

Areas of concern

There are some aspects of WwTW and STC operation that lead us to consider potential areas for improvement.

Operations during adverse weather conditions

During periods of light onshore winds (generally less than a speed of 3 m/s and, particularly, harr conditions), there exists the potential for emissions from the PSTs to generate noticeable odours as far to the west as Leith Links and beyond. We consider that this is the case, even taking into account best practice operation of the WwTW site, because the surface area of the four operating open PSTs containing settled sewage is very large (approximately 9,200 m^2) and there are additional emissions from the PST air uplift carbon filters. The measurement survey carried out in September 2017 identified that the odour emission rate from the two PSTs sampled was 0.84 $ou_E/m^2/s$. This emission rate is just slightly above the minimum rate in the Amec Foster Wheeler database, which has 126 individual PST measurements over a 12-year period from WwTW sites in the UK. It is also less than 50% of the "Typical" emission rate identified by UKWIR for PSTs (2.1 $ou_E/m^2/s$), which, itself, is widely regarded by practitioners as being optimistic. The emission rate used by WRc in their 2003/4 work was 2.53 $ou_E/m^2/s$ and this would be sufficient to cause detectable odours off-site.

Under these adverse weather conditions, even emissions at low levels from such a large area source will give rise to detectable odours off-site.

Quality of the incoming wastewater

It is most likely that the low emission rate measured in September 2017 can only be sustained when there is no significant septicity in the incoming wastewater flow and when the sludge blanket levels in the PSTs are maintained at a low level (< 0.4 m). During dry periods, when the flow into Seafield WwTW is lower than average and when septicity arises in the wastewater (possibly also from a small "first flush" through the sewers following limited rainfall), the odour emission rate from the PSTs will increase significantly. Under such conditions, with a low-speed onshore wind, annoying levels of odour are likely to persist off-site and even the most careful management of the PSTs can do little to mitigate this.

Sludge blanket levels in the PSTs

Allowing sludge blanket levels to increase and be sustained in the PSTs (effectively “storing” sludge in the PSTs) cannot be regarded as best practice. This has been established in a number of previous odour nuisance cases in the UK. In the majority of cases where levels of primary sludge in PSTs have been allowed to increase, thus increasing septicity in the sludge and the overlying settled sewage (the tell-tale signs of which are bubbles bursting on the surface of the PSTs from anaerobic activity within the accumulated sludge), this has been caused by the following, either individually or in combination at a number of other WwTW sites in the UK:

- A restriction in the downstream capacity for sludge storage or processing;
- Equipment breakdowns;
- A simple lack of physical capacity;
- Ineffective sludge stock management; and
- Non-availability of a recovery or disposal route.

Storm tank use, emptying and cleaning

Over a period of years, Veolia has developed a systematic procedure for emptying and cleaning of the storm tanks (Figure 6.28 on page 95). Previously, final emptying of the residual contents of the storm tanks was delayed until there was an offshore wind. However, this was often confounded by changes in wind directions, resulting in odour complaints (see Figure 6.1 on page 57 – for example, April 2014).

The procedure has now been amended, so that the contents of the storm tanks are mixed prior to draining-down, leaving a layer of water over the settled solids and then the tanks are emptied and cleaned as soon as possible, largely irrespective of wind direction, the objective being to prevent septicity development in the storm water and increased odour emissions.

Having observed the storm tank cleaning procedures, we are of the opinion that this is currently conducted in the optimum manner possible to minimise odour emissions, taking into consideration the design of the tanks. However, it does appear that there will still remain a risk of significant odour emissions from time to time.

Sludge cake pad building operations

Dewatered, centrifuged sludge cake is delivered into the sludge cake pad building via conveyors from the centrifuges, where it is deposited directly onto the building floor in piles. From there, when sludge is dispatched, it is transferred by wheeled bucket loader into lorries and transported to the recovery site. Our observations on site and discussions with operational staff confirm that there is often an issue with high ammonia levels within the building, emanating from the dewatered sludge piles, and that personnel entry is not always safe, unless booster extraction fans are operated to improve the quality of the internal building atmosphere.

In our experience, this is a not uncommon problem with sludge cake dispatch operations, the response to which at many WwTW sites has been to "containerise". This has involved the provision of sludge cake discharge chutes, each dedicated to a specific sludge-receiving skip or container, which may or may not be covered or enclosed. If covered or enclosed containers or skips are used, then air can be extracted from around the chute discharge points to prevent odour escape into the building envelope. This means that the building atmosphere is less contaminated, personnel entry is possible without respiratory personal protective equipment (PPE) and it will only be necessary to ventilate the building envelope at a relatively low air change rate, thus saving on air handling and treatment costs. This containerisation and combination of effective and efficient local and general exhaust ventilation represents current best practice.

Proactive approaches to enhanced odour management

We understand and accept that the site operators, Stirling Water/Veolia, carry out their agreed duties on the sewerage network and at Seafield WwTW in accordance with the PFI contract conditions and requirements. In relation to management of odour in accordance with the OMP, this achieves an acceptable odour climate off-site in the Leith Links area to the west of Seafield WwTW for greater than 75% of the year, when the wind is offshore. However, for the remaining 25% of the time, there is a risk of onshore odour. In 2016, there were 755 hours when the wind was blowing onshore at a speed of less than 3 m/s (between 50 degrees to 150 degrees from North), equal to 8.6% of the year, four times greater than the 2% of hours in the year which forms the basis for the accepted odour annoyance benchmarks (see box on page 80 above).

It is entirely likely, therefore, that odour annoyance does arise at times during this 8.6% of hours, even when the WwTw and STC are being operated in accordance with the OMP – it is just that the scale of the odour emissions under these weather conditions and normal operations is sufficient to cause detectable odours off-site. To address this issue, therefore, requires additional measures in the OMP, the detail and content of which we suggest could be identified and agreed through a technical/engineering workshop or series of workshops between Scottish Water, Stirling Water and Veolia. This could also address actions to be taken to cope with periods of low flow in the network and wastewater septicity.

Table 7.1 below contains recommendations for changes to the OMP.

Table 7.1 Suggested amendments to the OMP

Rationale for improved odour control	Recommended change
Routine, objective, on-site measures using a reliable proxy for odour should be used to provide an early alert to odours and overcome 'adaptation' to odours by site staff	Use current, online H_2S measurements on-site as a basis for triggering odour limit levels. These can be determined using odour modelling where emission values are matched with odour concentration units.

Rationale for improved odour control	Recommended change
As above	Regular (at least weekly) walk-over surveys of inlet, PST and STC areas should be included as routine monitoring for H_2S monitoring across the site. This should incorporate use of a hand-held H_2S monitor (Arizona Instruments "Jerome" or similar, reading down to 3 ppb H_2S). Surveys should be carried out at the upwind and downwind boundaries of the site and process units. This approach should also be adopted by the on-site Odour Technician in response to odour complaints received.
It recommended that emissions are sampled, modelled and reviewed with independent technical oversight. **Use of emission modelling studies to determine the areas where the highest emission sources (volume x concentration) exist on site.**	Undertake emissions measurements and modelling to determine the off-site impact of operations. This is advised to be completed annually initially, then reported to a forum for stakeholders to review the implementation and prioritisation of control measures.
Greater openness and transparency of data will help ensure the visibility of key operations and work to build trust with the community. **It is advised that a web site of live information is provided to report on routine measurements and key data such as operational changes, maintenance and failures that are likely to have an impact on odour control or result in increased emissions.**	Provide a web page that includes daily updates on odour incidents reported from the site and community, i.e. H_2S exceedances, spills and incidents on site, complaints (anonymised by postcode and detail of the report), PST sludge levels exceeding an agreed value – to be determined, e.g., >0.2m in each tank or what is deemed to be operationally appropriate.
Use precautionary methods to predict the risk of increased odour emission.	Apply HAZOP and or Risk Assessment principles to all operations with the potential to cause an increase or risk emission of odour off-site
Provide an alert to the community where an increase in odours is predicted	Using the web site above in addition to informing the site regulators, CEC and SEPA of a risk of or predicted increases in odour emissions. This should include

Rationale for improved odour control	Recommended change
	the reason for the incident, the potential duration, and methods to mitigate the impact.

8. Options appraisal for odour emissions reduction

This section of the report provides a series of recommendations for future improvement of the odour climate around Seafield WwTW, focusing upon both operational and capital changes to the sewer network and the Seafield WwTW site, on a short, medium and long-term basis. The order of costs for these changes are high level estimates, together with commentary on features and feasibility.

8.1 Introduction

The results of these investigations, as summarised in Section 6.5 of this report, have identified, being consistent with the experiences of stakeholders in the local community over the last few years, that Seafield WwTW can still be a source of detectable odours in Leith. This is not a constant stimulus; the wind only blows onshore from Seafield WwTW towards Leith for approximately 25% of the year. There are also periods of calm or very low wind speeds (on average (for approximately 2.5% of the year), during a proportion of which, odours from Seafield WwTW can travel by advection into nearby residential areas. Under such conditions, dispersion and dilution of odours in the atmosphere will be insufficient to reach undetectable concentrations.

The main sources of these odour emissions have been identified as:

- Emissions from exposed wastewater, including the PSTs, storm tanks and, to a lesser extent, the detritors, which contribute to a low level of ongoing odour. The level of odour emission is affected by septicity in the sewer network and management and operation of the PST sludge blanket levels;
- Fugitive emissions from the sludge cake pad building; and
- Odour emissions arising from unplanned occurrences, such as sludge spillages, biogas pressure relief releases

8.2 The regulatory framework

Scottish Water operates within a regulatory framework established by the Scottish Parliament in which Scottish Ministers, acting on behalf of the people of Scotland, set the objectives for the industry to be delivered at least cost to customers. A key player in this regulatory framework is Scottish Water's economic regulator, the Water Industry Commission for Scotland. The Commission is a non-departmental public body with statutory responsibilities. Its role is to manage an effective regulatory framework which encourages the Scottish water industry to provide a high-quality service and value for money to customers. It acts independently of Ministers.

In November 2014, the Commission published its Final Determination, which set charge caps for the regulatory control period from April 2015 to March 2021. This determination set out that household customers' bills will increase below the rate of inflation over the six-year regulatory control period. This meant that typical household water and sewerage bills will increase by £5 or less each year. In simple terms, well before the next regulatory control period, Scottish Water identifies what new developments, existing plant improvements, maintenance and legal compliance measures it needs to take over the future six-year period to meet Scottish Ministers' objectives and then compiles a reasoned, costed plan that is submitted for consideration. The Commission, in discussion with the Government and various other bodies[24], then comes to a Final Determination, deciding, *inter alia*, which proposed schemes should be funded by customer revenues.

The next regulatory control period starts in April 2021 and runs to March 2027. The Final Determination on pricing caps for the next regulatory control period will be announced in 2020. For the remaining 3 years of the current regulatory control period, it is considered unlikely that significant capital expenditure could be made at Seafield WwTW or in the surrounding network under its control, as the investment objectives set in the Scottish Water submission to inform the 2014 Final Determination will be largely committed by now; indeed, a good number of schemes will already be under way.

This is not a matter that is within our ability to influence – it is for Scottish Water and the Scottish Government to determine whether financial budgets can be moved around to facilitate investment in the short-term at Seafield WwTW. What our experience of undertaking recent consultancy work in the industry does tell us is that there is a strong emphasis on achieving best value for the customers' money and that the financial stringency present since the period of austerity that started in 2008 is continuing.

An added complexity is the PFI contract under the terms of which Stirling Water and Veolia operate Seafield WwTW on behalf of Scottish Water. This contract runs until 2029. We are not privy to the terms of this contract and are unable to speculate what, if any, contract variations could be developed to improve the odour climate at Seafield. That, again, is a matter for Veolia, Stirling Water, Scottish Water and, ultimately, the Scottish Government.

8.3 Recommendations

With the above in mind, we have made our recommendations on the basis that short-term measures to improve the odour climate around Seafield WwTW, that is, over the next 2 years, will be unlikely to feature any high-cost capital measures. Rather, the thrust of the recommendations is focused upon generating evidence-based proposals for future capital investment that could be considered for the next regulatory control period(s). These recommendations are contained in the following Tables 8.1 to 8.6.

[24] The Drinking Water Quality Regulator; the Scottish Environment Protection Agency; the customer representative body, Customer Forum [] Please check; and for investigation of complaints, the Scottish Public Services Ombudsman.

Table 8.1 Short Term (0 – 2 years) Feasibility Study Recommendations (Feed into Medium- and Long-Term Measures Implementation)

Study	Justification	Commentary	Order of cost, £
Engineering feasibility study for conversion of the storm tanks to sequential and selective filling and for installation of automated cleaning procedures (scrapers, AmJets/SwingJets)	Whilst the current developed procedures for emptying and cleaning of the storm tanks are optimised, any further refinement is constrained by the technology and the requirement to apply manual cleaning techniques. The potential for odour impacts in the community persists.	The storm tanks at Seafield are approximately 100 metres by 25 metres. Storm tanks at Davyhulme in Manchester are 250 metres by 30 metres and incorporate motorised scrapers to automate the cleaning process. This regularly achieves a high level of empty tank cleanliness. Feasibility study would need to consider, *inter alia*, structural integrity of storm tank dividing and end walls and floor, any structural changes required and provision of manual/automated SwingJets. Potential covering of some/all of the storm tanks could then be considered.	~£250K
Engineering feasibility study for replacement of Primary Settlement Tanks (PSTs) – identification of alternatives and options for providing enclosed or covered process	A key finding of this Strategic Review is that the PSTs will remain, at times, a significant source of odour that will be detected by the local community and, therefore, action is required to abate this source of odour.	These are large open sources of wastewater odour, which are subject to variations in the quality of the incoming wastewater. There are examples around the UK of WwTW sites where PSTs are covered (Davyhulme, Mogden, Deephams, Beckton, Howdon, Ford) and where PSTs are enclosed in buildings (Reading, Weatherlees). Feasibility study should focus upon alternative, small-footprint, high-rate processes, such as lamella settlers, which would also require enhanced	~£300K

Study	Justification	Commentary	Order of cost, £
		preliminary treatment and FOG (fat, oil, grease) removal upstream. Also consider the possibility of floating and rotating covers, although these have only been applied to relatively small to medium diameter PSTs. Also consider more radical options, such as rebuilding smaller, higher-capacity PSTs with covers within the existing PST structures, eradicating the PSTs and converting the treatment process to oxidation ditches such as at Shieldhall (front ends may require odour control). Shieldhall serves 600,000 population equivalents and most oxidation ditch plants serve small to medium populations. Some in North America serve up to 100 ML/day, one-third the size of Seafield.	
Develop a contingency plan for dosing the network at key locations during periods of low or no rainfall to alleviate septicity, with the objective of having this in place for Spring 2018.	Experience of low rainfall periods in April and May 2017 is that low flow (two-thirds of normal) gave rise to long retention times of wastewater in the sewer network, septic wastewater entering Seafield and demonstrable relationship between septicity and odour complaints.	There is no doubt that this was a major cause of odours in and the complaints from the community in April & May 2017. Whilst there is a Nutriox dosing rig already installed at Wallyford (see below), in the event of a repeat of 2017's unusually dry Spring, a plan needs to be in place to address this quickly. The study should focus upon the short-term use of mobile dosing rigs at key locations in the network and a ferric dosing installation at MEPS.	~£50 - £100K

Study	Justification	Commentary	Order of cost, £
Carry out a detailed ventilation, air flow and damper evaluation of the current covered and extracted areas of Seafield WwTW (inlet works, PST weirs & launders, inlet channels, secondary pumping station, ASP main distribution chamber, ASP sub-distribution chambers).	There is no evidence of this having been carried out and should be done on an annual basis, initially, to ensure proper balancing of flows in the ductwork and correct containment of odours beneath covers and in OCUs.	Whilst there is no evidence that fugitive emissions of odour from covered areas or ductwork is occurring, this represents a best practice operation.	~£50K
Undertake a review of sludge storage capacity on the Seafield site and determine what additional capacity is required.	There is evidence that primary sludge has been held-up in the PSTs as a result of downstream processing bottlenecks from time to time. This is a departure from accepted best practice.	In the majority of cases where high PST sludge levels have occurred, this has been a consequence of issues with downstream processing capacity. Additional storage, even of a temporary nature, with appropriate odour control, is desirable.	~£100K
Carry out a detailed air balance and ventilation study on the sludge cake building to identify improvements to achieve better containment of air during normal operation.	Direct experience during this Strategic Review of fugitive odour releases from this building at the site boundary and on Leith Links.	Ammonia levels in the sludge cake pad building inhibit personnel entry and booster fans have to be used to improve air quality within the building. A short-term fix is required, by increasing the air exchange rate and, possibly, transferring this additional foul air flow to the main OCU, which is currently under-loaded.	~£50 - £100K

Study	Justification	Commentary	Order of cost, £
Undertake an initial feasibility study of providing treatment of wastewaters at intermediate points in the network.	Network study has identified H_2S levels at Wallyford and it is likely that the “coastal towns” branch of the network from Longniddry to Eastfield will also generate septicity.	This should focus upon the potential provision of secondary treatment at intermediate pumping station sites (additional land required and note that new-build residential is already encroaching closer to the site) and also for the coastal towns network. Land availability and acquisition and public acceptance will be significant issues.	~£150K

Table 8.2 Short Term Implementation of Measures for the sewer network (0 - 2 years)

Measure	Justification	Commentary	Order of cost, £
Re-commission and implement the Nutriox dosing installation at Wallyford.	Wallyford has been identified during the September 2017 network survey as the point at which H_2S levels are detectable (< 2.5 ppm) in the inlet manhole chambers.	Re-commissioning the chemical dosing would reduce septicity in the downstream network and also prevent development.	Capital Cost ~£100K plus annual Opex depending upon chemical usage, to be determined by modelling of network.
Install H_2S monitoring at the Siphon House	Survey during September 2017 identified slightly elevated levels at the Siphon House and the monitoring could be used to initiate and control dosing at MEPS.	Chemical dosing at MEPS to “mop-up” generated sulphides in the incoming wastewater (see next item in Table) could be controlled by monitoring at the Siphon House.	Capital cost ~£30K plus annual maintenance of £5K.
Install and implement chemical dosing facility at MEPS	Occurrence of septic incoming wastewater.	This could be used to mop-up sulphide in the incoming wastewater and reduce odour emissions from the PSTs during treatment. There would be a greater sludge make from the PSTs and, hopefully, improved settlement. Would have to consider implications for downstream sludge processing of changes in sludge characteristics.	~£250K capital plus Opex

Measure	Justification	Commentary	Order of cost, £
Investigate further the status of the vent pipe on the Ropeworks development site. Investigate sealing of the vent, if still open to atmosphere.	If this is still connected to the Water of Leith 1889 gravity sewer, then the potential exists for odours to be drawn out of the pipe.	A search of Scottish Water plans and documents has revealed little and the construction company on the Ropeworks site is unaware of the status of the vent. A detailed search of Scottish Water archives will be needed to ascertain exact status, possibly also involving intrusive investigations.	~£25K
Extend the septicity survey in the sewer network. Consider the effects of sludge contributions at Prestonpans and Glencorse Pumping Stations	Need to identify exactly where in the network the major septicity generation arises.	As part of the Strategic Review a 10-day survey was conducted at four locations. With the acquisition of the OdaLog instruments, Scottish Water/Veolia have the ability to conduct additional studies which will feed into the dosing locations and intermediate treatment studies.	~£20K

Table 8.3 Medium Term (2 – 7 years) Measures

Measure	Justification	Commentary	Order of cost, £
Depending upon the outcomes of the feasibility study (see Table 8.1 above), consider conversion of storm tanks with scrapers and SwingJets to automate cleaning and enable sequential filling.	Identification of storm tanks as significant odour source.	This would enable more effective cleaning of the storm tanks and removal of the requirement for regular man-entry for cleaning. Given the regular use (302 days in 2016/17), this would be an advantage in reducing odour emission risks. Also would facilitate the installation of covers, should this be necessary.	~£5 - £10 million
Depending upon the outcomes of the feasibility study, consider re-development of sludge cake building to provide an airlock-controlled, full negative pressure facility with efficient air containment and treatment.	Fugitive sludge odours from building.	This would involve clearing-out of the redundant equipment from the former dryer building, establishing an incoming/outgoing sludge transport vehicles airlock system, uprating the air extraction and abatement system, re-organising the sludge cake discharge arrangements, so that sludge discharge directly into covered/enclosed skips (to avoid current practice of double-handling).	~£3 - £5 million
Pending the outcomes of the feasibility study, identify options for provision of additional sludge storage capacity at Seafield WwTW.	Reduce need to hold-up sludge in PSTs, process sludge more rapidly.	Assuming space is available in the correct locations on the site, one or two additional tanks may be required and perhaps an additional PFT.	Capital cost ~£2 - £4 million.

Measure	Justification	Commentary	Order of cost, £
Depending upon the outcome of the feasibility study (see Table 8.1. above), identify a phased approach to replacement of the open PSTs at Seafield with either covered or enclosed, high-rate, small footprint settlement processes, with additional odour abatement plant	High-risk sources of odour.	Construction will have to be in a phased manner to facilitate ongoing treatment operations at Seafield and to minimise odour during replacement. Final replacement could extend to 10 years.	Capital cost of replacement with lamellas, for example, including building and odour control, with FOG removal up-front of the order ~£20-£25 million.

Table 8.4 Long Term (7 – 20 years) Measures

Measure	Justification	Commentary	Order of cost, £
Develop a long-term vision and strategy for the Seafield site, involving re-development of the entire Seafield WwTW site, either with or without accelerated asset replacement. Points for consideration would include: replacement of each of the preliminary, primary, secondary and tertiary wastewater treatment processes and sludge treatment processes, with state-of-the art high-rate, low footprint, low energy processes; the re-development would proceed based on an architectural competition design brief, incorporating sustainable construction practices and materials; designing-in renewable energy (wind, solar, biogas) generation, with added potential for gas clean-up and grid injection;	Provision of a "best neighbour", state of the art renewable energy hub which is part of the future circular economy. Odour emissions are minimised, contained, abated and odour complaints are a phenomenon of the past.	It is likely that such a strategy would be 5-10 years in the development and would have to fit into Edinburgh's development strategy and the future vision for Leith	~£150 million

Measure	Justification	Commentary	Order of cost, £
The site could be compatible with potential future planned land uses in the Port of Leith area and would be a flagship development for Scottish Water, the Scottish Government and the local community including schools and higher education. It is also consistent with the future vision planning of the Leith area.			
Relocation of Seafield WwTW and STC to a site remote from population (greenfield/brownfield) and establishment of an entirely new treatment facility identical to that referred to in the above item in this Table.	Removal of potential odour annoyance source from a crowded and growing urban area.	Land availability is a key issue here, with no sites available to the east or west within 10 km of Seafield. There would need to be a preliminary treatment plant, storm tank facility and major pumping station at Seafield on a reduced-size site, possibly with additional wastewater dosing to combat septicity.	~£200-£300 million

Table 8.5 Operational Improvements

Measure	Justification	Commentary	Order of cost, £
Carry out amendments to the OMP as suggested in table 7.1 above, incorporating additional on-site H_2S measurements on a regular basis, including in response to odour complaints.	Will provide additional information to identify the sources and causes of elevated odour emissions.	Will require purchase of monitoring instruments and personnel time	~£20K instrument costs plus ~£20K pa other costs
Introduce a tight H_2S emission limit value on the measured emissions from the air uplift carbon filters on the PSTs.	Measured H_2S concentrations during the September 2017 site survey were 5.1 ppm on PST 3 and 7.8 ppm on PST 5. Odour concentrations were 41,868 and 48,900 ou_E/m^3 respectively.	These are high concentrations and a reasonable limit should be in the range 0.1 to 0.5 ppm H_2S. A more sensitive measurement method should be used.	£Neg
Carry out annual odour emissions surveys and dispersion modelling to assess ongoing odour footprint.			~£20K pa

Measure	Justification	Commentary	Order of cost, £
Develop or acquire a medium-term (1-10 days) weather forecasting system form which it is possible to identify forthcoming dry periods.	Septic incoming wastewater generating elevated odour emissions at Seafield and community complaints.	Weekly or 10-day forecasts, updated daily, can be obtained from the UK Met Office and also from the Norwegian Met.No services.	~£10K pa
Develop a HAZOP-type odour risk identification procedure for any changes in plant/process operation or introduction of new processes on-site.	Introduction of siloxane filter gave rise to unexpected odour emissions during filter regeneration.	Performing a HAZOP-type procedure, with supplier/manufacturer inputs, may well have identified issue up-front and avoided odour complaints.	~£20K pa
Carry out a sludge tanker drivers' odour education and awareness induction programme and ensure that new drivers are identified and inducted.	There are small, occasionally larger, sludge spillages during tanker discharge of sludge and the cleaning-up procedure needs to be uniformly complete and monitored.	Because of the pipework and valving arrangements, there is usually a small spillage that needs to be cleaned-up prior to tanker departure.	~£10K pa
Implement a series of technical/engineering internal workshops to identify enhancements to the OMP.	To identify additional measures that could be implemented to mitigate odours during periods of low speed onshore winds.	Participants to be Scottish Water, Stirling Water and Veolia.	~£15K

Table 8.6 Communication Improvements

Measure	Justification	Commentary	Order of cost, £
Develop a more interactive web site for Seafield WwTW for secure public access. Publish a regular electronic newsletter about the site and personnel and celebrate successes and challenges. Provide access to odour and process-related reports, including data from the boundary monitors and also performance data for processes and OCUs. Publish the minutes of liaison meetings. Conduct and publish annual surveys of public experiences and attitudes.	This would help to foster a more open and collaborative relationship between the site owners/operators and the local community.	An example of this can be found on the Thames Water web site for Mogden WwTW (https://uat-web.thameswater.co.uk/corporate/corporate/about-us/investing-in-our-network/mogden-sewage-treatment-works/odour-and-mosquitoes). This contains monitoring data, inspection reports and storm flow reports.	~£10K
Consider adding a real-time odour dispersion model display to the web site	Would provide real-time display of odour plumes and possibly also a forecast system	Examples are OdoWatch (https://www.odotech.com/en/odowatch/) or Purenviro (https://www.purenviro.com/en/products/purenviro-tom)	~£50K

Measure	Justification	Commentary	Order of cost, £
Develop the complaints response system to be more response-friendly and to provide more positive information.	Many stakeholders of the opinion that some responses are peremptory and unhelpful. Examples of instances where odour experienced in community, complaints of odour made, WwTW site inspection undertaken and no abnormal operations found.		£Neg

Appendix A
Strategic Odour Review – Terms of Reference

SEAFIELD WwTW – TERMS OF REFERENCE

By reference to the terms of the "Code of Practice on Assessment and Control of Odour Nuisance from Waste Water Treatment Works" ("COP") and the site specific "Odour Management Plan" undertake a detailed evidence based review of;

- The operation, design and maintenance of Seafield WwTW with a direct focus on the way in which odour is managed through both infrastructure and operational systems to reduce as far as practicable the risk of odour nuisance under all operating and weather conditions, analysing this using appropriate odour generation and dispersion modelling;
- The operation and maintenance of the major elements of the sewerage network with specific reference to odour control which ultimately discharge to Seafield WwTW;
- The effectiveness of and current implementation of the:

  1. COP;
  2. Odour Management Plan; and
  3. Site controls.

in relation to odour management and monitoring at Seafield WwTW;

- Odour complaint data and consult with all relevant stakeholders (i.e. Scottish Water, Stirling Water, City of Edinburgh Council, SEPA, Community Groups), regarding their perspectives [and aspirations] regarding odour management,
- The major risks likely to give rise to elevated levels of odour emission using existing data, research outputs and WwTw inspection; and
- Major sources of emissions and complete where appropriate a programme of practical and emission monitoring.

and thereafter provide;

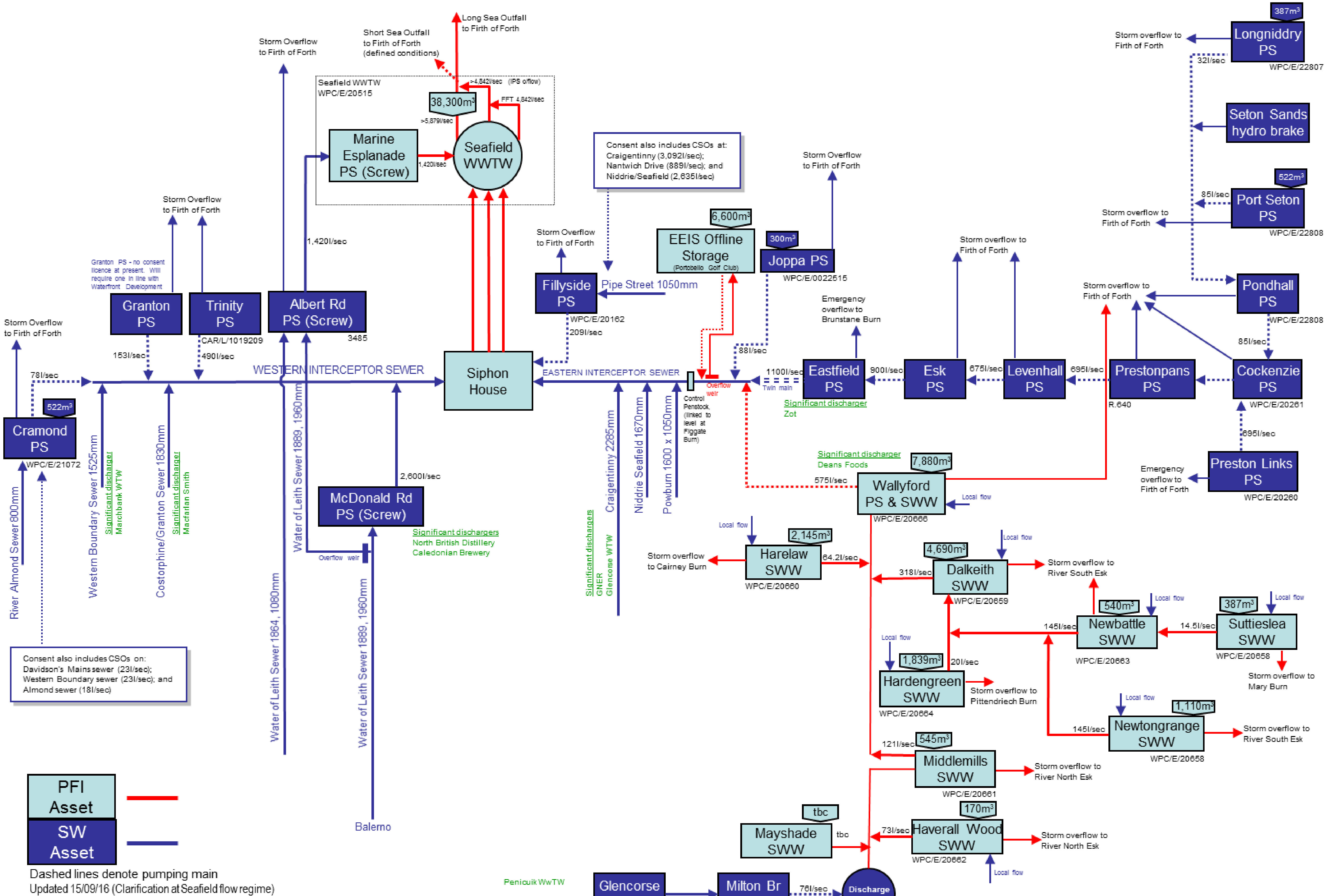
- Recommendations as to what improvements may be made of physical nature such as infrastructure repair, replacement or enhancement to the site; and
- Recommendations as to what improvements may be made of an operational nature.

These should apply either at Seafield WwTW, especially to tackle periods when the risk of odour generation and emission, and in particular odour nuisance are greatest, the operation of the network which supplies the works or as a combination of the two;

- Structured guidance for the on-going monitoring of odour emissions from the WwTW with a view to ensuring rapid data availability and response;
- An updated odour management plan for Seafield WwTW that demonstrates proactive as well as responsive activities; and
- Feedback from the stakeholder discussions within the context of current legislation and guidelines in relation to odour management.

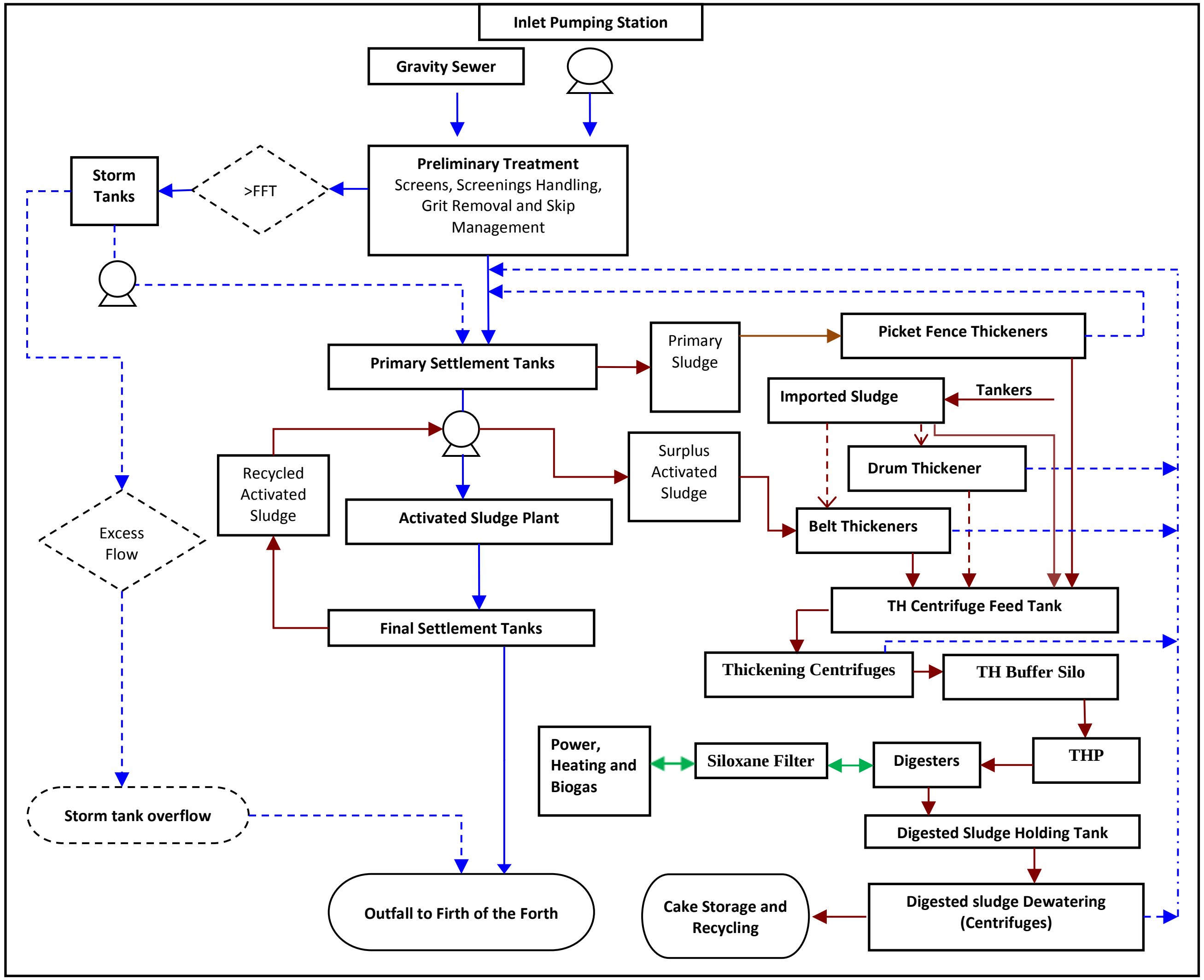
August 14, 2017

Appendix B
Seafield Catchment Schematic



AVSE PFI – Seafield WWTW catchment schematic

Appendix C
Process Flow Diagram Seafield WwTW


Inlet Pumping Station
Gravity Sewer
Preliminary Treatment
Screens, Screenings Handling, Grit Removal and Skip Management
Storm Tanks
>FFT
Primary Settlement Tanks
Primary Sludge
Picket Fence Thickeners
Imported Sludge
Tankers
Recycled Activated Sludge
Surplus Activated Sludge
Drum Thickener
Activated Sludge Plant
Belt Thickeners
Excess Flow
Final Settlement Tanks
TH Centrifuge Feed Tank
Thickening Centrifuges
TH Buffer Silo
Power, Heating and Biogas
Siloxane Filter
Digesters
THP
Storm tank overflow
Digested Sludge Holding Tank
Outfall to Firth of the Forth
Cake Storage and Recycling
Digested sludge Dewatering (Centrifuges)

Appendix D
Silsoe Emissions Monitoring Report

Report
To
Alun McIntrye, AMECFW

Odour Emissions from the Seafield Site
19th and 20th September August 2017

Date of report 28 September 2017

Robert Sneath, CEnv, MIAgrE
Silsoe Odours Ltd
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Contents

Silsoe Odours Ltd.

Silsoe Odours Ltd. operates the independent odour measurement service with the first odour laboratory to gain UKAS accreditation since in October 2005.

Silsoe Odours Ltd offers a complete odour survey, measurement and consultancy service.

1. Objective and Details of the Site

The objective of the odour survey is to quantify the odour emissions from the Seafield WwTW to enable an accurate odour model of the current site & conditions to be built.

The work will require

An odour survey

Provision of the odour survey results in a form ready for use in a dispersion model showing the extent of the existing plume and projections of the plume when new works have been carried out.

The address of the site is
20 Marine Esplanade
Edinburgh
EH6 7LU

1.1. Seafield Sewage Treatment Works

The works comprises a wastewater treatment works including:

- Inlet works & preliminary treatment
  - Sewage screw lift pumping station (Marine Esplanade Pumping Station (MEPS))
  - Inlet from Siphon House
  - Five coarse screens

- Five fine screens
- Four detritors

- Storm separation and treatment
  - Overflow weir
  - Four rectangular storm tanks
- Primary treatment
  - Six radial primary settlement tanks of which four are in use at any one time. Sludge is removed using an air-lift pump system, separated air is discharged through a carbon filter on each PST.
- Secondary treatment by the activated sludge process
  - Feed pumping station
  - Six aeration lanes with fine bubble diffused aeration of which four are in use at any one time
  - Eight small radial flow final settlement tanks
  - One large radial flow final settlement tank
- UV disinfection (seasonal)
- Outfall of secondary effluent to the Firth of Forth.

The sludge treatment plant includes:

- Imported sludge reception
  - Initial sludge reception tank
  - Second sludge reception tank
  - Sludge screen
  - Screenings skip
- Drum thickener for imported sludge thickening
- Three picket fence thickeners for indigenous primary sludge
- SAS storage tank
- Four belt thickeners for sludge thickening
- Thickened sludge storage tank
- THP plant
- Six anaerobic digesters
- Biogas storage and flare stack
- Digested sludge storage tanks
- Three dewatering centrifuges
- Sludge cake storage building

Various items of plant are contained within buildings or covered and connected to odour control units. There are four odour control units.

The main odour control unit (Main OCU) (two stage wet chemical scrubber and carbon filter) treats air extracted from:

- MEPS
- Inlet from Siphon House

Odour measurement & consultancy services
Building 42,
Wrest Park, Silsoe,
Bedfordshire MK45 4HP

- Screens and associated channels
- Channels to and from detritors (but not the detritors themselves)
- Channels distributing flow to primary tanks
- Channel taking storm flow to the storm tanks
- Primary settlement tank weirs and launder channels
- Channel taking settled sewage to the secondary treatment feed pumping station

The sludge import OCU (biofilter) treats air extracted from:

- The initial and second sludge reception tanks
- The picket fence thickeners

The digester OCU (carbon filter) treats air extracted from:

- The digester limpet chambers
- There is an OCU associated with the THP

The thickened sludge OCU (biofilter) treats air extracted from:

- Drum thickener
- SAS belt thickeners
- Thickened sludge storage tank
- Cake storage pad
- Centrifuge building

- The primary settlement tank air-lift pumps extracted through a carbon filter.

1.2. Odour sampling

Sampling was carried out to the requirements of BSEN13725.

Samples were taken from key area and point sources for odour analysis to enable an odour dispersion model to be built. The sample locations proposed were:

Detritors - 4
PSTs - 4
ASP - 6
Storm tanks - 4
Sludge Cake Building - 4
Main OCU - 4
THP OCU - 4
Digester Spill OCU - 4
OCU 1 - 4
OCU 2 - 4
Sludge Import Area - 2
FSTs - 4
Total of 24 sets of duplicate samples

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2. Methodology for sampling

The odour samples were collected into Nalphan NA sample bags through PTFE sampling tubes. The sample bags were fitted in rigid "barrels" which are partially evacuated to provide the vacuum to draw air along the sample tube into the bags (lung principle). The vacuum was generated by portable 12v battery electric pumps.

2.1. Sampling the area sources

For area sources a Lindvall hood was used to collect the samples, this method followed the guidance in the EA draft H4 document (2003 version) and BSEN13725;2003 to provide an emission rate from surface sources. Sampling was undertaken by covering a portion of the surface with a suitable ventilated hood. A Lindvall type sampling hood of approximately 0.6m^2 was used and ventilated with odour free air at a known volumetric flow rate. An odour sample was then collected at the outlet of the canopy. The rate of air injected into the hood was monitored and adjusted as close to 1.3 m/s as possible for each sample and used to calculate a specific odour emission rate per unit area per second (Esp) as follows:

$E_{sp} = C_{hood} \times L \times V$

Where,

C_{hood} is the odour concentration measured from the sample bag.

L is the hood factor, which is equal to the path length (m) of the hood divided by the covered area (m^2).

V is the velocity (m/s) of air presented through the hood.

The hood was placed on open solid surfaces, but floats were used when using the hood on liquid surfaces.

2.2. Point Source sampling

Sampling for analysis of the point sources was taken for both odour content and hydrogen sulphide. Ducts leading to the odour control units were sampled. A tube was attached to a suitable sampling point and air will be drawn into a sampling bag. Other sources within buildings will be treated as point sources and sampled internally at a representative location. In these cases an estimate of airflow rates will be made or measured to calculate odour emission rates.

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3. Laboratory Odour analysis

The Principle of Olfactometry technique is as follows:-

The odour concentration of a gaseous sample of odorants is determined by presenting a panel of selected and screened human subjects with that sample, varying the concentration by diluting with neutral (odourless) gas, in order to determine the dilution factor at the 50% detection threshold.

At that dilution factor the odour concentration is 1 ou_Em^{-3} by definition. The odour concentration of the examined sample is then expressed as a multiple (equal to the dilution factor at Z_{50}) of one European Odour Unit per cubic metre [ou_Em^{-3}] at standard conditions for olfactometry.

The Silsoe Odours Ltd laboratory operate a forced choice olfactometer, it has two outlet ports from one of which the diluted odour flows and clean odour-free air flows from the other.

The measurement starts with a dilution of the sample large enough to make the odour concentration beyond the panel members' thresholds, the concentration is increased by factor between 1.4 and 1.5 in each successive presentation. The port carrying the odorous flow is chosen randomly by the control sequence on each presentation. The assessors indicate from which of the ports the diluted odour sample is flowing using a personal keyboard. They also indicate whether their choice was a guess, whether they had an "inkling" or whether they were certain they chose the correct port. Only when the correct port is chosen and the panel member is certain that their choice was correct is it taken as a TRUE response. At least two consecutive TRUE responses must be obtained for each panel member. The geometric mean of the dilution factors of the last FALSE and the first of at least two TRUE presentations determines the individual threshold estimate (ITE) for a panel member. The odour concentration, ou_Em^{-3}, for a sample, is calculated from the geometric mean of at least two ITEs for each panel member.

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Figure 1 Sampling on the aeration lane with the Lindvall type sampling hood as used on tank surfaces in this study.

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4. Results of Odour measurements

The laboratory results are contained in Appendix 1

Table 1 Results of tank and process odour concentration measurements and calculated emission rates 19 and 20 September 2017

Sampling date and time	Sample source	inlet air speed m/s	Mean air speed under hood, m/s	Area, m^2	odour concentration uplift, ou_E/m^3	odour emission rate, $ou_E m^{-2} s^{-1}$
19-September-17						
15:01	Storm Tank 1		0.28	0.5625	290	1.99
15:19	Storm Tank 2		0.27	0.5625	296	2.00
20-September-17						
9:29	FST 2		0.38	0.563	49	0.27
9:42	FST 3		0.31	0.563	51	0.23
11:33	ASP 1/6th		0.34	0.563	58	0.49
11:47	ASP ½		0.35	0.563	51	0.44
12:05	ASP 5/6th		0.27	0.563	67	0.44
13:25	PST 3		0.26	0.563	71	0.46
13:50	PST 3 Carbon Filter	0.446			41,868	330 ou_E/s
14:10	PST 5		0.29	0.563	380	1.53
14:30	PST 5 Carbon Filter	1.119			48,900	967 ou_E/s
15:10	Detritor 2		0.23	0.563	514	2.97
15:23	Detritor 3		0.27	0.563	705	4.64
15:40	Sludge Building				2028	

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Table 2 Results of OCU odour concentration measurements and calculated emission rates 19 September 2017

Sampling time	Sample Source and Position	Odour concentration of sample, $ou_E\ m^{-3}$	emission ou_E/s	flow, m3/s	H2S, ppm	Velocity in duct m/s	Duct diameter m
10:19	OCU 2 Inlet	14,676	59405	4.05	1.7	24.49	0.4572
10:19	OCU 2 Outlet	9,282	15543	1.67	0.745	3.97	0.6096
11:26	THP Biofilter Inlet	14,730	5424	0.37	1.3	5.42	0.294
11:32	THP Biofilter Outlet	1,832	675	0.37	0.035	nm	
11:57	THP Carbon Inlet	567	14039	24.78	0.20	22.90	1.1176
11:57	THP Stack	573	14412	25.15	0.18	nm	
13:54	Main OCU Inlet	2,769	26306	9.50^{nm}	0.485	9.00	
13:54	Main OCU Outlet	58	546	9.50	0.011	nm	
14:22	AD OCU Inlet	8,376	1332	0.16	0.675	9.00	0.15
14:22	AD OCU Outlet	67	11	0.16	0.27	9.00	0.15

*nm = not measured, as shown on monitor in 2013.

*sum of THP biofilter inlet and air from sludge pad shed

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Bedfordshire MK45 4HP

Appendix 1 Laboratory analysis report

Odour measurement & consultancy services

Building 42,
Wrest Park, Silsoe,
Bedfordshire MK45 4HP

Olfactometric measurements

Client: AMEC CFW
Location: Seafield
Measurement Date: 20 and 21 September 2017

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Contract report number:		CR/SO1705/17/AMEC186
Customer reference:		
Measurements carried out by:		G. A. Liddle
1.	Contact:	Alun McIntyre Amec Foster Wheeler E+I UK Ltd Floor 3, Block 2, Booths Park, Chelford Road, Knutsford, Cheshire. WA16 8QZ Mobile +44 (0) 7866 852618 Office +44 (0)
2.	Odour source:	WWTW
3.	Sampler: *	R.W. Sneath, J. Sneath
4.	Sampling date: *	19, 20 September 2017
5.	Laboratory temperature and CO_2	23.6°C; 1,080 ppm, 22.7 °C, 1,418ppm
6.	Measurement date	20, 21 September 2017
7.	Presentation mode:	Forced choice
8.	Olfactometer:	PRA Odournet B.V. Serial number OLFACTON-E
9.	Pre-Dilution Gas Meter:	Kimmon Model SK25 Ser No 0003171
10.	Reference odorant/accepted reference value	n-butanol. 60 ppm / 40ppb
11.	Calibration Status of Laboratory	A_{od} = 0.096; r = 0.400, A_{od} = 0.066; r = 0.383
12.	Method:	Following Odour Lab Procedure OL2 which incorporates BSEN13725 "Air quality – Determination of odour concentration measurement by dynamic olfactometry".
13.	Special remarks:	Nalophan NA bags 25µm thick
14.	Approved by	Compiled by

R W Sneath

R. W. Sneath, Head of Laboratory.

G.A. Liddle

G.A. Liddle Laboratory Operator

"This laboratory is accredited in accordance with the recognised International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communiqué dated April 2017)"

* Sampling is outside the scope of UKAS Accreditation:

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Bedfordshire MK45 4HP

Olfactometric measurements

Client: AMEC CFW
Location: Seafield
Measurement Date: 20 and 21 September 2017

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www.silsoeodours.com

Results:

Table 1: Results for Seafield odour samples analysed on 20 September 2017

Samples collected 19/09/17 at:	Samples analysed 20/09/17 at:	Sample No.	Sample Source and Position	S. O. H_2S ppm	Odour Panel Threshold, $ou_E\ m^{-3}$	Lab. Pre-dilution factor	Odour concentration of sample, $ou_E\ m^{-3}$ (including laboratory pre-dilution)
10:19	15:50	20170920 S1	OCU 2 Inlet	1.7	1,204	11:1	14,448
10:26	16:07	20170920 S2	OCU 2 Inlet	1.7	1,242	11:1	14,904
10:19	15:07	20170920 S3A	OCU 2 Outlet	0.76	697	11:1	8,364
10:26	14:58	20170920 S4	OCU 2 Outlet	0.73	850	11:1	10,200
11:26	15:21	20170920 S5	THP Biofilter Inlet	1.3	1,298	11.1	15,576
11:26	15:38	20170920 S6	THP Biofilter Inlet	1.3	1,157	11.1	13,884
11:32	10:38	20170920 S7	THP Biofilter Outlet	0.032	1,779	None	1,779
11:32	10:52	20170920 S8	THP Biofilter Outlet	0.037	1,885	None	1,885
11:57	11:35	20170920 S9	THP Carbon Inlet	0.20	593	None	593
11:57	11:13	20170920 S10	THP Stack	0.18	468	None	468
12:01	11:50	20170920 S11	THP Carbon Inlet	0.20	540	None	540
12:01	11:22	20170920 S12	THP Stack	0.18	678	None	678
13:54	13:02	20170920 S13	Main OCU Inlet	0.23	1,415	None	1,415
13:58	13:11	20170920 S14	Main OCU Inlet	0.74	4,123	None	4,123
13:54	09:37	20170920 S15	Main OCU Outlet	0.012	54	None	54
13:58	09:26	20170920 S16	Main OCU Outlet	0.009	61	None	61
14:22	14:26	20170920 S17	AD OCU Inlet	0.74	660	11:1	7,920
14:26	14:40	20170920 S18	AD OCU Inlet	0.61	736	11:1	8,832
14:22	13:22	20170920 S19	AD OCU Outlet	0.27	99	None	99
14:26	13:44	20170920 S20	AD OCU Outlet	0.27	<35*	None	<35*
15:01	09:54	20170920 S21	Storm Tank 1	0.018	206	None	206
15:06	10:07	20170920 S22	Storm Tank 1	0.020	408	None	408
15:19	10:25	20170920 S23	Storm Tank 2	0.019	308	None	308
15:36	10:18	20170920 S24	Storm Tank 2	0.011	284	None	284

* Below lower detection threshold limit of 35 $ou_E\ m^{-3}$

Deviation from the standard: None

The following data is not covered by our UKAS Accreditation:
S. O. H_2S measurements in Table 1 not accredited

Odour measurement & consultancy services
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Bedfordshire MK45 4HP

Olfactometric measurements

Client: AMEC CFW
Location: Seafield
Measurement Date: 20 and 21 September 2017

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info@silsoeodours.co.uk
www.silsoeodours.com

Table 2: Results for Seafield odour samples analysed on 21 September 2017

Samples collected 20/09/17 at:	Samples analysed 21/09/17 at:	Sample No.	Sample Source and Position	S. O. H_2S ppm	Odour Panel Threshold, $ou_E\ m^{-3}$	Lab. Pre-dilution factor	Odour concentration of sample, $ou_E\ m^{-3}$ (including laboratory pre-dilution)
09:47	09:29	20170921 S1	FST 2	0.001	59	None	59
09:56	09:42	20170921 S2	FST 2	0.003	40	None	40
11:03	09:59	20170921 S3	FST 3	0.001	58	None	58
11:13	10:17	20170921 S4	FST 3	0.001	44	None	44
11:33	10:28	20170921 S5	ASP	0.004	56	None	56
11:37	10:40	20170921 S6	ASP	0.003	60	None	60
11:47	10:54	20170921 S7	ASP	0.001	35	None	35
11:53	11:10	20170921 S8	ASP	0.001	74	None	74
12:05	11:27	20170921 S9	ASP	0.001	59	None	59
12:10	11:46	20170921 S10	ASP	0.001	75	None	75
13:25	13:08	20170921 S11	PST 3	0.004	76	None	76
13:30	13:15	20170921 S12	PST 3	0.006	67	None	67
13:50	15:40	20170921 S13	PST 3 Carbon Filter	5.1	3,489	11:1	41,868
14:10	14:30	20170921 S14	PST 5	0.072	489	None	489
14:15	14:47	20170921 S15	PST 5	0.041	296	None	296
14:30	15:54	20170921 S16	PST 5 Carbon Filter	7.8	4,075	11:1	48,900
15:10	13:46	20170921 S17	Detritor 2	0.040	566	None	566
15:13	13:58	20170921 S18	Detritor 2	0.035	467	None	467
15:23	14:06	20170921 S19	Detritor 3	0.062	787	None	787
15:27	14:17	20170921 S20	Detritor 3	0.070	632	None	632
15:40	15:15	20170921 S21	Sludge Building 1	0.14	1,410	None	1,410
15:42	15:00	20170921 S22	Sludge Building 2	0.21	2,916	None	2,916

*** Below lower detection threshold limit of 35 $ou_E\ m^{-3}$**

Deviation from the standard: None

The following data is not covered by our UKAS Accreditation:
S. O. H_2S measurements in Table 1 & 2 not accredited

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Olfactometric measurements

Client: AMEC CFW
Location: Seafield
Measurement Date: 20 and 21 September 2017

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Table 3: Odour descriptions from four samples when diluted to detection threshold on 21st September 2017

Sample 20170921	Process	Sewage	Fish	Refuse / Garbage	Manure	Compost	Drains	Rotten Eggs	Rotting Cabbage	Tarry	Smoky	Excreta, Faecal Odour	Onions	Earthy	Damp	Seaweed	Gas		
S1	FST 2			1	1	4													
S2	FST 2			1	1	4													
S3	FST 3			2		5			1	1									
S4	FST 3			3		4			1										
S5	ASP		1	3		3							2	1	1				
S6	ASP			2		3								1	1				
S7	ASP	1		2		4							1		1				
S8	ASP			2		3							1	1	1				
S9	ASP			1		3							1	1	1				
S10	ASP			1		2					1		1	1	1				
S11	PST 3	5	1	2	2		1									1			
S12	PST 3	3	1	1	2	1	1									1			
S13	PST 3 Carbon	3		3	1	2							2			1			
S14	PST 5	4		1	2	1		3											
S15	PST 5	4		2		1		1											
S16	PST 5 Carbon	3		3	3	3							2				1		
S17	Detritor 2	2		2	1			2	1										
S18	Detritor 2	3		4	1		1	1											
S19	Detritor 3	2		3	1	1	1	1	1										
S20	Detritor 3	3		2	2	2	1	2											
S21	Sludge Building	3		2	1	2	1	1											
S22	Sludge Building	2		4	2	1	1	1											
Samples analysed 20/09/2017																			
S21	Storm Tank	1		2	2		1		3				1						
S24	Storm Tank	4		5	1	1			4				1						

The numbers are the number of times that descriptor was used by the 6 panellists

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Table 4. The 6 panellists were given the following list to select odour descriptions from or add their own description:

Sample code 21 September 2017

Sewage	
Fish	
Refuse / Garbage	
Manure	
Compost	
Drains	
Rotting Eggs	
Rotting Cabbage	
Tarry	
Smokey	
Excreta, faecal odour	
Other	

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