Transport and Environment Committee

10:00am, Tuesday, 26 August 2014

Seafield Waste Water Treatment Works – Monitoring of Scottish Water Odour Improvement Plan

Item number	7.15
Report number	
Executive	Executive
Wards	City wide

Executive summary

At a meeting on 23 November 2012, Committee agreed that representations should be made to Scottish Water to provide an independent emissions inventory at Seafield Waste Water Treatment Works to identify further possible odour reduction measures. Committee also requested that Scottish Water advise the Council of measures that will be taken to address operational management, risk planning and staff training inadequacies.

This report provides the key findings of the independent odour consultant and a summary by Scottish Water of the measures taken in response to the Committee's recommendations of 23 November 2012.

This report also provides a comparison of two complete periods of the Council's ongoing odour monitoring and assessment programme, 1 March 2012 to 31 October 2012 and 1 March 2013 to 31 October 2013 and information on the outcome of discussions with Scottish Water regarding the future use and provision of storm tanks in the Waste Water Treatment Works (WWTW). This report also provides a description of the key actions from two recent meetings in July and August 2014 attended by Council officials, elected members, Leith Links Residents Association (LLRA) and their representative, Professor Jackson.

Links

Coalition pledges	51
Council outcomes	Edinburgh's citizens experience improved health and wellbeing, with reduced inequalities in health.
Single Outcome Agreement	Edinburgh's communities are safer and have improved physical and social fabric.

Report

Seafield Waste Water Treatment Works – Monitoring of Scottish Water Odour Improvement Plan

Recommendations

It is recommended that Committee:

1.1 notes that the Council's odour and monitoring programme indicates that sewerage nuisance and major odour incidents affecting local residents have reduced since 2012, although it is recognised that local residents continue to complain about odour nuisance;

1.2 notes the key findings of the Scottish Water independent Odour Emission Inventory, carried out between May and September 2013;

1.3 notes that the Seafield WWTW storm tanks continue to be identified as an odour source from the plant.

1.4 notes that LLRA are concerned that on several occasions the cleaning of the storm tanks has created odours within the community, and they are keen that prevention measures are put in place to prevent any future recurrence of these odours during this process. The Council therefore seeks reassurances from Scottish Water that all appropriate measures will be pursued to mitigate and minimise the impact of odour generated by storm tank cleaning in the local community.

1.5 notes the outcome of discussions with Scottish Water on current storm tank use and provision and instructs officers to engage in further dialogue with Scottish Water on their future plans for odour minimisation at the storm tanks at Seafield WWTW;

1.6 notes that the findings of the Council's odour monitoring and assessment programme indicate that Scottish Water and Veolia Water are currently compliant with the Sewerage Nuisance (Code of Practice) (Scotland) Order 2006 (CoP) and that the Odour Improvement Plan (OIP), allied to the improvements in operational management of the works, is currently minimising odour nuisance; and

1.7 notes that Abatement Measure A as defined in the Scottish Water and Stirling Water OIP is fully implemented, albeit recognising that the level of complaints regarding odour emanating from the plant which continue to be received from the local community is an ongoing cause for concern for all stakeholders;

1.8 notes that the current Council monitoring programme will continue to ensure that improvements in operational management and sewerage nuisance are sustained and will be reported on following the end of the monitoring period on October 2014;

1.9 instructs officers to formally advise Scottish Water that Abatement Measure A as set out in the Scottish Water and Stirling Water OIP has been fully implemented and to explore with Scottish Water which of the remaining potential odour improvement measures contained in the further options B to E outlined in the OIP continue to be relevant. To consider those which could still be employed to further reduce odour emissions from the WWTW, and to consider those measures which have already been implemented.

1.10 instructs officers to contact all other Scottish local authorities to request information on their experience of dealing with odour nuisance from WWTW within their area, with a particular focus on storm tank use and measures introduced to mitigate odour release during cleaning.

1.11 requests a future report on the outcome of ongoing and requested research from elected members and LLRA on the issues of:

- legal interpretation of a material breach of the CoP
- information on planning conditions attached to relevant planning consents relating to boundary odour monitoring
- along with data on any exceedences of a 10 parts per billion of hydrogen sulphide over the past 5 years.

1.12 The Committee notes that the Mott MacDonald Report concludes that the storm tanks are responsible for 53% of the odours coming from Seafield.

1.13 The Committee also notes that on several occasions the cleaning of the Storm Tanks has created odours within the community and that a future re-occurrence of these odours, during this process, may well require the serving of an Enforcement Notice.

1.13 The Council therefore urges Scottish Water to find an engineering solution to this process.

Background

2.1 The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006 (CoP) placed a duty on Scottish Water to develop an Odour Improvement Plan (OIP) to minimise sewerage odour emissions detectable out with the boundary of Seafield Waste Water Treatment Works (WWTW). The CoP also places a duty on the Council to monitor and assess the effectiveness of Scottish Water's Seafield OIP.

2.2 The Water Services etc. (Scotland) Act 2006 places a duty on the Council to monitor compliance with the CoP and to investigate complaints of sewerage nuisance.

2.3 The Council's monitoring programme to assess the OIP commenced on 1 June 2011 following implementation of the OIP in May 2011. A report to Committee on 23 November 2012 provided the findings of the programme from 1 June 2011 to 31 August 2012.

2.4 The report of 23 November 2012 recommended that representations be made to Scottish Water to provide an independent emissions inventory to identify further possible odour reduction measures. It also requested that Scottish Water advise the Council of measures that will be taken to address operational management, risk planning and staff training inadequacies.

2.5 This report also provides a comparison of two complete periods of the Council's ongoing odour monitoring and assessment programme, 1 March 2012 to 31 October 2012 and 1 March 2013 to 31 October 2013 and information on the outcome of discussions with Scottish Water regarding the future use and provision of storm tanks in the Waste Water Treatment Works (WWTW).

Main report

3.1 The Council's Monitoring and Assessment Programme to assess Scottish Water's Seafield OIP commenced on 1 June 2011. Progress reports on the programme were made to Committee on 29 November 2011, 18 June 2012, 13 September 2012 and 23 November 2012. It is anticipated that a further report will be made to Committee following the completion of the current year's programme on 31 October 2014

3.2 As the programme has continued since 1 June 2011, it is possible to provide a comparison for two complete periods, 1 March 2012 to 31 October 2012 and 1 March 2013 to 31 October 2013 which can be used to assess the effectiveness of the OIP. These periods represent the warmer months when residents are most likely to experience odour release from the WWTW. Partial information for the current year is also supplied in Table 1. The results of staff monitoring during these comparison periods is also summarised in Table 1 below.

Table 1

Monitoring Period	1 March 2012 to 31 October 2012	1 March 2013 to 31 October 2013	1 March 2014 to 30 June 2014
Complaints received	182	82	59
No. of days where complaints were received	63	49	28

Complaint visits where staff detected odour	11	10	12
Days where 3+ complaints were received	16	6	6
Number of individual household complaining	60	33	27
Major Odour Incidents	4	0	1
Surveillance visits by staff to assess odours	452	124	54
Days when staff detected moderate or strong odour	14	4	4

3.3 It can be seen from the table that there has been a reduction in complaints received by the Council in 2013 compared with the same period in 2012. The number of individual households registering a complaint has similarly reduced from 60 to 33. It is believed that the measures taken by Scottish Water and Veolia, as requested by the Council to address operational management and risk planning inadequacies, have prevented any major odour release events in 2013. This compares with 2012, when four were recorded. Information recorded in the period 1 March 2014 to 30 June 2014 indicates a similar trend. A major odour release event is defined as the generation of a significant number of contemporaneous complaints which can be directly attributed to a source within the WWTW. It is however recognised that LLRA have expressed concerns that residents may no longer complain to the Council when odours are apparent.

3.4 During the period 1 March 2014 to 30 June 2014, the risk based monitoring programme has been maintained with a flexible response to the requirement for on site monitoring with 54 assessment visits carried out.

3.5 In recognition of the ongoing community concerns, and responding to the findings from the Scottish Water independently commissioned Mott MacDonald, specifically section 5.2.3 as noted in Appendix 2, the Council has indicated to Scottish Water, in writing, that it considers that the operation of the storm tanks at the WWTW is still potentially a significant source of odour release. Discussions around their operation have been held at regular liaison group meetings, attended by Scottish Water, Veolia Water, SEPA and officers from Services for Communities. Scottish Water has therefore assessed the Urban Waste Water Treatment (Scotland) Regulations 1994, which govern the requirement for storm tank provision and determined that all four are still required.

3.6 On the morning of 15 April 2014, nine contemporaneous odour complaints were received from local residents and promptly investigated by Council staff. These investigations indicated that the odour release was due to a change in wind direction during planned storm tank cleaning operations. Veolia management took remedial action by covering the exposed material with fresh sewage to minimise further odour release and delaying cleaning operations until another suitable period where offshore winds would prevail. Following this event, a meeting was convened on 21 July 2014 between Council representatives, Leith Links Residents Association (LLRA) representatives and Professor Robert Jackson of Jackson Consulting, an independent Forensic Engineering Expert in Water, Construction and the Environment, to discuss a number of concerns raised by LLRA including:

- Storm Tank cleaning operations;
- How a Local Authority determines the success or failure of the first phase of an Odour Improvement Plan submitted in accordance with Section 10 of the Sewerage Nuisance (Code of Practice) (Scotland) Order 2006 (CoP)
- What constitutes a material failure to comply with the CoP;
- Recent operational and management changes undertaken by Scottish Water and Veolia Water;
- The Council's decision to serve an enforcement notice on Veolia Water in one instance where odour was witnessed in the local community but not serve notice on a subsequent occasion.

3.7 As the Council noted that a number of significant odour emissions in 2012 were due to foreseeable events and inadequate operational management controls, Scottish Water were requested to advise the Council on measures which would be taken to address those issues. A Seafield stakeholder meeting took place on 19 April 2013, Veolia Water presented an overview of those measures already implemented or due to be implemented and a summary is contained within Appendix 1.

3.8 It is noted that since the report to Committee in November 2012, Scottish Water in addition to undertaking the improvements set out in paragraphs 2.5 – 2.7 above, have also invested a further £1.16m in infrastructure improvements and £830K on additional operating costs associated with odour treatment. These works include:

- Improvements to storm tank control;
- Routine replacement of plant components;
- Modifications to the cake pad building;
- Further odour control associated with the installation of the new thermal hydrolysis project; and
- Operating costs related to power, chemicals and odour related staff training.

The Council acknowledges that Scottish Water have implemented Phase 1 of the OIP comprising Abatement Measure A which entails an agreed range of capital improvement measures including the provision of a new central odour control unit, the Preliminary Treatment Works Improvement Measures (as described in the OIP) and range of agreed operational improvements.

3.9 The report submitted to Committee on 23 November 2012 recommended that representations be made to Scottish Water to provide an independent emissions inventory to identify further possible odour reduction measures. 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 report does not identify any asset or operation currently responsible for odour release from Seafield WWTW that had not been identified previously and addressed during the design and implementation of the OIP.

3.10 A “fit for purpose” audit of the WWTW, requested by the Council in 2007 was carried out by independent consultants on behalf of Scottish Water, giving a 25 year lifespan for the works at that time. Although the emissions inventory did not identify any recommendations for current odour abatement capital investment, it is considered that future investment and improvements will continue to be required to ensure that odour minimisation is achieved throughout the life of the WWTW. Scottish Water has given assurance that the plant will be maintained to ensure it is fit for purpose for the duration of its operation. Recent correspondence received from Scottish Water indicates that in the period to the end of the PFI contract asset plans will continue to focus on maintaining all existing levels of performance through the implementation of the Veolia’s ongoing asset refurbishment and replacement programme. Scottish Water has indicated that this will involve a significant level of investment in the Seafield facility over the next 15 years focused on environmental and odour compliance.

3.11 A meeting took place, on 21 July 2014, between representatives of Leith Links Residents Association and Council officers, to discuss issues of odour nuisance and the officer’s interpretation of what constitutes a breach of the CoP which could result in enforcement action, along with a range of other matters. Officers are currently progressing 3 action points agreed at the meeting around the legal interpretation of a material breach of the CoP, information on planning conditions attached to relevant planning consents relating to boundary odour monitoring, along with data on any exceedences of a 10 parts per billion of hydrogen sulphide over the past 5 years.

3.12 A further meeting was held on 5 August 2014 chaired by Councillor Lesley Hinds and attended by local elected members, LLRA representatives, Professor Robert Jackson and Council Officials, where a series of further actions for the Council were agreed.

- To request clarification from Scottish Water as to the additional measures and investment which will be taken to mitigate the ongoing issue of odours affecting the community during storm tank cleaning operations, such as that which occurred on the morning of 15 April 2014.

- To request from Scottish Water an analysis of the remaining potential odour improvement measures contained in the further options B to E outlined in the Scottish and Stirling Water OIP, see **Table 2** below which could still be employed to reduce further odour emissions from the WWTW. In addition to provide details of measures already taken or planned relating to Abatement Options B to E, or further mitigation measures implemented based on more current information, including improved working and management practices of the plant and up to date awareness of new and emerging technologies.

Table 2
Abatement Measures B to E

Abatement Mesure	Description
B	As Abatement Measure A but also includes: The treatment of odours from the detritors, and The treatment of odour from the final effluent weirs.
C	As Abatement Measure B but also to include the provision of raised sludge cake storage silos to allow lorries to collect the sludge cake from within an enclosed area.
D	As Abatement Measure C but also to include the full enclosure of the Primary Settlement Tanks and the provision of odour treatment.
E	As Abatement Measure D but also to include the treatment of odours from the activated sludge plant.

- To contact all other Scottish local authorities to request information on their experience of dealing with odour nuisance from WWTW within their area with a particular focus on storm tank use, and measures introduced to mitigate odour release during cleaning.
- To make appropriate representations to the Scottish Government seeking a review of the CoP and the regulatory framework of the European Urban Waste Water Treatment Directive, which underpins the provision of storm tank provision at waste water treatment works.

Measures of success

4.1 A decrease in the number of major odour emission events from Seafield and a reduction in complaints from the local community.

4.2 That implementation of the Scottish Water Odour Improvement Plan, allied to improvements in operational management, results in minimisation of odour as required by the Sewerage Nuisance (Code of Practice) (Scotland) Order 2006.

Financial impact

5.1 The cost of continuing to operate the current odour assessment and monitoring programme can be met from existing budgets.

Risk, policy, compliance and governance impact

6.1 Compliance with the Water Services etc. (Scotland) Act 2006 and the associated Sewerage Nuisance (Code of Practice) (Scotland) Order 2006, and demonstration of compliance with the Odour Improvement Plan.

Equalities impact

7.1 This report proposes no changes to current policies or procedures and as such, a full impact assessment is not required. The contents have no relevance to the public sector Equality Duty of the Equality Act 2010.

Sustainability impact

8.1 Scottish Water's Odour Improvement Plan is intended to reduce odour output from Seafield WWTW to a level which will not constitute a sewerage nuisance, in accordance with the Sewerage Nuisance (Code of Practice) (Scotland) Order 2006.

Consultation and engagement

9.1 Community representatives, local MSP's and the Council are members of the Seafield Stakeholder Liaison Group which meets six monthly with Scottish Water and Veolia Water to discuss the Council's role as regulator, actions being taken by Scottish Water and Veolia Water to minimise odour emissions and any other issues relating to the impact of the works on the local community.

9.2 Mott McDonald, Scottish Water's independent odour consultants contracted to carry out the Odour Emission Inventory Report requested by the Council, carried out stakeholder interviews with a number of local residents to assist in the preparation of the report.

9.3 Meetings with elected members and LLRA representatives have taken place in July and August 2014, to agree a series of actions to progress the exploration of further potential mitigation measures.

Background reading/external references

Seafield Waste Water Treatment Works - Monitoring of Scottish Water Odour Improvement Plan - November 2012

Seafield Waste Water Treatment Works - Monitoring of Scottish Water Odour Improvement Plan - September 2012

Seafield Waste Water Treatment Works - Odour Improvement Plan Update - June 2012

Seafield Waste Water Treatment Works - Odour Improvement Plan Update - November 2011

Seafield Waste Water Treatment Works - Odour Improvement Plan Update November 2010

Seafield Waste Water Treatment Works - Odour Improvement Plan Update - November 2009

Seafield Waste Water Treatment Works - Odour Improvement Plan Update May 2008

Seafield STW Odour Emissions Inventory – Final Report – November 2013

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Links

Coalition pledges	51
Council outcomes	Maintain and enhance the quality of life in Edinburgh
Single Outcome Agreement	Edinburgh's citizens experience improved health and wellbeing, with reduced inequalities in health. Edinburgh's communities are safer and have improved physical and social fabric
Appendix	Appendix 1 - Scottish Water Seafield Wastewater Treatment Works – Summary Paper Appendix 2 – Executive Summary - Section 5 Odour Emissions Inventory – Seafield STW Odour Emissions Inventory Final Report – Mott MacDonald

Appendix 1

Scottish Water Seafield Wastewater Treatment Works
– Summary Paper

This paper summarises Scottish Water's actions taken in response to the recommendations contained in CEC's Transport & Environment Committee Report 7.11 of 23rd November 2012.

6.1 It is recommended that the Committee: b) makes representations to Scottish Water to undertake an independent emissions inventory of the Treatment Works to assist in identifying further odour reduction measures and to deal with foreseeable non-routine events; subsequently, to develop an incremental plan, in accordance with the Code of Practice, including appropriate investment requirements to address these measures;
In March 2013, Scottish Water invited tenders from 6 independent environmental consultancy firms to undertake an independent odour emissions inventory at Seafield Waste Water Treatment Works (WwTW). To maintain an independent approach, Scottish Water was not prescriptive in defining the exact detail of the inventory and it was left to the consultants to formulate a comprehensive and representative inventory of the Summer 2013 Seafield operations. The selection process was based on a matrix scoring system, taking account of the consultant's approach to the inventory project. Mott MacDonald was appointed and commenced site work at the end of May 2013. Mott Macdonald was given unfettered access to all parts of the site paperwork and was party to meetings, daily reports and operational notifications. The sampling programme was flexible enough to account for site conditions worthy of specific assessment (e.g. storm tank use). Through a series of process unit samples and weekly sniff tests, Mott Macdonald developed a baseline odour inventory, 'overlaid' four non-routine events and produced a comprehensive report detailing all findings. The Edinburgh summer of 2013 was both drier and warmer than the 1981-2010 long term average as measured by the Met Office. The summer was the driest since 2006 and conditions during July in particular attracted local and national media with heatwave conditions comparable to Barcelona. Whilst noting that the inventory project did not identify any source of 'unknown' odour, the inventory report outlined a number of recommendations which shall be taken forward: • That the report be used to inform dialogue between SW and CEC. • That the report be used to inform future revisions of the Odour Management Plan. • That SW investigate the observed H2S spikes within the Seafield siphon house (offsite from WwTW). • Continued monitoring of OCU2 against design parameters. • That the site staff (Veolia or Stirling Water) continue with sniff tests to supplement the work currently undertaken by Odour Technicians. • Note that H2S may be used as a surrogate to odour units, subject to further data collection and analysis.
6.1 It is recommended that the Committee: c) notes that a number of significant odour emissions were due to foreseeable events and demonstrated inadequate operational management controls; Scottish Water is requested to advise the Council of the measures which will be taken to address operational management, risk planning and staff training relating to the future operation of the Treatment Works;
A wide range of operational management controls have been implemented since November 2012. These have been highlighted at Stakeholder meetings and via the regular Odour Liaison Meetings. As well as specific odour management and treatment related changes, other asset and contingency changes have been implemented which have consequential benefits, consisting of: • Sludge management changes including the commissioning of a sludge dewaterer and the procurement of a mobile sludge centrifuge (both as learning actions following the Cake Pad issues of March 2012). • Development of the Sludge Thermal Hydrolysis Plant which will deliver a fully pasteurised and inert sludge cake together with new odour containment and treatment.

Key changes with a focus on odour management are: • Covering of the inlet screening skips. • Introduction of a competency based framework for all employees with inclusion of odour management. • A focus on operation and maintenance strategies so as to reduce reactive work and have a more planned operational environment across the site. • Greater monitoring and awareness of key process indicators such as inlet solids loading, sludge cake quality and chemical usage. • The design and implementation of a new control system for the storm tanks so that the four units can be filled in series rather than in parallel. This will allow containment of smaller storm events in a controlled fashion thereby allowing quicker cleaning of a smaller surface area. • A change to the staffing structure of Seafield WwTW to provide greater emphasis on planned maintenance work and greater odour management support to the 24hr Unit Controllers. • Closer linkage between operational and communications teams to ensure co-ordination of key messages and to inform the odour risk assessment process.
6.1 It is recommended that the Committee: d) indicates to Scottish Water that operation of the storm tanks is a significant source of odour release that requires further action to address the problem
Scottish Water noted the report recommendation and formed a working group to consider and review the sewerage system and treatment plant as a “system”. The Urban Waste Water Treat (Scotland) Regulations 1994 set out the minimum requirements for treatment and containment of stormwater discharges. The catchment flow characteristics were considered as if Seafield was a greenfield site in order to determine if the storm tanks as built in the 1970s exceeded current regulations. With input from Scottish Water’s Regulation team, it was calculated that all four storm tanks are required in order to meet the storage volume as required by the Regulations. This was advised to the full Stakeholder group in April 2013. However, in recognition of the odour risk the focus returned to the management of the storm tanks and the understanding of upstream flows and catchment characteristics. As outlined above, work has progressed in order to allow the tanks to fill in series rather than in parallel. This will translate across into the Odour Management Plan and supplement the good work that has been achieved in this area of the plant. Running in parallel to the Seafield activities, Scottish Water are working with City of Edinburgh Council to understand the interaction between the sewerage system, watercourses and flood areas. This may inform options for further stormwater management in the catchment or at Seafield. This £1.5m modelling project (i.e. building the model) is due for completion by 7th January 2015, thereafter the Needs and Options will be assessed in conjunction with the Council as a key stakeholder.
6.1 It is recommended that the Committee: e) requests Scottish Water to provide a timescale for completion of the emissions inventory and the programme of operational management developments;
As advised at Stakeholder and Odour Liaison Group level, timescales and updates have been provided to Council officers.

6th February 2014

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Mott MacDonald

5 Odour Emissions Inventory

5.1 Baseline inventory

The baseline scenario takes into account odour emissions generated from the current operations and existing equipment at the site and provides a benchmark for comparison with the odour impacts for other scenarios.

Baseline odour emission rates were generally derived from average odour emission rates measured in the survey. Where data were not available these have been estimated based on Mott MacDonald's experience elsewhere.

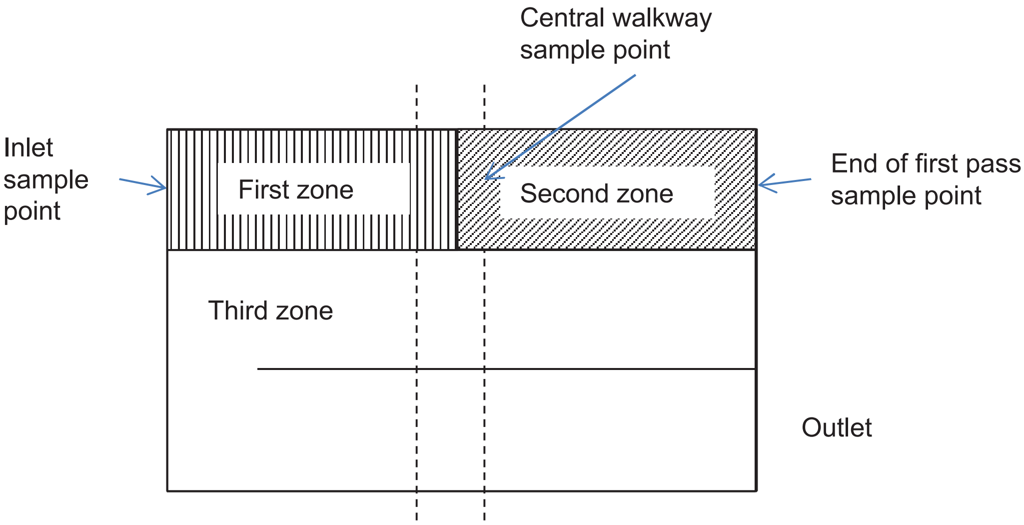
In the baseline case, the following has been assumed:

- All process units normally in operation are in service and operating normally
- All odour control systems extracting and treating extracted air to remove a minimum of 95% of incoming odour.
- All storm tanks clean and empty.
- All covers are in place
- Doors on sludge treatment buildings are closed
- Complete biogas combustion – hence not odorous
- Pressure relief valves on sludge digesters not activated

For the purpose of calculating the aeration tank emission rates the tanks were assumed to be split into three zones. The first zone was from the inlet to the central walkway in the first pass. The second zone was from the central walkway to the end of the first pass. The third zone was deemed to be the final two passes. The emission rates for the first and second zones were calculated from the mean of the inlet and outlet samples from each zone ie for the first zone the emission rate was calculated from the mean of the "Inlet" and "Central walkway" samples and for the second zone the emission rate was calculated from the mean of the "Central walkway" and "End of first pass" samples.

The sampling locations and how these relate to the aeration tank zones for calculating emission rates is shown in Figure 5.1.

Figure 5.1: Aeration lane sampling locations and zones



The mass balance from which the odour emissions inventory has been derived is detailed in Appendix D. The baseline odour emissions inventory is shown in Table 5.1.

Of the total odour emissions from the site, 39% (59,598 OU_E/s) are from the aeration lanes 35% (53,997 OU_E/s) are from the primary sedimentation tanks and 9% (13,403 OU_E/s) are from the detritors. These values show that during baseline conditions 83% of the odour load originates from three odour sources.

Table 5.1: Seafield STW baseline odour inventory

Odour source	No of units	Total emission area m²	Emission rate $OU_E/m^2.s$	Odour load OU_E/s	Emissions measured/ assumed	Comments
Coarse screen skips (screenhouse)	2	12	1	12	Assumed	Washed screenings
Fine screen skips (screenhouse)	4	24	64	1,539	Assumed	Emission rate includes for 40% reduction due to covers
Fine screen skips (outside screens)	3	18	64	1,154	Assumed	Emission rate includes for 40% reduction due to covers
Coarse screen skips (outside screens)	3	18	1	18	Assumed	Washed screenings
Detritors	4	1,003	13.4	13,403	Measured	Based on first two surveys since some units out of operation in subsequent survey
Grit skips	4	24	1	24	Assumed	Equal to coarse screenings emission rate
Storm tanks	4	12,000	0.44	5,280	Assumed	Empty with background emission rate assumed equal to final settlement tanks emission rate
Storm tanks distribution channel	1	454	0.44	200	Assumed	Emission rate equal to storm tanks
Storm overflow channel	1	451	0.44	199	Assumed	Emission rate equal to storm tanks
Primary sedimentation tanks	4	9,677	5.6	53,997	Measured	
Aeration lane – First zone	4	1,006	30.3	30,521	Measured	
Aeration lane – Second zone	4	1,006	14.9	14,995	Measured	
Aeration lane – Third zone	4	4,023	3.5	14,082	Measured	
Final effluent channel	1	782	0.44	344	Assumed	Emission rate equal to final settlement tanks emission rate
Final effluent UV channel	1	322	0.44	142	Assumed	Emission rate equal to final settlement tanks emission rate
Final sedimentation tank distribution chamber	2	37	12.4	458	Measured	

Table 5.1 continued overleaf.

Table 5.1: Seafield STW baseline odour inventory (continued)

Odour source	No of units	Total emission area m²	Emission rate $OU_E/m^2.s$	Odour load OU_E/s	Emissions measured/ assumed	Comments
Final sedimentation tanks	8	11,376	0.44	5,005	Measured	
Final sedimentation tank (converted PST)	1	2,419	0.44	1,064	Measured	
SAS balancing tank	1	98	2.5	248	Measured	
Digested sludge holding tank	1	380	5.7	2,176	Measured	
Primary sludge screenings skip	1	6	106.9	641	Assumed	From previous surveys on other sites
Imported sludge screenings skips	2	12	106.9	1,283	Assumed	From previous surveys on other sites
OCU 1	1	-	-	3,095	Measured	
OCU 2	1	-	-	1,428	Measured	
Main OCU	1	-	-	919	Measured	
Digester OCU	1	-	-	6	Measured	
Total				**152,234**		

5.2 Impact of non-routine events on inventory

The impact on odour emissions on a number of non-routine events has been assessed. The events identified, which the survey results could be used to assess, were:

- A reduction in the performance of OCU1
- A reduction in the performance of OCU2
- Storm water contained within the storm tanks
- Sludge cake storage building door left open[2]

A period of reduced removal efficiency by OCU2 occurred during the survey period and there were also periods where the storm tanks were in operation. During the survey period there were no periods of reduced removal efficiency by OCU1 and, apart from routine usage, there was no occasion during the survey period where the sludge cake storage building was left open for extended periods of time.

2 The sludge treatment at Seafield is being modified in 2013 and 2014 to provide enhanced anaerobic digestion in the form of thermal hydrolysis. As part of this project the existing sludge cake storage building will be disconnected from OCU2 and the air from the cake pad building will be extracted to a new odour control unit. No allowance has been made for this as part of the development of this inventory. Once connected to the new odour control unit it is understood that the ventilation rate will increase and reduce the likelihood of fugitive emissions from the cake pad building, even with the door open. Again no allowance has been made for this.

5.2.1 Reduced performance of OCU1

In this scenario it is assumed that the performance of the biological treatment in OCU1 has reduced for some reason such as loss of the wetting system. It is assumed that the associated fans are still extracting air from the picket fence thickeners and the imported sludge storage tanks and therefore the odour would be dispersed into the atmosphere from the stack.

OCU1 has a measured average inlet concentration of 91,965 OU_E/m^3 along with an air flow of 2,491m^3/h. If treatment within the odour control unit were to fail completely, an odour load of 63,640 OU_E/s is estimated to be released from the stack.

Total failure of treatment is unlikely hence a partial reduction in treatment performance and the worst case emissions measured during the survey have also been considered. The impact of the various scenarios is presented in Table 5.2.

Table 5.2: Impact of reduced performance of OCU1 on baseline emissions

Scenario	Odour removal	Odour load from OCU1 (OU_E/s)	Total odour load from site (OU_E/s)	Odour increase above baseline
Baseline from OCU1	>95%	3,095	152,234	0%
Partial reduction in treatment performance	50%	31,817	180,956	19%
Total treatment failure	0%	63,640	212,779	40%
Worst case during survey	92%	4,964	154,103	1%

5.2.2 Reduced performance of OCU2

In this scenario it is assumed that the performance of the biological treatment in OCU1 has reduced for some reason such as loss of the wetting system. This actually occurred during the sampling period. It is assumed that the associated fans are still extracting air from the all the various sludge treatment locations from which they currently extracts[2] and therefore the odour would be dispersed into the atmosphere from the stack.

OCU2 has a measured average inlet concentration of 25,842 OU_E/m^3 along with an air flow of 4,792m^3/h. If treatment within the odour control unit were to fail completely, an odour load of 34,399 OU_E/s is estimated to be released from the stack.

Total failure of treatment is unlikely hence a partial reduction in treatment performance and the worst case emissions measured during the survey have also been considered. The impact of the various scenarios is presented in Table 5.3.

Table 5.3: Impact of reduced performance of OCU2 on baseline emissions

Scenario	Odour removal	Odour load from OCU2 (OU_E/s)	Total odour load from site (OU_E/s)	Odour increase above baseline
Baseline from OCU2	>95%	1,428	152,234	0%
Partial reduction in treatment performance	50%	17,200	168,006	10%
Total treatment failure	0%	34,399	185,205	22%
Worst case during survey	40%	20,700	171,506	13%

5.2.3 Storm tank usage

In the base scenario (storm tanks empty), all horizontal surfaces in contact with the storm water are estimated to emit a background odour of 0.44 $OU_E/m^2.s$ (equal to the final effluent emission rate). Survey results for storm water give an average surface emission rate of 2.66 $OU_E/m^2.s$, which increases the average odour load from the storm tanks to 34,328 OU_E/s during storm conditions.

The highest surface emission rate measured during the survey was obtained while the storm tanks had being drained and were awaiting cleaning. This scenario has also been considered. The impact of the various scenarios is presented in Table 5.4.

Table 5.4: Impact of storm tanks on baseline emissions

Scenario	Odour emission rate from storm tanks ($OU_E/m^2.s$)	Odour emission rate from storm tanks (OU_E/s)	Total odour emissions from site (OU_E/s)	Odour increase above baseline
Baseline from storm tanks	0.44	5,280	152,234	0%
Average from storm tanks	2.66	34,328	181,282	19%
Worst case during survey	6.9	89,046	236,000	55%

It was noted that there is a procedure within the site Odour Management Plan for emptying storm tanks that requires that the storm tanks contents be returned as soon as possible to prevent the contents becoming odorous. There is also a requirement to clean the storm tanks when the wind is blowing offshore. The significant increase in the overall odour produced by the site indicates the validity of the approach detailed within the Odour Management Plan.

5.2.4 Cake pad open door

The cake storage building is a potential odour source with high odour concentrations inside the building. Due to frequent truck movement the vehicle access door to the building is opened frequently. There is no air lock to prevent odours escaping from the building. The site Odour Management Plan requires that the cake pad door only be open during entry and exit of vehicles from the cake pad building but as this is an automatic operation on entry and a manual operation on exit the door could conceivably be left open for extended periods.

The average cake pad odour concentration measured during the survey was 10,837 OU_E/m^3.

The key assumption for assessment of the impact of the door being open is the air exit velocity. This will be dependent on a number of different factors including wind direction, the temperatures inside and outside the building and the pressure difference between the inside and outside of the building. The impact of a range of exit velocities is presented in Table 5.5. The mass balance within Appendix D assumes an exit velocity of 0.5m/s.

Table 5.5: Impact of cake pad door opening on baseline emissions

Exit velocity (m/s)	Odour emission rate from cake pad (OU_E/s)	Total odour emissions from site (OU_E/s)	Odour increase above baseline
0 (Baseline – door closed)	0	152,234	0%
0.1	27,093	179,327	18%
0.25	67,731	219,965	44%
0.5	135,463	287,697	89%

The results above validate the approach set out in the Odour Management Plan since there could be a substantial release of odour from the sludge cake building if the door is left open for an extended period of time



Seafield STW Odour Emissions Inventory

Final Report

November 2013

Scottish Water

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Odour Emissions Inventory

Final Report

November 2013

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0A	01 November 2013	M Smith J Van de Moortel	A Paskins	G Helders	Initial issue	
0B	11 November 2013	M Smith	A Paskins	G Helders	Final report	

Contents

Executive Summary

Seafield STW treats the wastewater from Edinburgh, much of Midlothian and coastal East Lothian. It is also a sludge treatment centre treating sludge from various water and wastewater treatment works in the surrounding area. The works is operated on behalf of Scottish Water by Stirling Water (the Concessionaire) and Veolia Water Outsourcing Ltd (VWOL) (the Operator). City of Edinburgh Council has requested that Scottish Water prepare an odour emissions inventory in order to better understand the range of emissions from the site. In response to this request, Mott MacDonald has been appointed to undertake a survey of the works and to prepare an inventory for the odour emissions within the site boundary.

In order to develop the odour inventory data was gathered through a combination of sampling from process units, and through conducting weekly sniff tests on site. Mott MacDonald subcontracted the sampling and analysis to Silsoe Odours Ltd. Silsoe Odours' laboratory is accredited by UKAS to undertake the determination of odour concentration measurement by dynamic dilution olfactometry required by BS EN 13725.

Summer 2013 was predominantly warmer and drier than those preceding it. Consequently the incoming wastewater was of generally of higher concentration and lower volume than during a typical summer. It is likely that this has caused higher odour emissions from the treatment works; however there is no sample data from previous available for comparison.

From the results, a baseline odour inventory was developed with the following being assumed:

- All process units normally in operation are in service and operating normally
- All odour control systems extracting and treating extracted air to remove a minimum of 95% of incoming odour.
- All storm tanks clean and empty.
- All covers are in place
- Doors on sludge treatment buildings are closed
- Complete biogas combustion
- Pressure relief on the sludge digesters not activated

The baseline inventory identifies a range of emissions from Seafield STW. The detailed inventory is presented in Section 5. The largest sources of emissions are:

- Detritors (9% of total baseline emissions)
- Primary settlement tanks (35% of total baseline emissions)
- Aeration tanks (39% of total baseline emissions)

The final settlement tanks (4%) and OCU1 (2%) also contribute a significant proportion of the total baseline emissions from the site. The remainder of the emissions comes from minor sources around the site.

The impacts of four non-routine events on the baseline were assessed, namely:

- A reduction in the performance of OCU1
- A reduction in the performance of OCU2
- Storm water contained within the storm tanks
- Sludge cake storage building door left open

A period of reduced removal efficiency by OCU2 occurred during the survey period and there were also periods where the storm tanks were in operation. During the survey period there were no periods of reduced removal efficiency by OCU1 and, apart from routine usage, there was no occasion during the survey period where the sludge cake storage building was left open for extended periods of time.

Each of these non-routine events as assessed leads to an increase in the average odour load from the site.

The impact from the storm tanks appears to be related to the point in the storm tank operational cycle with the highest emissions being recorded during storm tank cleaning.

The performance of OCU2 during the final two surveys indicated that the unit was not able to meet the 95% odour removal required by The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006" (CoP); however because the unit was installed prior to 22 April 2006 the CoP only requires an equipment upgrade if the unit is causing an odour nuisance. There is no evidence to indicate that the reduced performance of the unit caused an odour nuisance. The reduced performance appears to have been at least partially as a result of temporary mechanical failure and may not be representative of normal performance. VWOL has subsequently addressed the mechanical failure.

The findings of this study should be used to inform future discussions between Scottish Water and CEC. The findings should also be used to inform future revisions of the Odour Management Plan for Seafield.

The reason for the H_2S spikes observed at the siphon inlet should be investigated further by Scottish Water with a view to preventing these recurring.

The on-going performance of OCU2 should be monitored to determine the range of inlet odour concentrations and whether they fall within the design capacity of the OCU. Cognisance should also be taken of the fact that the cake pad building, which is a major contributor to the odour load to OCU2, is to be connected to a new odour control unit as part of the thermal hydrolysis project and thus the load to OCU2 will reduce.

Consideration should be given to the Operator or the Concessionaire continuing the sniff tests, perhaps including visiting locations beyond the site boundary, so that Veolia and Stirling Water get an ongoing appreciation of the changes in odour arising from the various process units to supplement the walks round site currently undertaken by the Odour Technicians.

An initial review suggests that there is a reasonably good correlation between H_2S concentration and odour concentration from the various process units. There may be an opportunity to use H_2S monitoring as a surrogate for odour; however a greater level of understanding of the relationships for individual process units, is required including the identification of threshold levels to indicate when operator intervention might be required.

1 Introduction

This report details investigations into odour emissions from the Seafield Sewage Treatment Works (STW) in Edinburgh and develops these into an inventory of odour emissions from the site. The report also considers the impact of a range of foreseeable non-routine events on the emissions inventory.

The methodology for collecting the data and the results are presented within the report.

1.1 Project Background

Seafield STW, Edinburgh is operated on behalf of Scottish Water by Stirling Water (the Concessionaire) and Veolia Water Outsourcing Ltd (VWOL) (the Operator).

Between 2008 and 2011, Scottish Water and Stirling Water implemented the Seafield Odour Improvement Project (SOIP). This comprised:

- Covering the inlet works channels (apart from the quiescent areas of the detritors)
- Covering the channels transferring screened and degritted sewage to the primary settlement tanks and storm tanks
- Covering the primary settlement tank weirs and launders
- Covering the channels collecting primary settled sewage and conveying it to the activated sludge plant feed pumping station.
- Covering the distribution chambers to the activated sludge plant
- Extracting odorous air from the underneath these covers and conveying it to a new odour control unit

City of Edinburgh Council (CEC) is the authority responsible for monitoring and enforcing performance regarding odour. It also conducts periodic surveys within the community both randomly and in response to specific complaints. CEC representatives also visit Seafield, usually in response to multiple complaints, but are also frequently unable to identify what has caused the complaints to be made.

CEC has requested that Scottish Water prepare an odour emissions inventory to better understand the range of emissions from the site. In response to this request Mott MacDonald has been appointed by SW to undertake an odour survey and to prepare an odour inventory for emissions from within the site boundary.

1.2 Site Description

Seafield STW treats the wastewater from Edinburgh, much of Midlothian and coastal East Lothian. As well as treating wastewater it is also a sludge treatment centre treating sludge from various water and wastewater treatment works in the surrounding area. The treatment works is located in the north east of Edinburgh beside the Firth of Forth. An annotated site layout is shown in Appendix A.

1.2.1 Wastewater treatment

The wastewater treatment works comprises

- 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
  - Outlet weir and channels
- Primary treatment
  - Six radial primary settlement tanks of which only four are in use at any one time
- Secondary treatment by the activated sludge process
  - Feed pumping station
  - Activated sludge plant distribution chambers
  - Six aeration lanes with fine bubble diffused aeration of which only four are in use at any one time
  - Nine radial flow final settlement tanks (including one converted primary settlement tank)
- UV disinfection (only used in summer but has flow passing through year round)
- Outfall of secondary effluent and storm water to the Firth of Forth.

1.2.2 Sludge treatment

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 thickening indigenous primary sludge
- Surplus activated sludge (SAS) storage tank
- Four belt thickeners for thickening SAS
- Thickened sludge storage tank for combined imported sludge, primary sludge and SAS
- Six anaerobic digesters
- Biogas storage and flare stack
- Digested sludge storage tank
- Three dewatering centrifuges
- Sludge cake storage building

1.2.3 Odour control

Various items of plant are contained within buildings or covered and connected to odour control units (See Appendix A). There are four odour control units.

The main odour control unit (Main OCU) (comprising two stage wet chemical scrubber and carbon filter, extraction system and vent stack to atmosphere) treats air extracted from:

- MEPS
- Inlet from Siphon House
- 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
- Activated sludge plant distribution chambers

OCU1 (comprising odour biofilter, extraction system and vent stack to atmosphere) treats air extracted from:

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

The digester OCU (comprising carbon filter, extraction system and vent stack to atmosphere) treats air extracted from:

- The digester limpet chambers

OCU2 (comprising odour biofilter extraction system and vent stack to atmosphere) treats air extracted from:

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

2 Methodology

2.1 General

In order to develop the odour inventory data was gathered through a combination of sampling from process units, and through conducting weekly sniff tests on site. Where sampling of minor emissions could not be justified, professional judgement was used to assume values for emissions.

In addition to the sampling work for the duration of the project Mott MacDonald participated in the monthly Odour Liaison meetings where issues relating to odour at Seafield are discussed by Scottish Water, Stirling Water, Veolia, CEC and SEPA. Mott MacDonald was also provided with the daily odour reviews provided by Veolia and with details of odour complaint investigations.

2.2 Sampling and analysis

Mott MacDonald subcontracted the sampling and analysis to Silsoe Odours Ltd to a programme developed by Mott MacDonald. This programme was reviewed following each sampling period in order to account for necessary changes resulting from operational conditions prevalent during the sampling periods. For example, sampling active emissions from the storm tanks was not possible during dry weather.

Silsoe Odours' laboratory is accredited by UKAS to undertake the determination of odour concentration measurement by dynamic dilution olfactometry required by BS EN 13725. The sampling is not covered by Silsoe Odours' UKAS accreditation. Silsoe Odours' report on the sampling survey is included within Appendix B.

For each sample point during a given survey three consecutive samples were taken and each individual sample analysed in accordance with BS EN 13725. The geometric means of the samples were used in developing the inventories. The samples were also analysed for hydrogen sulphide (H_2S) to protect the olfactometry panel from dangerous levels of H_2S. The data can also be used to determine whether and where measurement of H_2S can be used as a surrogate measurement for odour in future surveys

In addition to the bag samples taken from individual process units Odalog® monitors were installed in the suction side of Marine Esplanade Pumping Station and at the inlet chamber from the Siphon House to record hydrogen sulphide (H_2S) concentrations in the incoming sewage. This information can provide information concerning the generation of septic conditions in the catchment that could give rise to enhanced odour emissions at the inlet works.

2.3 Sniff tests

Each week Mott MacDonald attended site and carried out a sniff test. An extensive route around the site was followed covering all major processing areas. The route was varied from week to week to ensure that units were visited in different orders and from different directions. During the sniff tests various members of the teams from Scottish Water, Stirling Water and Veolia accompanied Mott MacDonald in order to understand the approach and validate the findings.

The sniff tests included the weather conditions, the strength and persistence of odours and where possible identification of the source of the odours. The approach varied slightly from the approach described in Technical Guidance Note IPPC H4 Horizontal Guidance for Odour Part 1 – Regulation and Permitting in that:

- No assessment of location sensitivity was made since all visited locations were within the treatment works.
- The extent of persistence was limited to whether the odour was constant or intermittent at the individual sniff test locations.
- No assessment of offensiveness was made since this is entirely subjective.

While the sniff tests were not specifically used to develop the inventory they helped shape the sampling programme. They were also a useful tool for identifying various housekeeping issues that required attention and provided a sense check on the results of the sampling and the inventory derived from the sampling results.

3 Sampling Programme

3.1 Proposed programme

Table 3.1 shows the proposed sample programme where an "x" indicates sampling to be undertaken.

Table 3.1: Initially proposed sample survey

					Survey
Sample Location	1	2	3	4	5
Main OCU inlet	x	x	x	-	x
Main OCU outlet	x	-	x	-	x
Digester OCU inlet	x	x	-	x	x
Digester OCU outlet	x	-	-	x	x
OCU1 (Sludge Import/PFT OCU) inlet	x	x	x	-	x
OCU1 (Sludge Import/PFT OCU) outlet	x	-	x	-	x
OCU2 (Thickened sludge OCU) inlet	x	x	-	x	x
OCU2 (Thickened sludge OCU) outlet	x	-	-	x	x
Detritor	x	-	x	x	x
PST	x	-	x	-	x
Aeration Tank	x	x	-	x	-
FST	x	-	x	x	-
Digested sludge storage tank	x	x	x	-	-
Storm tanks	-	x	-	x	x
Marine Esplanade Pumping Station	-	x	-	x	x
Siphon chamber inlet	-	x	x	-	x
SAS tank	-	x	x	x	-
Sludge cake building	-	x	x	x	-
Sludge import area	-	x	x	x	-
Inlet screens building	-	x	x	x	-

3.2 Actual programme

For various reasons the initial programme was modified over the course of the surveys. These reasons included:

- The start of the survey period was warm and with low rainfall meaning that the storm tanks were clean and empty when a sample was due to be taken.
- Recognition that the odour release varied along the length of the aeration tanks and that a single sample point would not adequately define the emissions.
- Identification of an additional sampling location at the FST distribution chamber.
- Observing little variability in measured conditions in the inlet screens building and digested sludge storage tank.
- Observing significant variability in measured conditions at the siphon inlet.

Table 3.2 shows the actual sample survey programme undertaken.

Samples were taken at various locations along the length of the aeration tanks to reflect the reduction in odour emissions along the length of the tank.

Numbers in brackets indicate multiple samples and in particular the number of sampling locations. Access to the aeration lanes restricted the number of locations from where samples could be taken.

Table 3.2: Actual odour inventory sampling locations

					Survey
Sample Location	**06/07 June**	**26/27 June**	**23/24 July**	**21/22 August**	**12/13 September**
Main OCU inlet	x	x	x	-	x
Main OCU outlet	x	-	x	-	x
Digester OCU inlet	x	x	-	x	x
Digester OCU outlet	x	-	-	x	x
OCU1 (Sludge Import/PFT OCU) inlet	x	x	x	-	x
OCU1 (Sludge Import/PFT OCU) outlet	x	-	x	-	x
OCU2 (Thickened sludge OCU) inlet	x	x	-	x	x
OCU2 (Thickened sludge OCU) outlet	x	-	-	x	x
Detritor	x	x	-	x	-
PST	x	-	-	x	x
Aeration Tank	x	x (2)	x (2)	x (3)	-
FST	x	-	-	x	-
Digested sludge storage tank	x	x	-	-	-
Storm tanks	-	-	x	x	x
Marine Esplanade Pumping Station	-	x	x	-	x
Siphon chamber inlet	-	x	x	x	x
SAS tank	-	x	x	-	-
Sludge cake building	-	x	x	-	x
Sludge import area	-	x	x	-	-
Inlet screens building	-	x	x	-	-
FST distribution chamber	-	-	-	x	-

4 Review of data collected

4.1 Bag sampling

4.1.1 Results

The full report by Silsoe Odours Ltd detailing the survey and the analytical results is included in Appendix B. A summary of the data is presented in Table 4.1 below. The values shown are the geometric means of the triplicate samples taken at each location.

Table 4.1: Sampling survey results

	Odour concentrations (OU_E/m^3)[1]				
Sample Location	06/07 June	26/27 June	23/24 July	21/22 August	12/13 September
Main OCU inlet	4,045	1,286	4,180	-	3,898
Main OCU outlet	0	-	135	-	101
Digester OCU inlet	2,202	12,389	-	8,071	38,380
Digester OCU outlet	0	-	-	0	0
OCU1 (Sludge Import/PFT OCU) inlet	32,344	26,708	71,455	-	237,352
OCU1 (Sludge Import/PFT OCU) outlet	79	-	1,219	-	12,118
OCU2 (Thickened sludge OCU) inlet	11,186	13,658	-	45,305	33,218
OCU2 (Thickened sludge OCU) outlet	24	-	-	15,986	10,810
Detritor	1,558	1,654	-	2,497	-
PST	1,571	-	-	223	73
Aeration Tank					
Inlet	-	-	5,973	1,617	-
Central walkway (1/6th of tank length)	-	3,970	239	6,433	-
End of first pass (1/3rd of tank length)	87	86	-	390	-
FST	48	-	-	50	-
Digested sludge storage tank	822	539	-	-	-
Storm tanks	-	-	56	767	103
Marine Esplanade Pumping Station	-	1,618	4,003	-	4,975
Siphon chamber inlet	-	3,794	40,445	1,237	1,590
SAS tank	-	183	384	-	-
Sludge cake building	-	10,124	17,495	-	4,170
Sludge import area	-	34,129	31,405	-	-
Inlet screens building	-	62	54	-	-
FST distribution chamber	-	-	-	1,379	-

1 A value of 0 indicates that a sample was taken and the odour concentration was below the level of detection for the panel during the olfactometry assessment. Where the value is shown as "-" no samples were taken at that location on that occasion.

4.1.2 Analysis of results

The variability in emission rates is of interest particularly from those process units and locations from where there is normally a constant rate of extraction such as the odour control unit serving the digester and OCUs 1 and 2. This would seem to indicate a significant variation in the rate of odour release from the source. No obvious causes of this variability could be identified from site data.

4.1.2.1 OCU2

The performance of OCU2 shows significant deterioration (in terms of percentage removal) in the fourth and final surveys; however the change in inlet odour concentration from the first survey indicates that the plant is removing more odour overall during the later surveys. At least part of the reason for the reduction in performance during these surveys may be attributed to a temporary partial failure of the water distribution system within OCU2.

Veolia reported that this failure led to part of the media being inadequately wetted and leading to a reduction in the effective treatment capacity. Further, Veolia reported that modifications made to the internal structure of the cake pad building, to reduce the risk of external spillage causing odour emissions, had resulted in sludge being stored in the corner of the building directly beneath the extraction pipework for much longer than normal causing the sludge to become more odorous. This could contribute to the higher odour concentrations observed. The general odour emissions from the cake building were relatively low during the final survey, possibly because the inventory of sludge within the building had been reduced to minimise odour emissions.

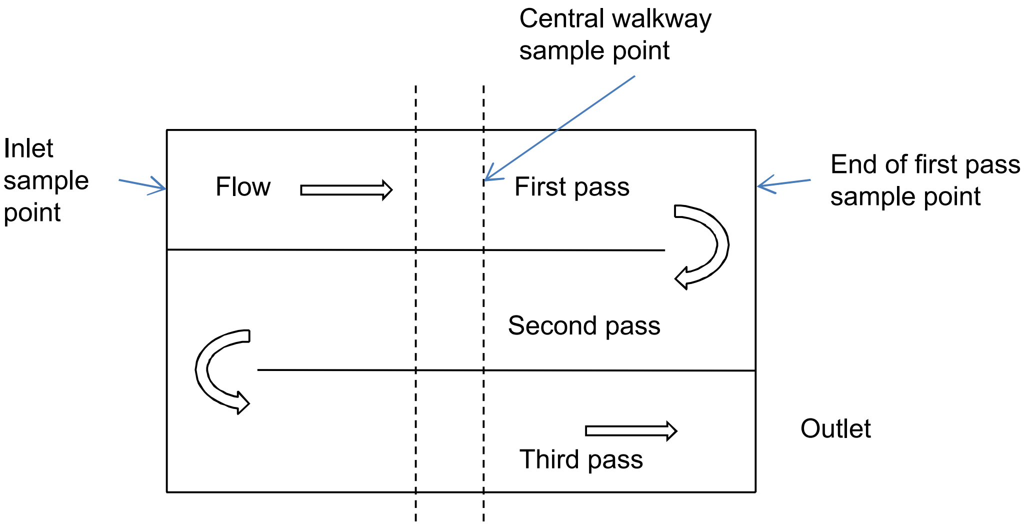
The percentage removal of odour in the fourth and final surveys was much less than the minimum 95% required by the CoP; however because the unit was installed prior to 22 April 2006 The Sewerage Nuisance (Code of Practice) (Scotland) Order 2006" (CoP) only requires an equipment upgrade if the unit is causing an odour nuisance. There is no evidence to suggest that OCU2 was causing a nuisance at this time.

The deterioration in performance and the subsequent actions that the Operator had taken to rectify this were discussed during the October 2013 Odour Liaison Meeting.

4.1.2.2 Aeration lanes

Further commentary is warranted on the various locations within the aeration tanks at which samples were taken. Each aeration lane comprises three passes, as indicated in Fig 4.1. Three sampling locations were identified within the aeration lane. The first was at the inlet to the tank, listed as "Inlet" in Table 4.1. The second was from the central walkway within the first pass, listed as "Central walkway" in Table 4.1. This second location is halfway along the first pass, which is 1/6th of the way along the entire aeration tank. The third location was from the walkway at the end of the first pass of the aeration tanks, listed as "End of first pass" in Table 4.1, which is 1/3rd of the way along the entire aeration tank. A diagram detailing this arrangement is shown in Figure 4.1.

Figure 4.1: Aeration lane configuration and sampling locations



Sampling within the second and third passes was not considered necessary because previous experience indicates that the odour emission does not reduce significantly after the first third of the aeration tank.

Profiling of the aeration lanes appears to indicate a variation in odour release along the length of the aeration lane. While the highest concentrations are observed towards the beginning of the lane the point at which the highest concentration is observed appears to vary. This is to be expected as the incoming BOD load and the available DO varies. See section 4.3 for further details.

4.1.2.3 H_2S and odour correlation

An initial review of the relationship between H_2S concentration and odour concentration has been undertaken. While this seems to suggest that there is good correlation between the two parameters there is some variability across the various stages of the process. A more detailed study involving further sampling and odour and H_2S measurements at each process stage would be required to confirm the relationships and what levels of H_2S from each process unit is likely to require operator intervention in order to prevent an odour nuisance. The initial analysis is presented in Appendix C.

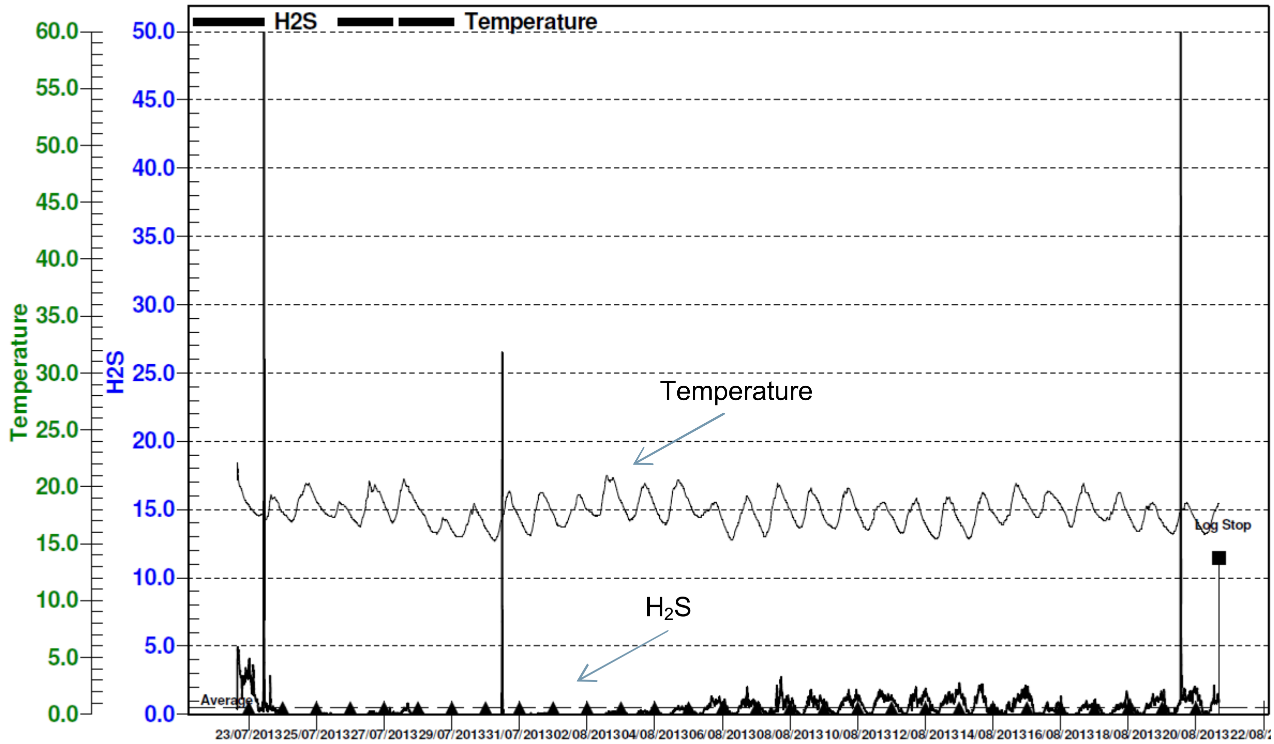
4.2 Inlet hydrogen sulphide monitoring

4.2.1 Results

The full results of the inlet H_2S monitoring are shown in Silsoe Odours' report in Appendix B.

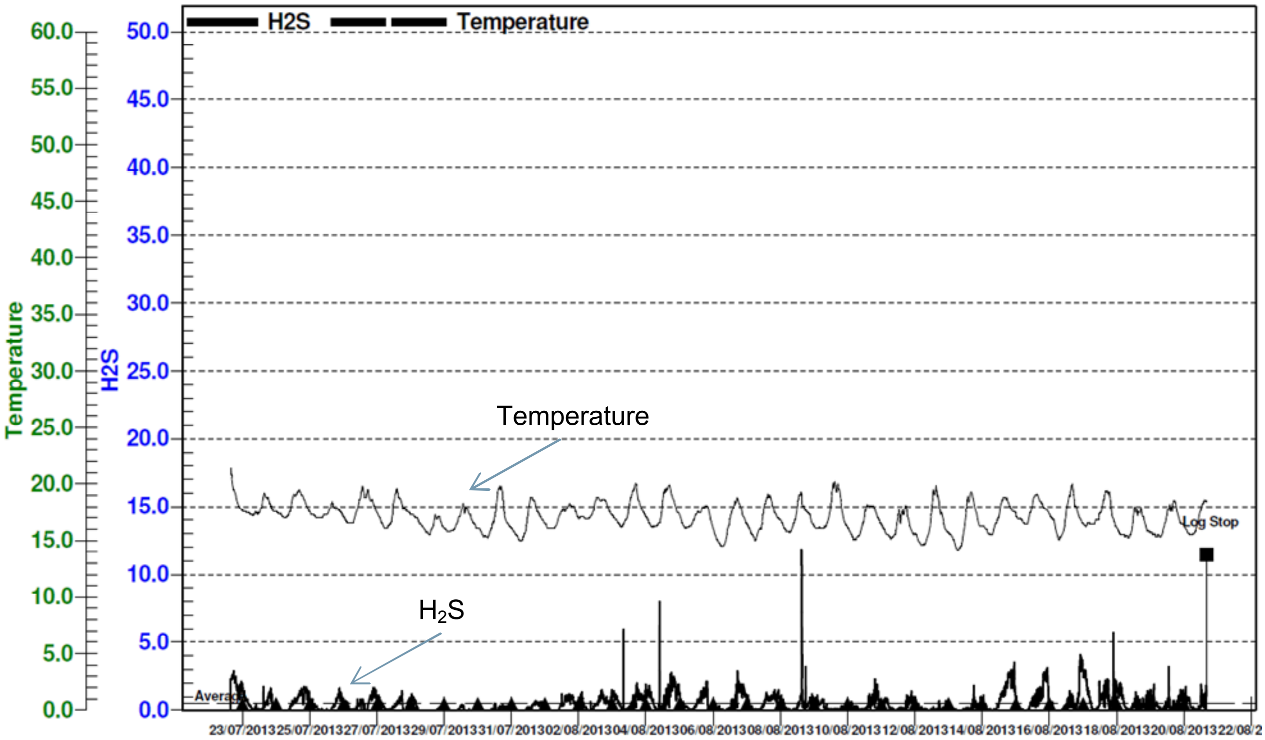
An example plot from the siphon inlet H_2S monitor is shown in Figure 4.2. This shows a distinct diurnal profile with periodic high level, short duration spikes in concentration.

Figure 4.2: Siphon inlet H_2S monitoring results



An example plot from the Marine Esplanade Pumping Station inlet H_2S monitor is shown in Figure 4.3. This also shows a distinct diurnal profile but with much lower spikes in concentration observed than at the siphon inlet.

Figure 4.3: Marine Esplanade Pumping Station inlet H_2S monitoring results



4.2.2 Analysis

Aside from the spikes in H_2S, the inlet profiles are typical for a primarily domestic sewage catchment with little or no saline intrusion where the H_2S concentration is linked to the strength of the incoming sewage. The weather conditions during the survey period were predominantly warm and dry during the survey leading to low incoming flows and generally higher sewage concentrations. It is therefore, possible that the H_2S concentrations are consequently elevated.

It seems likely that the spikes are caused by a plug of something in the influent sewage such as saline intrusion or trade effluent discharges. While an attempt has been made to correlate the spikes observed at the siphon inlet with tidal conditions or trade effluent discharges nothing is apparent. The spikes do not coincide with odour complaints and Veolia has reported that the spikes do not show up at the H_2S monitor permanently installed at the works inlet.

The monitors were installed during the first of Silsoe Odour's surveys and the data from the monitors was downloaded by Silsoe Odours after each subsequent sampling survey. Both installed monitors were changed for new monitors during the second survey, for reasons not related to the data being obtained. The new monitors showed similar patterns to the original monitors.

4.3 Sniff tests

The outputs from the sniff tests do not readily lend themselves to collation or presentation however general trends and observations can be reported.

The most pervasive odours detected i.e. those that could most readily be detected away from their point of release were from the primary tanks and the sludge cake storage building. The odours from the sludge cake building were generally only detectable when the door was open.

The strongest odours observed in the immediate vicinity of the source were from the skips containing the fine screenings from the inlet and the sludge screening (both imported and indigenous sludge). The odours from these skips were undetectable except when within a few metres of the skips.

There was generally very little odour in the vicinity of the works' inlets.

The only location around the covers provided as part of Seafield Odour Improvement Project where odour was detected during the sniff tests was in the vicinity of the fine screens. It is worth noting that there was also odour detected in the vicinity of the primary tanks however this is believed to originate from the uncovered surface rather than the covered sections.

The aeration tanks were covered in bacteriological foam, reported to result from the growth of *Nocardia* sp. in the activated sludge. Sodium hypochlorite, an anti-foaming agent and poly aluminium chloride were being added throughout summer 2013 in an attempt to control the foaming. The odour from the activated sludge tank was on occasions slightly stale and site data indicated that the dissolved oxygen concentration was very low on occasions. This may indicate that the biomass not being sufficiently aerated; however the final effluent still met the requirements of its discharge licence throughout the summer 2013 period.

A faint bleach-like chemical odour could sometimes be detected in the immediate vicinity of the Main OCU; otherwise no odours were detected from the odour control units. It is likely odour from the Main OCU is from the sodium hypochlorite added as part of the odour treatment process. Sodium hypochlorite was also being added to the activated sludge process but the bleach-like smell was not detected anywhere in the vicinity of the aeration tanks giving further certainty that the source was the Main OCU .

One sniff test was conducted in parallel with the regular site walk round by one of the Odour Technicians. The focus of the Odour Technician was primarily on ensuring that the equipment was as it should be (for example ensuring covers were in place, extraction fans were operating, identifying any spillages or maintenance requirements). The assessment was quite mechanistic and there did not appear to be much time spent on reflecting on the odours arising from the site and how these compared to the normal situation.

5 Odour Emissions Inventory

5.1 Baseline inventory

The baseline scenario takes into account odour emissions generated from the current operations and existing equipment at the site and provides a benchmark for comparison with the odour impacts for other scenarios.

Baseline odour emission rates were generally derived from average odour emission rates measured in the survey. Where data were not available these have been estimated based on Mott MacDonald's experience elsewhere.

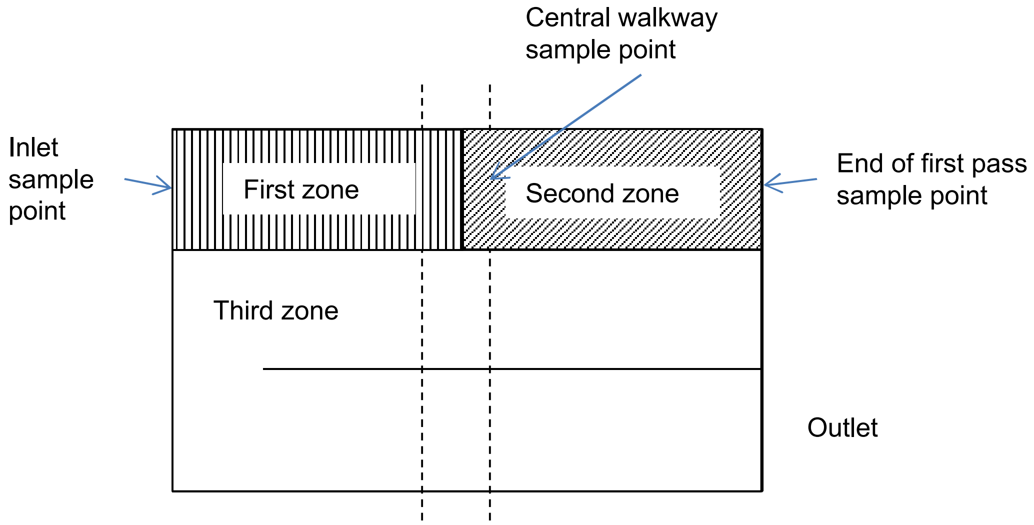
In the baseline case, the following has been assumed:

- All process units normally in operation are in service and operating normally
- All odour control systems extracting and treating extracted air to remove a minimum of 95% of incoming odour.
- All storm tanks clean and empty.
- All covers are in place
- Doors on sludge treatment buildings are closed
- Complete biogas combustion – hence not odorous
- Pressure relief valves on sludge digesters not activated

For the purpose of calculating the aeration tank emission rates the tanks were assumed to be split into three zones. The first zone was from the inlet to the central walkway in the first pass. The second zone was from the central walkway to the end of the first pass. The third zone was deemed to be the final two passes. The emission rates for the first and second zones were calculated from the mean of the inlet and outlet samples from each zone ie for the first zone the emission rate was calculated from the mean of the "Inlet" and "Central walkway" samples and for the second zone the emission rate was calculated from the mean of the "Central walkway" and "End of first pass" samples.

The sampling locations and how these relate to the aeration tank zones for calculating emission rates is shown in Figure 5.1.

Figure 5.1: Aeration lane sampling locations and zones



The mass balance from which the odour emissions inventory has been derived is detailed in Appendix D. The baseline odour emissions inventory is shown in Table 5.1.

Of the total odour emissions from the site, 39% (59,598 OU_E/s) are from the aeration lanes 35% (53,997 OU_E/s) are from the primary sedimentation tanks and 9% (13,403 OU_E/s) are from the detritors. These values show that during baseline conditions 83% of the odour load originates from three odour sources.

Table 5.1: Seafield STW baseline odour inventory

Odour source	No of units	Total emission area m²	Emission rate $OU_E/m^2.s$	Odour load OU_E/s	Emissions measured/ assumed	Comments
Coarse screen skips (screenhouse)	2	12	1	12	Assumed	Washed screenings
Fine screen skips (screenhouse)	4	24	64	1,539	Assumed	Emission rate includes for 40% reduction due to covers
Fine screen skips (outside screens)	3	18	64	1,154	Assumed	Emission rate includes for 40% reduction due to covers
Coarse screen skips (outside screens)	3	18	1	18	Assumed	Washed screenings
Detritors	4	1,003	13.4	13,403	Measured	Based on first two surveys since some units out of operation in subsequent survey
Grit skips	4	24	1	24	Assumed	Equal to coarse screenings emission rate
Storm tanks	4	12,000	0.44	5,280	Assumed	Empty with background emission rate assumed equal to final settlement tanks emission rate
Storm tanks distribution channel	1	454	0.44	200	Assumed	Emission rate equal to storm tanks
Storm overflow channel	1	451	0.44	199	Assumed	Emission rate equal to storm tanks
Primary sedimentation tanks	4	9,677	5.6	53,997	Measured	
Aeration lane – First zone	4	1,006	30.3	30,521	Measured	
Aeration lane – Second zone	4	1,006	14.9	14,995	Measured	
Aeration lane – Third zone	4	4,023	3.5	14,082	Measured	
Final effluent channel	1	782	0.44	344	Assumed	Emission rate equal to final settlement tanks emission rate
Final effluent UV channel	1	322	0.44	142	Assumed	Emission rate equal to final settlement tanks emission rate
Final sedimentation tank distribution chamber	2	37	12.4	458	Measured	

Table 5.1 continued overleaf.

Table 5.1: Seafield STW baseline odour inventory (continued)

Odour source	No of units	Total emission area m²	Emission rate $OU_E/m^2.s$	Odour load OU_E/s	Emissions measured/ assumed	Comments
Final sedimentation tanks	8	11,376	0.44	5,005	Measured	
Final sedimentation tank (converted PST)	1	2,419	0.44	1,064	Measured	
SAS balancing tank	1	98	2.5	248	Measured	
Digested sludge holding tank	1	380	5.7	2,176	Measured	
Primary sludge screenings skip	1	6	106.9	641	Assumed	From previous surveys on other sites
Imported sludge screenings skips	2	12	106.9	1,283	Assumed	From previous surveys on other sites
OCU 1	1	-	-	3,095	Measured	
OCU 2	1	-	-	1,428	Measured	
Main OCU	1	-	-	919	Measured	
Digester OCU	1	-	-	6	Measured	
Total				**152,234**		

5.2 Impact of non-routine events on inventory

The impact on odour emissions on a number of non-routine events has been assessed. The events identified, which the survey results could be used to assess, were:

- A reduction in the performance of OCU1
- A reduction in the performance of OCU2
- Storm water contained within the storm tanks
- Sludge cake storage building door left open[2]

A period of reduced removal efficiency by OCU2 occurred during the survey period and there were also periods where the storm tanks were in operation. During the survey period there were no periods of reduced removal efficiency by OCU1 and, apart from routine usage, there was no occasion during the survey period where the sludge cake storage building was left open for extended periods of time.

2 The sludge treatment at Seafield is being modified in 2013 and 2014 to provide enhanced anaerobic digestion in the form of thermal hydrolysis. As part of this project the existing sludge cake storage building will be disconnected from OCU2 and the air from the cake pad building will be extracted to a new odour control unit. No allowance has been made for this as part of the development of this inventory. Once connected to the new odour control unit it is understood that the ventilation rate will increase and reduce the likelihood of fugitive emissions from the cake pad building, even with the door open. Again no allowance has been made for this.

5.2.1 Reduced performance of OCU1

In this scenario it is assumed that the performance of the biological treatment in OCU1 has reduced for some reason such as loss of the wetting system. It is assumed that the associated fans are still extracting air from the picket fence thickeners and the imported sludge storage tanks and therefore the odour would be dispersed into the atmosphere from the stack.

OCU1 has a measured average inlet concentration of 91,965 OU_E/m^3 along with an air flow of 2,491m^3/h. If treatment within the odour control unit were to fail completely, an odour load of 63,640 OU_E/s is estimated to be released from the stack.

Total failure of treatment is unlikely hence a partial reduction in treatment performance and the worst case emissions measured during the survey have also been considered. The impact of the various scenarios is presented in Table 5.2.

Table 5.2: Impact of reduced performance of OCU1 on baseline emissions

Scenario	Odour removal	Odour load from OCU1 (OU_E/s)	Total odour load from site (OU_E/s)	Odour increase above baseline
Baseline from OCU1	>95%	3,095	152,234	0%
Partial reduction in treatment performance	50%	31,817	180,956	19%
Total treatment failure	0%	63,640	212,779	40%
Worst case during survey	92%	4,964	154,103	1%

5.2.2 Reduced performance of OCU2

In this scenario it is assumed that the performance of the biological treatment in OCU1 has reduced for some reason such as loss of the wetting system. This actually occurred during the sampling period. It is assumed that the associated fans are still extracting air from the all the various sludge treatment locations from which they currently extracts[2] and therefore the odour would be dispersed into the atmosphere from the stack.

OCU2 has a measured average inlet concentration of 25,842 OU_E/m^3 along with an air flow of 4,792m^3/h. If treatment within the odour control unit were to fail completely, an odour load of 34,399 OU_E/s is estimated to be released from the stack.

Total failure of treatment is unlikely hence a partial reduction in treatment performance and the worst case emissions measured during the survey have also been considered. The impact of the various scenarios is presented in Table 5.3.

Table 5.3: Impact of reduced performance of OCU2 on baseline emissions

Scenario	Odour removal	Odour load from OCU2 (OU_E/s)	Total odour load from site (OU_E/s)	Odour increase above baseline
Baseline from OCU2	>95%	1,428	152,234	0%
Partial reduction in treatment performance	50%	17,200	168,006	10%
Total treatment failure	0%	34,399	185,205	22%
Worst case during survey	40%	20,700	171,506	13%

5.2.3 Storm tank usage

In the base scenario (storm tanks empty), all horizontal surfaces in contact with the storm water are estimated to emit a background odour of 0.44 $OU_E/m^2.s$ (equal to the final effluent emission rate). Survey results for storm water give an average surface emission rate of 2.66 $OU_E/m^2.s$, which increases the average odour load from the storm tanks to 34,328 OU_E/s during storm conditions.

The highest surface emission rate measured during the survey was obtained while the storm tanks had being drained and were awaiting cleaning. This scenario has also been considered. The impact of the various scenarios is presented in Table 5.4.

Table 5.4: Impact of storm tanks on baseline emissions

Scenario	Odour emission rate from storm tanks ($OU_E/m^2.s$)	Odour emission rate from storm tanks (OU_E/s)	Total odour emissions from site (OU_E/s)	Odour increase above baseline
Baseline from storm tanks	0.44	5,280	152,234	0%
Average from storm tanks	2.66	34,328	181,282	19%
Worst case during survey	6.9	89,046	236,000	55%

It was noted that there is a procedure within the site Odour Management Plan for emptying storm tanks that requires that the storm tanks contents be returned as soon as possible to prevent the contents becoming odorous. There is also a requirement to clean the storm tanks when the wind is blowing offshore. The significant increase in the overall odour produced by the site indicates the validity of the approach detailed within the Odour Management Plan.

5.2.4 Cake pad open door

The cake storage building is a potential odour source with high odour concentrations inside the building. Due to frequent truck movement the vehicle access door to the building is opened frequently. There is no air lock to prevent odours escaping from the building. The site Odour Management Plan requires that the cake pad door only be open during entry and exit of vehicles from the cake pad building but as this is an automatic operation on entry and a manual operation on exit the door could conceivably be left open for extended periods.

The average cake pad odour concentration measured during the survey was 10,837 OU_E/m^3.

The key assumption for assessment of the impact of the door being open is the air exit velocity. This will be dependent on a number of different factors including wind direction, the temperatures inside and outside the building and the pressure difference between the inside and outside of the building. The impact of a range of exit velocities is presented in Table 5.5. The mass balance within Appendix D assumes an exit velocity of 0.5m/s.

Table 5.5: Impact of cake pad door opening on baseline emissions

Exit velocity (m/s)	Odour emission rate from cake pad (OU_E/s)	Total odour emissions from site (OU_E/s)	Odour increase above baseline
0 (Baseline – door closed)	0	152,234	0%
0.1	27,093	179,327	18%
0.25	67,731	219,965	44%
0.5	135,463	287,697	89%

The results above validate the approach set out in the Odour Management Plan since there could be a substantial release of odour from the sludge cake building if the door is left open for an extended period of time

6 Conclusions

Summer 2013 was predominantly warmer and drier than those preceding it. Consequently the incoming wastewater was of generally of higher concentration and lower volume than during a typical summer. It is likely that this has caused higher odour emissions from the treatment works; however there is no sample data from previous available for comparison.

The baseline inventory identifies a range of emissions from Seafield STW. The largest sources of emissions are:

- Detritors (9% of total baseline emissions)
- Primary settlement tanks (35% of total baseline emissions)
- Aeration tanks (39% of total baseline emissions)

Emissions from the final settlement tanks (4%) and OCU1 (2%) also contribute a significant proportion of the total baseline emissions from the site. The remainder of the emissions comes from minor sources around the site.

The impacts of four non-routine events on the baseline were assessed, namely:

- A reduction in performance of OCU1
- A reduction in performance of OCU2
- Storm water contained within the storm tanks
- Sludge cake storage building door left open

Each of these non-routine events leads to an increase in the average odour load from the site.

The impact of the storm tanks is related to the point in the storm tank operational cycle with highest emissions being recorded during storm tank cleaning where the odour emissions increase above the base load by 55% compared to an average increase of 19% when the tanks contain storm water.

The performance of OCU2 during the final two surveys indicated that the unit was not able to meet the 95% odour removal required by the CoP; however because the unit was installed prior to 22 April 2006 the CoP only requires an equipment upgrade if the unit is causing an odour nuisance. There is no evidence to indicate that the reduced performance of the unit caused an odour nuisance. The reduced performance appears to have been at least partially as a result of temporary mechanical failure and may not be representative of normal performance. VWOL has subsequently addressed the mechanical failure.

7 Recommendations

The findings of this study should be used to inform future discussions between Scottish Water and CEC. The findings should also be used to inform future revisions of the Odour Management Plan for Seafield.

The reason for the H_2S spikes observed at the siphon inlet should be investigated further by Scottish Water with a view to preventing these recurring. While these spikes do not correlate with complaints and the Main OCU appears able to treat any increase in load, the additional loads could lead to higher downstream emissions eg from the detritors and primary settlement tanks.

The on-going performance of OCU2 should be monitored to determine the range of inlet odour concentrations and whether they fall within the design capacity of the OCU. Cognisance should also be taken of the fact that the cake pad building, which is a major contributor to the odour load to OCU2, is to be connected to a new odour control unit as part of the thermal hydrolysis project and thus the load to OCU2 will reduce.

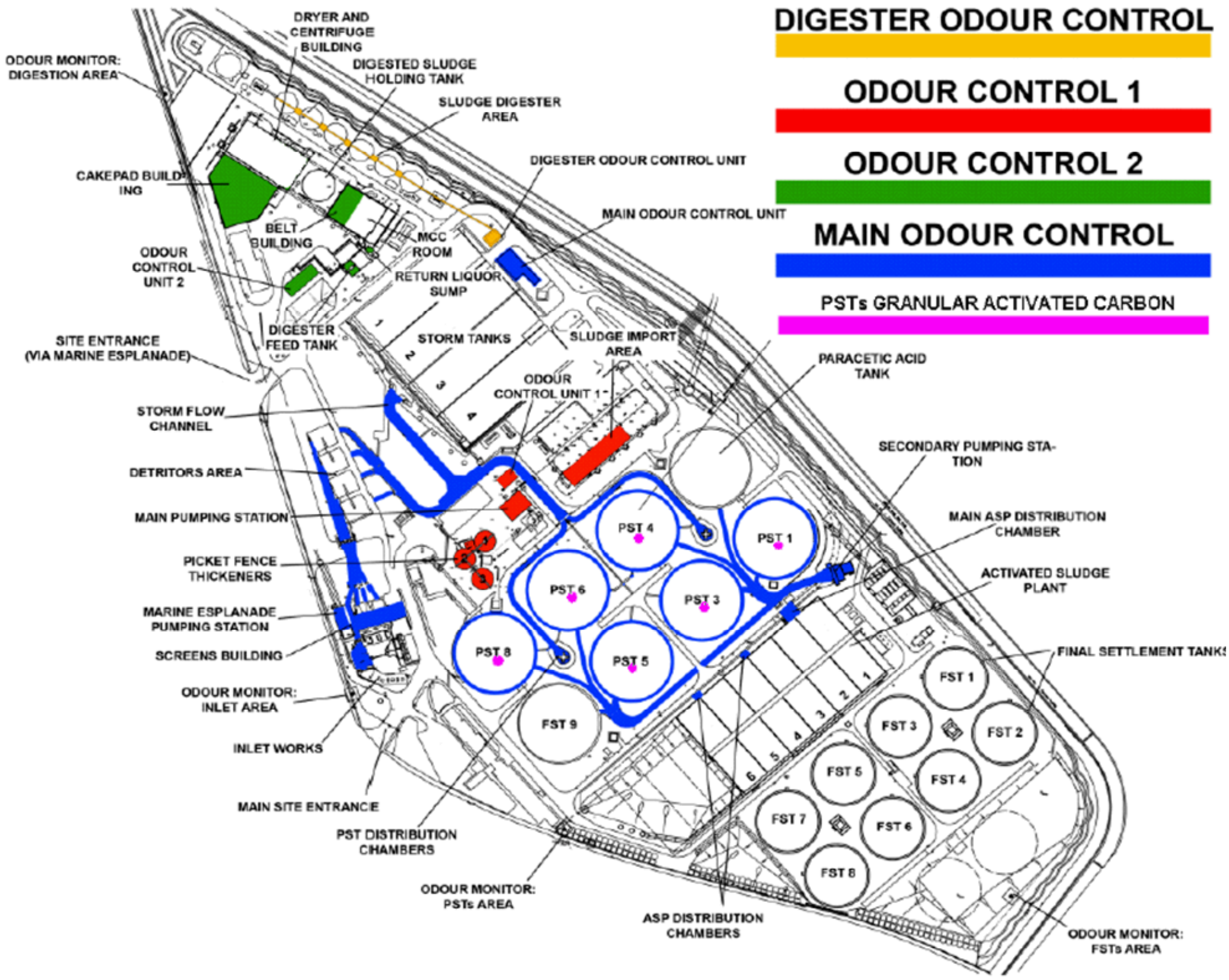
Consideration should be given to Operator or the Concessionaire continuing the sniff tests, perhaps including visiting locations beyond the site boundary, so that Veolia and Stirling Water get an ongoing appreciation of the changes in odour arising from the various process units to supplement the walks round site currently undertaken by the Odour Technicians.

An initial review suggests that there is a reasonably good correlation between H_2S concentration and odour concentration from the various process units. There may be an opportunity to use H_2S monitoring as a surrogate for odour; however a greater level of understanding of the relationships for individual process units, is required including the identification of threshold levels to indicate when operator intervention might be required.

Appendices

Appendix A. Site Layout

Figure A.1: Site layout showing odour control areas



Source: Odour Management Plan, Seafield WWTW, Issue 2 Version 4, Veolia Water Outsourcing Ltd., April 2013

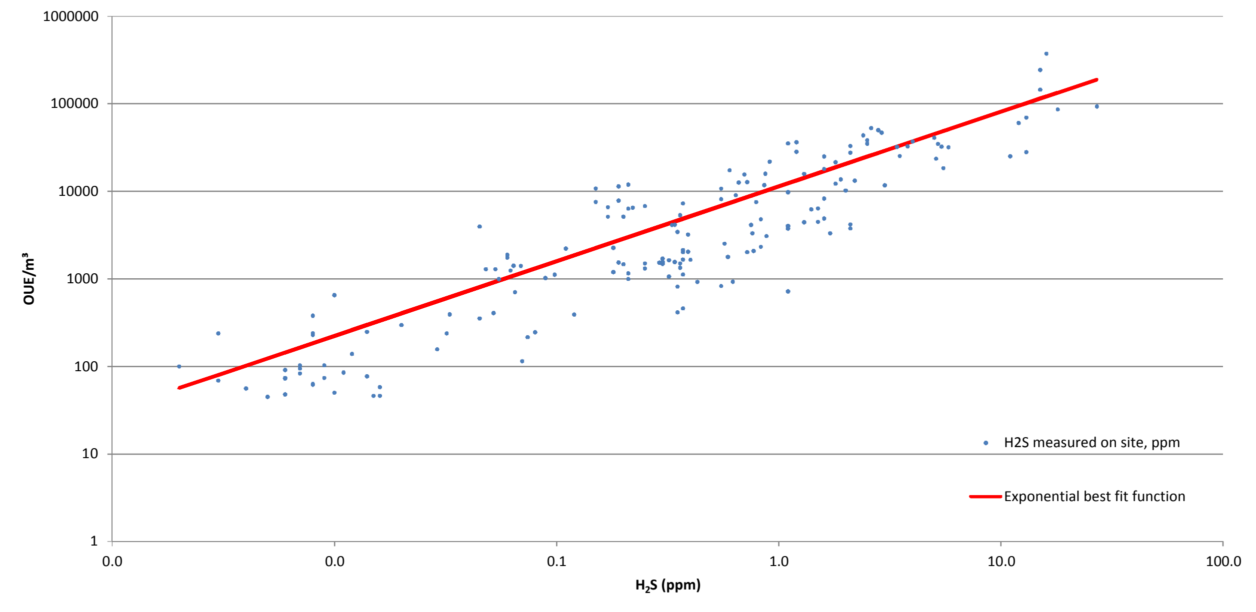
Appendix B. Silsoe Odours Ltd Report

Appendix C. H_2S and Odour Correlation

During the survey, each sample was analysed for both odour and H_2S concentration. An attempt has been made to capture a relationship between the two parameters to indicate whether H_2S could be measured to provide a reliable indication of odour concentration.

The measured data has been plotted in the following figures with H_2S on logarithmical horizontal axes and odour on logarithmical vertical axes.

Figure C.1: H_2S vs Odour logarithmic plot for all data



The graph in Figure C.1 fits an exponential curve through the data with the equation shown below:

$$Odour = 11{,}388\ x\ H_2S^{0.85}$$

It is unusual for data from such different areas of the sites to fit so neatly into a single curve since the characteristics of sludge, raw sewage and secondary treated sewage are so different therefore the data has been separated into sludge, sewage and aeration lane measurements. These are shown in Figure C.2 to Figure C.4. The categories are each plotted with H_2S on the horizontal axes and odour on the vertical axes. When separated into the individual categories the relationships are less clear and indicate that more data is required to be certain whether a relationship truly exists.

Figure C.2: H_2S vs Odour logarithmic plot for sludge

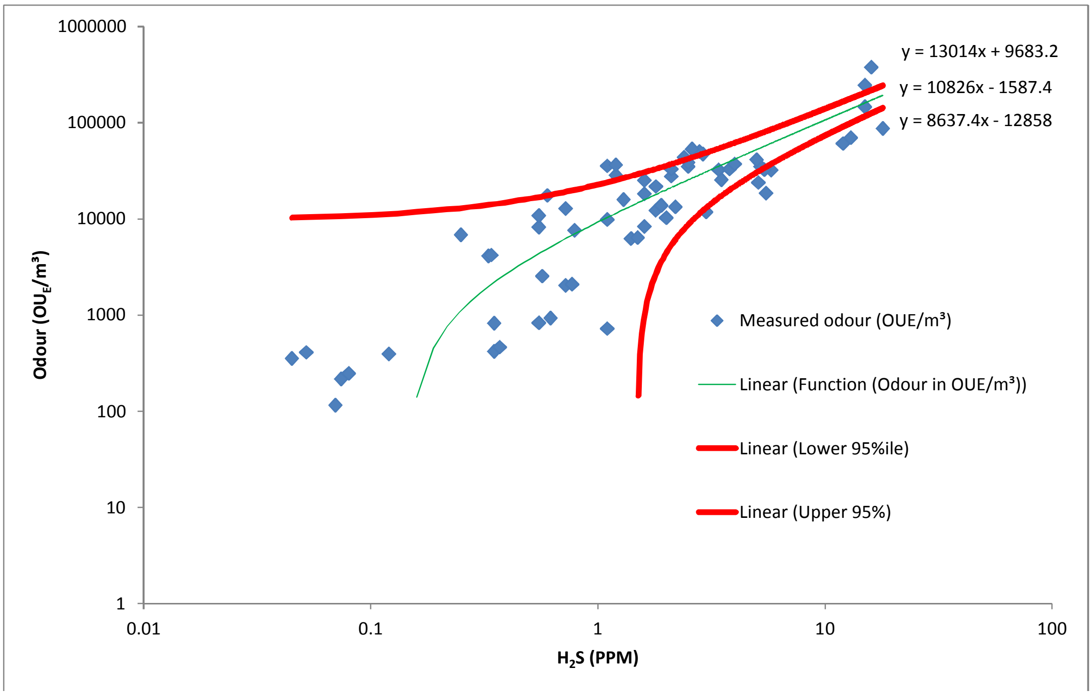


Figure C.3: H2S vs Odour logarithmic plot for sewage

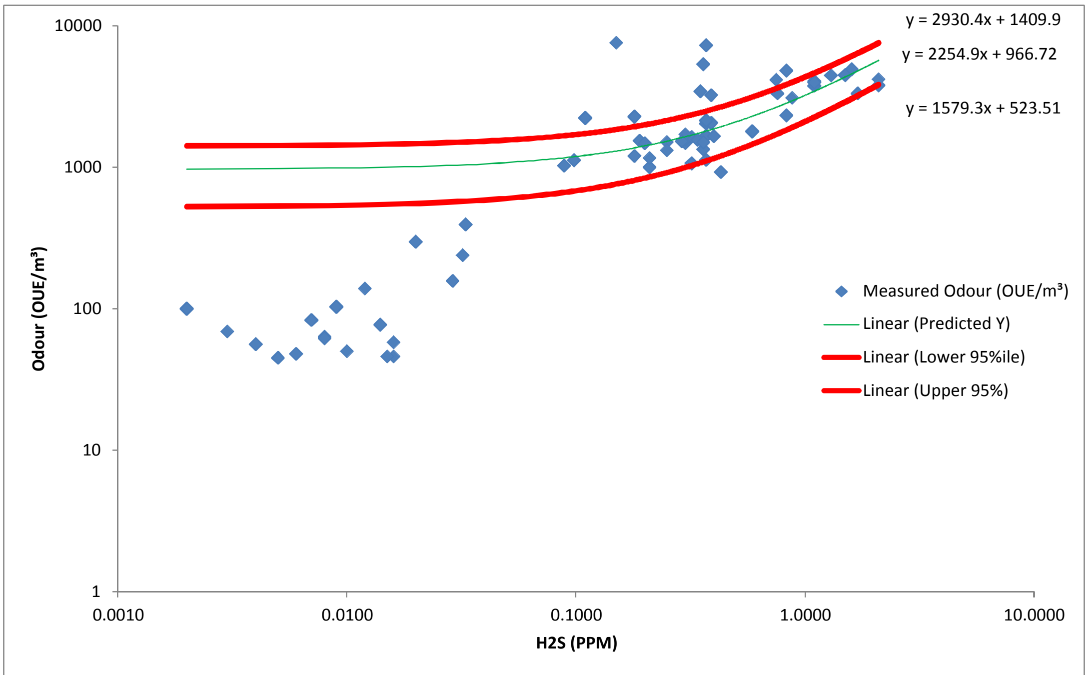
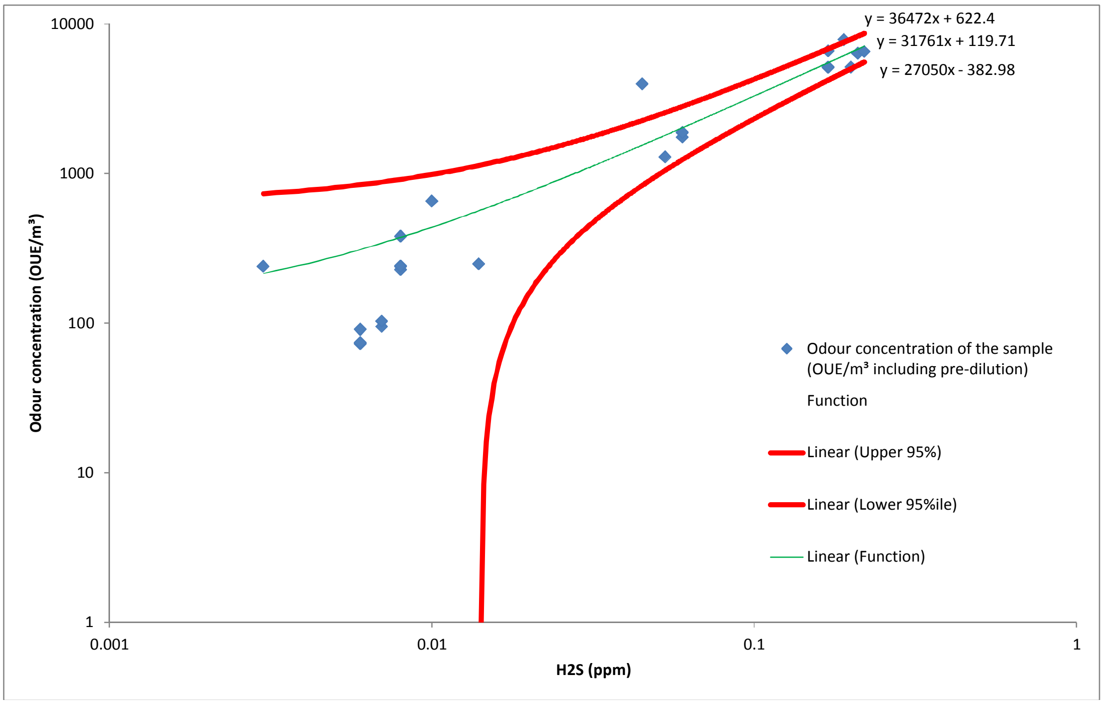


Figure C.4: H_2S vs odour logarithmic plot for aeration lane



Appendix D. Mass Balance

D.1 Mass balance and assumptions

Figure D.1: Odour sources, assumptions, dimensions and emission rate calculations

Site layout ref. number	Process units	Dimensions: No.	Length (m)	Width (m)	Diameter (m)	Structure height (m)	Weir drop (m)	Area per unit (m^2)	Total area (All units) (m^2)	Total volume (All units) (m^3)	Source elevation wrt ground (m)	Ventilation: Enclosed	Ventilated to scrubber	Air rate from ventilation (All units) (m^3/hr)	Emission from plant: Model As:	Odour potential or concentration (OU_E/m^3)	Specific odour emission rate, Area ($OU_E/m^2.s$)	Total odour emission rate (All units) (OU_E/s)	Removal: Scrubbed (OU_E/m^3)	Removal (%)	Residual emission rate to atmosphere in upgraded works (OU_E/s)	Comment
	Preliminary treatment																					
17	Inlet screw pumps (Marine Esplanade Pumping Station)											Yes	Yes								-	
16	Inlet syphon											Yes	Yes								-	
29	Diversion structure & additional inlet structure											Yes	Yes								-	
1	Screenhouse	1	33.5	10.0		10				3350		Yes	Yes		Silsoe survey data	48					-	Dimensions estimated
	Coarse screen skips (screenhouse)	2	3.0	2.0		1.5		6	12		1.5	No	No		Estimated emission		1.00	12			12	Estimated dimensions, low emission rate because screenings are washed
	Fine screen skips (screenhouse)	4	3.0	2.0		1.5		6	24			Yes	No		Estimated emission	11896	106.9	2,565		40	1,539	
	Fine Screens (outside)											Yes	Yes								-	
	Fine screen skips (outside screens)	3	3.0	2.0		1.5		6	18			Yes	No		Estimated emission	11896	106.9	1,924		40	1,154	
	Course screens (outside)	2										Yes	Yes								-	
	Course screen skips (outside screens)	3	3.0	2.0		1.5		6	18		1.5	No	No		Estimated emission		1.00	18			18	Estimated dimensions, low emission rate because screenings are washed
	Channels from inlet to primary											Yes	Yes								-	
2	Detritor	4	16.5	15.2		0		250.8	1003		0	No	No		Silsoe survey data	1606	13.36	13,403			13,403	
	Grit classifiers	4	3.0	2.0		1.5		6	24		1.5	Yes	No		Estimated emission						-	
	Grit skips	4	3.0	2.0		1.5		6	24		1.5	No	No		Estimated emission		1.00	24			24	Assumed all skips to be of the same dimension
	Channels to storm											Yes	Yes								-	
	Storm tanks distribution channels					0		454	454			No	No		Silsoe survey data	309	0.44	200			200	
5	Storm tanks	4	100.0	30.0		0		3000	12000			No	No		Silsoe survey data	309	0.44	5,280			5,280	
	Storm overflow channels		122.0	3.7		0		451	451						Silsoe survey data	309	0.44	199			199	
13	Grit washing mashine (OUT OF SERVICE)																				-	Out of service - assumed to be clean
	Primary and secondary treatment																					
	Channel from detritor to primary tanks											Yes	Yes								-	
	Primary sedimentation distribution chambers	2										Yes	Yes								-	
	Primary sedimentation tanks weir drop	4										Yes	Yes								-	
4	Primary sedimentation tanks	4			55.5	0	-	2419	9677			No	No		Silsoe survey data	622	5.58	53,997			53,997	
	Channels from primary tanks to secondarytreatment PS											Yes	Yes								-	
	ASP distribution chambers	3										Yes	Yes								-	
31	Aeration lane - First zone	4	35.5	7.08		5.9		251	1006		5.9	No	No		Silsoe survey data	3225	30.34	30,521			30,521	
31	Aeration lane - Second zone	4	35.5	7.08		5.9		251	1006		5.9	No	No		Silsoe survey data	1584	14.91	14,995			14,995	
31	Aeration lane - Third zone	4	71.0	14.2		5.9		1006	4023		5.9	No	No		Silsoe survey data	390	3.5	14,082			14,082	
	Final effluent channels					0		782	782			No	No		Estimated emission	49	0.44	344			344	Assumed same odour emission rate as FST
	Final effluent UV channels					0		322.1	322			No	No		Estimated emission	49	0.44	142			142	
	Final Sedimentation tank distribution chamber	2	4.3	4.3		0		18	37			No	No		Silsoe survey data	1379	12.4	458			458	Estimated using 9x10^-3m/s air velocity above liquid surface which is the average value in the Silsoe odour survey
	Final Sedimentation tanks	8			42.6	0		1422	11376			No	No		Silsoe survey data	49	0.44	5,005			5,005	
	Final Sedimentation tank (converted PST)	1			55.5	0		2419	2419			No	No		Silsoe survey data	49	0.44	1,064			1,064	
	Sludge treatment																					
43	Picket fence thickeners	3										Yes	Yes								-	
38	SAS balancing tank	1	10.0	9.8	-	4.65	-	97.5	98	453.38	4.0	No	No		Silsoe survey data	283	2.54	248			248	
36	Digester feed tank	1	10.0	7.0	-	4.65	-	70	70	325.5	4.0	Yes	Yes								-	
40	Digested sludge holding tank	1	-	-	21.99	4.92	-	379.8	380	1868.6	4.9	No	No		Silsoe survey data	680	5.73	2,176			2,176	
	Unscreened Imported sludge tank	1								500.0		Yes	Yes								-	
	Imported sludge tank (big)	1								750.0		Yes	Yes								-	
	Primary sludge screenings skip	1	3.0	2.0		1.5		6	6			No	No		Estimated emission	11896	106.9	641			641	Assumed H2S concentration of 0.17ppm from previous Silsoe survey. Assumed air velocity of 9x10^-3m/s. Odour relationship obtained from 95%th percentile curve from "Sludge H2S correlation"
	Imported sludge screenings skips	2	3.0	2.0		1.5		6	12			No	No		Estimated emission	11896	106.9	1,283			1,283	Assumed H2S concentration of 0.17ppm from previous Silsoe survey. Assumed air velocity of 9x10^-3m/s. Odour relationship obtained from 95%th percentile curve from "Sludge H2S correlation"
44	Cake storage building	1	43.0	22.0		7.5		946	946	7095	0.0	Yes	Yes		Silsoe survey data	10837					-	
	Cake storage building gate	1	5.0			5		25	25		0.0	No	No	12.5	Silsoe survey data	10837		135,463		100%	-	Assumed an exit velocity of 0.5m/s
41	SAS thickening belts	4										Yes	Yes								-	
47	Waste gas burner	1										No	No								-	No odour assumed
	Digested sludge centrifuge building											Yes	Yes								-	
	Imported sludge drum thickeners											Yes	Yes								-	
	Digester spill boxes	6										Yes	Yes								-	
	Digester pressure relief valves	6										No	No								-	
	Return liquor sump											Yes	Yes								-	
	Odour control units																					
54	OCU 1 - Import Sludge	1				10								2,491	Silsoe survey data	91,965			4,473	95.1%	3,095	Serving: 2 Holding tanks, import sludge screen imported sludge sump unscreened sludge tank, 3 PFT, splitter box and foul water/raw sump
18	OCU 2 - serving sludge thickening	1				10								4,792	Silsoe survey data	25,842			1,073	95.8%	1,428	Serving: 2 Dryer, wet cake silo, 3 centrifuges, dilution air inlet, digester feed tank, return liquor sump, 4x sludge thickener
	Main OCU - serving all covered channels and screening	1				10								36,749	Silsoe survey data	3,352			90	97.3%	919	Serving most channels before secondary treatment
	Digester OCU	1				10								522	Silsoe survey data	15,350			44	99.7%	6	Serving digester spill boxes only
	Total																					
	Total emission rate to atmosphere	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**152,234**	

D.2 Derivation of emission rates

D.2.1 Preliminary treatment

- Coarse screen skips (Five units) – An emission rate of 1.0 OU_E/m².s was assumed (coarse screenings are washed and therefore assumed to be within the emission range of final effluent and storm sewage).
- Fine screen skips (Seven units) – The emission rate of sludge screening skips is assumed to apply (106 OU_E/m².s). An H_2S concentration above the surface of 0.17 ppm was estimated and extrapolated to an odour concentration using the Seafield specific H_2S & odour relationship for sludge (see Appendix C for details). The derived odour concentration was then converted to an emission rate of 106 OU_E/m².s using an air speed above the surface of 0.0089 m/s[3]. Further reduction of 40% was allowed for reduction of emissions owing to the skips being covered.
- Grit skips (Four units) – Odour emission rates have not been measured during the survey. The same emission rate of coarse screen skips was assumed (1.0 OU_E/m².s).
- Detritors (Four units) – Three odour emission rates were derived from the survey data. Only the first two were used to calculate the baseline because the third measurement was taken when two detritors were offline.
- Storm channels and tanks – no odour emission rate has been included for storm water as they are assumed to be empty. There is however a background emission rate allowed for equal to the final effluent emission rate of 0.44 OU_E/m².s.

D.2.2 Primary treatment

- Primary sedimentation tanks (Four units were considered to be operational at any time) – Three odour emission rates were obtained from the survey. The average of the measured emission rates was used to estimate odour generated by the four primary sedimentation tanks. It is assumed that there are no emissions from the tanks out of service.

D.2.3 Secondary treatment

- Aeration lane (Four units were considered to be in operation at any time) – Eight odour emission rates have been measured across the aeration lane with summarized results in Table D.1. The aeration lanes are divided in three zones visualised in Figure 5.1. The last survey captured odour emission rates in all three zones and is used as a representative basis for the baseline scenario. Table D.2 details how the odour emission rates for each zone were obtained.
- Final effluent channels – An emission rate of 0.44 OU_E/m².s was assumed. These will be more turbulent than FSTs; however, on the other hand the FSTs contain sludge which is not the case for effluent channels.
- Final sedimentation tank distribution chamber – odour concentration was obtained from the survey and was converted to a surface odour emission rate of 12.3 OU_E/m².s using an air speed of 0.0089 m/s[1].
- Final sedimentation tanks (Nine units) – Three odour emission rates were obtained from the survey. The average of the emission rates was used to estimate the odour emission rate of 0.44 OU_E/m².s

3 Average air speed used by Silsoe during their survey.

Table D.1: Measured odour emission rates $OU_E/m^2.s$

Survey date	First zone emission rate ($OU_E/m^2.s$)	Second zone emission rate ($OU_E/m^2.s$)	Third zone emission rate ($OU_E/m^2.s$)
06 June 2013	-	-	0.78
26 June 2013	-	35.61$^{(*)}$	0.77
23 July 2013	53.6	2.25	-
20 August 2013	14.5	63.5	3.5

Note: (*) single sample reading
Source: Silsoe Odours Ltd – Odour Emissions from the Seafield WWTW Summer 2013

Table D.2: Aeration lane emission rate calculation

Zone	Formula used to obtain emission rate	Baseline emission rate used ($OU_E/m^2.s$)
First zone	Geomean of emission rate measured at inlet and central walkway	30.3
Second zone	Geomean of emission rate measured at central walkway and the end of the first pass	14.9
Third zone	Equal to the emission rate measured at the end of the first pass	3.5

D.2.4 Sludge Treatment

- SAS balancing tank (One unit) – Three odour emission rates were derived from the survey data. The average was 2.54 $OU_E/m^2.s$ for the survey data.
- Digested sludge holding tank (One unit) – Three odour emission rates were derived from the survey data. The average of 5.73 $OU_E/m^2.s$ was for the inventory.
- Imported sludge and primary screenings skips (Three units) –. An estimated emission rate was used based on Mott MacDonald experience with sludge screenings skips. An H_2S concentration above the surface of 0.17ppm[4] was estimated and extrapolated to an odour concentration using the Seafield specific H_2S and odour relationship for sludge (Appendix C). The derived odour concentration was then converted to an emission rate of 106 $OU_E/m^2.s$ using the average air speed of 0.0089 m/s^3.

D.2.5 Odour Control Units

- OCU 1 serving sludge imported region – Three odour concentrations at the stack were measured during the survey. The average of these three concentrations along with measured air flow rates was used to obtain the odour load of 3,095 OU_E/s.
- OCU 2 serving sludge thickening area – A single representative odour concentration was measured at the stack. The measured odour concentration along with measured flow rate was used to obtain the odour load of 1,428 OU_E/s.
- Main OCU serving most of the covered preliminary treatment units – Three odour concentrations were measured at the stack. The average of these three concentrations along with measured air flow rates was used to obtain the odour load of 919 OU_E/s.

4 Value measured by Silsoe on a different WwTW for a skip holding strain press screenings

- Digester OCU – Three odour concentrations at the stack were obtained from the survey. The average of these three concentrations along with measured air flow rates was used to obtain the odour load of 6 OU_E/s.