ADAS

IN CONFIDENCE

REPORT TO
Mr Fred Laycock
Rochford District Coucil

ODOUR EMISSIONS
AND
DISPERSION MODELLING

ROCHFORD WwTW,
STAMBRIDGE,
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SUMMARY

1. ADAS was commissioned to assess the effectiveness of odour controls at Rochford STW and to assess the likelihood of emissions from the works causing off site odour complaints.

2. Measured odour emissions from the primary settlement tanks at the Works were very high, and appeared to be caused by infrequent and/or incomplete de-sludging, as evidenced by gassing/bubbling, some sludge inversion and elevated H_2S emissions.

3. Measured odour emissions from the activated sludge plant were also very high, possibly as a result of carry-over of odorous compounds in settled sewage from the primary tanks.

4. High odour concentrations were measured in treated air off two “Peacemaker” odour control units at the site. The large unit dealing with air from the on-site sludge processing plant was particularly ineffective, suggesting that the scrubbing media might be exhausted. The smaller unit at the STW end of the works did not seem to cope well with load peaks.

5. The picket fence thickener tanks are not well sealed and the headspace air is very odorous. There is a significant risk of fugitive odour leakage from these tanks and subjective “sniffing” on site suggested that such leakage does occur.

6. Dispersion modelling, together with off-site odour assessments, demonstrated that the works has the potential to at least cause some loss of amenity, if not a nuisance, at residential properties in the area around the Works. The local sewage treatment facilities at the Works (rather than the sludge processing facilities) seem to be the main cause of off site odours, as perceived during the off-site assessments. The on site measurements demonstrated these processes are very odorous.

Recommendations - Anglian Water should be encouraged to review the following aspects of the Works operation and management to help demonstrate Best Practicable Mean controls of odour emissions:

1. The frequency and effectiveness of primary settlement de-sludging regimes. More effective procedures should be put in place. Comparative (before and after) odour or H_2S

measurements should be undertaken to assess the effectiveness of any such improvements in reducing emissions.

2. The effectiveness of the sludge treatment centre Peacemaker should be reviewed and appropriate improvements put in place to reduce emissions. Consideration should be given to some form of pre-treatment to reduce the very high hydrogen sulphide loading and more thorough, routine, monitoring procedures should be put in place. Objective odour or H_2S measurements should be undertaken to assess the effectiveness of such improvements in reducing emissions.

3. The effectiveness of the smaller (Sewage Treatment Works) Peacemaker should be reviewed and appropriate improvements put in place to reduce emissions if necessary.

4. Better sealing of the Picket Fence Thickener tanks to reduce fugitive odour loss.

5. Site, boundary and off site mapping of hydrogen sulphide concentrations in the summer or late spring, after appropriate improvements have been made to the works, to demonstrate the effectiveness of these measures and/or to highlight any remaining "hotspots".

6. In the longer term – some covering of the inlet works facilities could be considered, if complaints persist, but this is NOT a high priority in comparison to other potential odour sources at the Works.

2. INTRODUCTION

It is understood that the Rochford Wastewater Treatment Works near Stambridge has some history of odour complaints. The Works provides a conventional wastewater treatment facility (the Sewage Treatment Works or STW) for the local catchment, and it also accommodates a Sludge Treatment Centre (or STC plant) to de-water sludge pumped to Stambridge from Southend. Separated liquor or centrate from the STC is, it is understood, returned to Southend. The STC plant has in the past included a lime based sludge stabilisation process, which was the cause of local environmental concerns.

ADAS was commissioned by Mr Fred Laycock, Senior Environmental Health Officer at Rochford District Council, to undertake a programme of odour sampling, analysis and dispersion modelling at Rochford WwTW as part of investigations into the veracity of, and causes of off-site odour complaints. Off site hydrogen sulphide concentration measurements and subjective "sniffing" were also undertaken to provide additional information about the odour impact of the works.

This report sets out the methods used in odour sampling and analysis, the results of these measurements, and some discussion of the results with recommendations to help minimise odour impact of the works. The results of this measurement work have then been used as the basis of dispersion modelling to assess the off site odour impact of the existing works, with measured emissions, and after some proposed improvements.

3. ODOUR SAMPLING AND ODOUR EMISSION RATE MEASUREMENTS

3.1 Odour Sampling Programme

Odour sampling locations were selected during a preliminary meeting and site inspection undertaken on 9 September 2004.

The main objectives of the proposed sampling were to quantify the most significant odour emissions on the site, to help focus future efforts in controlling potential off site odour impact, and to provide emission data for dispersion modelling. The number of odour samples collected from each source was selected to reflect the potential significance of each odour source with regard to both odour concentrations and flux rate of the emission.

Triplicate samples or pairs of samples were collected from the most important sources and single samples from those sources envisaged to have least potential for off-site impact.

The sampling programme was as follows:

20 September 2004

- Primary Settlement Tank with Lindvall Hood – 3 samples (A1 to A3).
- Supernatant/Centrate Tank Peacemaker – 2 samples from outlet stack (B1 & B2).
- Activated Sludge Plant with Lindvall Hood – 3 samples (C1 to C3).

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- Inlet Works – Rising Main Chamber – 1 sample (D1)
- Sludge Cake RoRo Skips (Nos. 3 & 7) Air Outlets – 3 samples (E1 to E3).
- Sludge Treatment Peacemaker Odour Control Stack – 3 samples (F1 to F3).
- Sludge Treatment Picket Fence Thickener Extract Duct – 3 samples (G1 to G3).
- Sludge Cake Conveyor Hopper Well – 1 samples (H1)
- Untreated (inlet) air on Supernatant/Centrate Tank Peacemaker – 1 samples (J1)

3.2 Odour Sampling and Analysis

All odour samples were collected using inert PTFE sampling tube, with stainless steel fittings, into PET sample bags. Inert materials are used to avoid sample contamination or leakage.

Direct Sampling - Air samples were collected directly from ducts and air outlets from a number sources. Ventilation rates were measured or estimated from airflow measurements. These sources were:

1. Centrate Tank Peacemaker Stack – Sampled direct from stack and airflow measured with pitot tube and micro-manometer.
2. Inlet Works – Sampled direct from rising main chamber and emissions rate estimated from this sample.
3. Sludge Cake RoRo Skips – Sampled from container air outlet with displaced air ventilation rate calculated from sludge cake volumetric fill rate.
4. Sludge Treatment Peacemaker Odour Control Stack – Sampled direct from stack and airflow rate information provided by Anglian Water.
5. Sludge Treatment Centre Picket Fence Thickener Extract Duct – Sampled from extract duct to odour controls and odour leakage/ventilation rate estimated from tank volumes.

6. Sludge Cake Conveyor Hopper Well – Sampled in the well, and emission rate estimated for natural ventilation.
7. Untreated Inlet Air on to Centrate Tank Peacemaker – Sample direct from inlet duct to Peacemaker.

Lindvall Sampling Hood - A covering method employing a Lindvall hood was used to measure the odour emissions from area sources. A floating cover is ventilated at a known rate with activated carbon filtered air. Samples of the outlet odour streams are collected and analysed. The increase in odour concentration between inlet and outlet is caused by the odour emitted from the covered surface. Odour emission rates can be calculated from the measured hood ventilation rate. The following sources were sampled with a Lindvall hood:

1. Primary settlement tank.
2. Aeration lanes.

On the day following sampling odour samples were dispatched for analysis at Silsoe Research Institute in Bedfordshire, using procedures set out in BS EN 13725 for olfactometric analysis.

Odour concentrations were determined using a dynamic dilution olfactometer (Project Research) with a forced choice method of sample presentation to an odour panel. Six dilutions of each sample, differing from each other by fixed factors (each step is a defined factor of around 1.7), were presented to the panellists previously selected within the limits set out in the BS standard. Dilutions are made using odour-free air supplied by a compressor fitted with carbon filters and an air dryer.

The olfactometer has two sniffing ports, one containing the diluted sample air and the other, odour-free air. For each presentation panellists indicate via a keyboard which port they think is delivering the odorous air.

The olfactometer quantifies the concentration of odour in air samples by diluting the air sample under test with known ratios of odour-free air. The diluted samples are presented to the panel to determine the odour threshold value. This is the odour concentration just perceived by 50% of the panel via a statistical analysis of the dilution test results. Odour concentration results are expressed in European odour units per cubic metre (ou_E/m^3), which equates to the number of dilutions to the detection threshold. The odour concentration of an undiluted sample that is at threshold level is defined as 1 ou_E/m^3.

3.3 Additional On-site Observations

The times over which odour samples were collected were recorded and hydrogen sulphide concentrations were sub-sampled from most sample bags submitted for olfactory analysis (3 readings per bag) using an ADAS Arizona Instruments "Jerome" meter.

Airflow rate data was measured, where feasible, using a pitot tube with an *Airflow Developments* micro-manometer.

3.4 Off-site Odour Observations and Hydrogen Sulphide Concentrations

Off-site observations were undertaken on 29 and 30 September at a number of locations around the Works. Background air was sampled with a Jerome 631-x hydrogen sulphide meter. Records were made of wind speed and air temperature, and any odour detected during these assessments. Observations were made at the following locations:

a) Springs Lane near the Works (29th September only)
b) Talana,
c) The Bays
d) The Police House
e) Moat and Springs (30th September only)
f) Wheldon Road
g) Upwind of the Works on the access road (30th September only)

4. RESULTS

4.1 On-Site Odour and Hydrogen Sulphide Concentration Results

Odour concentration results are summarised in Table 2 below, together with calculated emission rates and a mean H_2S concentration for each set of odour samples.

Table 2. Odour and H_2S Concentration Results for Rochford STW – September 2004

Odour Source and Date	Odour Concentrations (ou_E/m^3) Measured	Geo. Mean	Emission Rate (ou_E/s)	Mean H_2S Conc. (ppm)
Inlet Works	4,867	4,867	16,750*	0.69
Primary Settlement Tanks	6,057 6,439 3,830	5,306	78,983	2.9
Aeration Lanes	762 905 993	881	9,157	0
Filtrate/STW Tank Peacemaker Stack	72,921 48,316 **	59,357	14,914	10.9
Filtrate/STW Tank Peacemaker Inlet	28,317 **	28,317	N/a	29.5
Sludge PFT Tanks (SPC)	26,650 52,457 43,217	39,239	10,069***	38
STC Sludge Cake Container Vents	2,516,348 2,831,717 2,508,180	2,614,527	3,221	N/a
STC Sludge Cake Conveyor Well	30,088	30,088	5,000	8.5
Large Peacemaker Air Outlet (SPC)	31,969 23,682 26,650	27,224	75,410	35.3
Final Settlement Tanks	Estimated at 2 $ou_E/s/m^2$		960	N/A

*Estimated from area of inlet works and screens
**Stack and inlet samples not collected on the same day on centrate tank "Peacemaker"
*** Estimate based on fugitive leaks of approximately one tank volume air change per hour

4.2 Off-site Hydrogen Sulphide Sampling

Observations are summarised below in Table 3 and Table 4.

Table 3 – Off-site Monitoring on 20th September 2004 from 17:00 hours

Location	**Hydrogen Sulphide Concentrations (ppb or parts per billion)**
Spring Lane, near Works	2, 3, 2
Talana, Stambridge Road	2, 1, 1
The Bays, Stambridge Road	2, 2, 2
The Police House,	3, 2, 2
Wheldon Road	3, 2, 3
Wind - northerly at 0.80m/s. Dry, ambient temperature 7.3^{0}C No obvious odours detected at any locations, but wind not passing over the Works towards any of the monitored locations	

Table 4 – Off-site Monitoring on 21st September 2004 from 09:15 hours

Location	**Hydrogen Sulphide Concentrations (ppb or parts per billion)**
Wheldon Road	6, 7, 6
Talana, Stambridge Road	9, 7, 6
The Bays, Stambridge Road	1, 2, 1
The Police House, Stambridge Road	1, 1, 1
Roadside opposite Talana (Stambridge Rd)	13, 14, 13
Moat and Springs at 09:45	15, 14, 16, 17
Upwind of Works on access road	3, 3, 3, 2
Wind - easterly at 1.4m/s. Dry, clear sky following frosty night Distinctive raw sewage odours detected at Talana and on the roadside opposite these properties. Wind was passing over Works towards monitored locations on Stambridge Road. No such odours detected up wind of the Works.	

Comments - The odours detected at properties on Stambridge Road were not strong, but they were distinctive, and this characteristic, together with their intermittent nature, would be sufficient to have some negative effects on residents' enjoyment of their gardens and property, especially if such odours were experienced on warm summer evenings. Distinctive raw sewage odours had previously been detected during site visits, on the Works approach road.

4.3 Discussion of Results

The following comments relate to measured emission values and to the use of both measured and estimated emissions rates in the dispersion modelling study. Dispersion modelling has been undertaken for two scenarios, with an "existing" scenario dealing with the current, measured, emissions and with an "abated" scenario examining the effects of some possible improvements suggested (by ADAS) as a result of the measurement work undertaken.

4.3.1 STW Inlet Works – Estimated Emissions of 16,750ou$_E$/s

The inlet works had a fairly distinctive effluent/sewage type odour and the relatively low hydrogen sulphide concentration (especially compared to the primary settlement tanks) does not suggest any significant septicity in the incoming effluent at the time that the sampling was undertaken. There would be some merit in H_2S monitoring at the inlet works with a Jerome meter during warmer weather conditions (June-August) to confirm these observations.

Odour emissions from the inlet works area could be reduced by covering some parts of the plant, such as the "turbulent" rising main reception chamber. However, given the size of these facilities it is suggested that, at this stage, a higher priority should be given to reducing emissions in other areas of the works.

4.3.2 STW Primary Settlement Tanks - Emissions of 78,983 ou$_E$/s

Area specific odour emissions, that is odour per square metre of primary tank area, were measured at 164.5 ou$_E$/m^2/s. More typically emission rates on primary tanks are around, or less than, 25-30ou$_E$/m^2/s.

High emission rates might be caused by particularly odorous sewage entering the works and/or by some sludge septicity within the primary tanks, which might be caused by inadequate or infrequent de-sludging. The primary tanks were seen to be "gassing" or "bubbling" and there was some evidence of sludge inversion (sludge rising and floating), suggesting that the existing de-sludging regimes do not control anaerobic decay and septicity in settled sludge. The relatively high hydrogen sulphide concentrations also suggest that this is the case.

Emissions from the primary tanks represent around one third of total measured emissions from the works and these emissions are released at relatively low height. Furthermore, the primary tanks are the closest significant odour source to the residential receptors on Stambridge Road, and the odours detected at these properties on 30 September were of raw sewage type odours, rather than sludge type odours.

It is understood that current practice at the Works has been to de-sludge the primary tanks once a day. The likelihood is that more effective and/or more frequent de-sludging could effect a very significant reduction in odour emissions from the primary tanks. This should be seen as the highest priority in future efforts to reduce odour emission from the Works as a whole.

For the purposes of evaluating the effects of better de-sludging it has been assumed that emissions could be reduced to a relatively conservative 50$ou_E/m^2/s$, but more substantial improvements could well be feasible. An emission rate of 50$ou_E/m^2/s$ has therefore been used in the "abated" scenario dispersion model.

4.3.3 STW Aeration/Activated Sludge Plant - Emissions of 78,983 ou_E/s

As with the primary tanks, the measured emission rates are high in comparison with works elsewhere. In this case odour emissions were measured at 27$ou_E/m^2/s$. More typically emission rates on activated sludge processes elsewhere might be around 5-10$ou_E/m^2/s$. It is possible that these high emissions are at least partly caused by some characteristics of the incoming sewage or the processes at the Rochford Works, but septicity in the primary tanks is very likely to be at least partly, if not primarily, responsible.

For the purpose of dispersion modelling of an "abated" scenario of the works it has been assumed that emissions from the activated sludge tanks might be reduced to about 15$ou_E/m^2/s$ as a consequence of improvements to the primary tank de-sludging regime. It is expected that better de-sludging will help reduce the odour potential of effluent transferred to the activated sludge plant.

4.3.4 STW Final Settlement Tanks – Estimated Emissions of 960ou_E/s

A typical odour emission rate of 2ou_E/m^2/s has been assumed for the final tanks in both the "existing" and "abated" modelling scenarios.

4.3.5 STW Supernatant Centrate Tank Peacemaker Odour Control - Emissions of 14,914ou_E/s

There is a buffer or storage tank on the STW part of the Works site which holds separated liquor or centrate from the sludge centrifuge plant. This tank is covered and headspace air is extracted to a "Peacemaker" odour abatement filter, that is a dry scrubbing system.

Both odour (72,921 & 48,316ou_E/m^3) and hydrogen sulphide concentrations (8.8 & 13ppm) were high at the time that the odour samples were collected on 20 September, and suggest poor control of emissions at that time. Spot measurements with the Jerome meter at other times suggested that this poor performance might not be typical. At 11:05 on 21 September H_2S concentrations on the inlet and outlet to the Peacemaker were 37.5 and 0.94ppm, and at 15:55 the outlet concentration was 0.31ppm. These results suggest that the Peacemaker unit is not particularly effective at dealing with peak odour loading.

The "existing" modelling scenario was based on the measured emission rate of 14,914ou_E/s. For the "abated" scenario it was assumed that treated air could be restricted to odour concentrations not exceeding 5,000ou_E/m^3, a reasonably conservative target for effective abatement plant, with emissions consequently down to 1,256ou_E/s. Performance improvements from the Peacemaker might be affected by replacement of the existing media, if it is expended, or possibly by supplementing the existing unit with the addition of a larger volume of scrubbing media to help it deal with peak loads.

4.3.6 STC Picket Fence Thickener Tanks – Estimated Fugitive Emissions 10,069ou_E/s

It was observed during the initial site visit that there appeared to be some fugitive leaks down wind of these tanks. There are some obvious opportunities for odour leakage, especially around the mixer shafts in the centre of the covers. High odour concentrations in the tank headspaces were measured (geometric mean concentration of 39,239ou_E/m^3), demonstrating that any leakage has the potential to generate significant emissions. An estimated air exchange rate or leakage of one air change an hour would generate total emissions of 30,207ou_E/s (from all three tanks).

It would be reasonable to halve this emission rate by better sealing of the tanks, and such an assumption has been included in the modelled "abated" scenario. It is important that adequate pressure relief protection is provided, if the tank sealing is improved, to protect the tanks from negative pressure implosion damage.

4.3.7 Sludge Cake Container Skips – Estimated Emissions 3,221ou$_E$/s

Sludge cake is rotationally "pumped" into one of a series of covered roll-on, roll-off type skip containers. As a consequence, extremely odorous air (geometric mean concentration of 2,614,527ou$_E$/m^3) is displaced from the container headspace. Despite these high odour concentrations the emission rate is calculated to be relatively low, because of the low cake loading/filling rate.

Odour emission could be reduced by use of the odour extraction system that was originally included in the container installation. The resulting improvements would be of little significance to overall odour emissions from the site, but would help demonstrate some commitment to odour control and that "Best Practicable Means" are being used to control emissions. No improvement has been assumed in the "abated" scenario dispersion model.

4.3.8 Sludge Cake Conveyor Well – Estimated Emissions 5,000ou$_E$/s

The sludge centrifuging equipment is well enclosed within a trailer unit. Freshly processed sludge cake is removed from the trailer unit through an enclosed conveyor and then drops into another conveyor hopper in an open well area. An odour sample was collected in this area and it had a high odour concentration (27,224ou$_E$/m^3). Odour emissions where estimated at about 5,000ou$_E$/s by taking account of the area of emitting sludge and a typical wind speed. Enclosing this area could reduce emissions, but there are higher priorities. No reduction was assumed in the modelled "abated" scenario.

4.3.9 STC "Peacemaker" Odour Control Stack – Emissions of 75,410ou$_E$/s

Odour emissions from this source are very high, as a result of very high treated air odour concentrations (geometric mean 27,224ou$_E$/m^3) measured in the treated air off the Peacemaker and the high ventilation rate. The high H_2S concentrations in treated air 35ppm suggest that the Peacemaker was not achieving effective reductions in concentrations of odorous compounds, especially when compared with concentrations in air extracted from the Picket Fence Thickener tanks (about 38ppm) which form part of the air stream treated by this unit. Emissions are about a third of the total for the Works, although off-site impact may be less than say the primary tanks because of the elevated release height, and the greater distance to receptors on Stambridge Road.

These results suggest either that the Peacemaker media was exhausted, or that the residence time is inadequate. The high H_2S loading on to the Peacemaker seen during this assessment will accelerate scrubbing media consumption. If this system is to be retained, then consideration should be given to some form of pre-conditioning of air, such as the use of a catalytic iron treatment to help reduce the media loading with H_2S.

With effective treatment the treated air off such a unit could be expected to have an odour concentration no higher than 5,000ou_E/m^3, and that would reduce the emission rate to around 13,850m^3. This emission rate has been used in the “abated” scenario modelling.

5. DISPERSION MODELLING

5.1 Emission Rates

Two dispersion model runs have been undertaken. The **Existing Scenario** modelled in Run 1 represents the dispersed impact of all significant measured and estimated odour emission rates for the existing works, as set out in Table 5 below.

The **Abated Scenario** modelled in Run 2 demonstrates the effect of improving performance of various aspects of the Work as discussed above.

Table 5 - Emission Rates Inputs in Model Runs 1 and 2

Odour Source	Measured Odour Concs. (ou_E/m^3)		Emissions Rate(ou_E/s)	
	Measured	Geo. Mean	Run 1 EXISTING	Run 2 ABATED
Inlet Works	4,867	4,867	16,750	16,750
Primary Settlement Tanks	6,057 6,439 3,830	5,306	78,983	24,000
Aeration Lanes	762 905 993	881	9,157	5,025
Final Settlement Tanks		Estimated	960	960
Filtrate/STW Tank Peacemaker	72,921 48,316 59,357	59,357	14,914	1,256
Three Sludge PFT Tanks (SPC)	26,650 52,457 43,217	39,239	30,207	15,103
Large (SPC) Peacemaker	31,969 23,682 26,650	27,224	75,410	13,850
SPC Sludge Cake Container Vents	2,516,348 2,831,717 2,508,180	2,614,527	3,221	3,221
SPC Sludge Cake Conveyor Well	17,606 6,338	10,563	5,000	5,000
		Totals	234,602	85,165

5.2 Odour/Impact Exposure Standards

Environmental exposure to gaseous contaminants is, by widespread current convention, expressed as a 98th percentile frequency concentration. Exposure to specific contaminant is expressed as a concentration which is not exceeded for more than 2% of all time.
Most consultants involved in sewage treatment odours have used a benchmark of 5ou_E/m^3 at the 98th percentile for the last few years, following a precedent set at Public Inquiry in the 1990s (the Newbiggin STW case). It has generally been found that there are few odour complaints at exposures of 5ou_E/m^3, and in some cases odour complaints do not occur until exposure approaches 10 or 15ou_E/m^3 at the 98th percentile.

The output of the dispersion modelling reported here is all based on 98th percentile frequency.

5.3 Choice of Odour Dispersion Model

Pollutant emissions from stacks are subject to a highly turbulent wind profile in the wake of buildings. In view of this complexity (and also availability of suitable weather records – see below) the ISC-PRIME dispersion model was chosen to predict patterns of dispersion from the site. An outline of the ISC-PRIME model is given in Appendix 3. The ISC-PRIME model is 'fitted for the purpose of the modelling procedure' as defined by the guidelines published by the Environment Agency and the Royal Met. Society (R Met Soc., 1995).

5.4 Method

The ISC-PRIME model was run for a 5 year sequential meteorological file using wind and weather records from the most suitable meteorological station with long period hourly wind speed and direction records. The Met Office recording site at Shoeburyness, 8 km south east of the works, was selected as being the most representative for the Rochford area with suitable weather records.

A standard Met Office wind rose for the Shoeburyness station is given in Appendix 4. Odour dispersion is influenced by atmospheric stability, as well as wind direction and speed. An outline of the effects of atmospheric stability is given at Appendix 2.

The weather data used in this modelling was supplied directly to the Met Office Rural Environment Team at ADAS as a complete, quality controlled, data set by the Met Office. Five years of data is used to eliminate any short-term variability in weather within individual years.

The odour emission parameters in Table 5 were used in the atmospheric dispersion model. From the calculations made of odour concentration in surrounding areas, each hour over the full five-year period, statistics have been produced of the predicted 98th percentile odour concentrations. That is, the odour concentration which is exceeded for only 2% of all hours (around 14 hours per month). All calculations were performed on a regular grid (50m resolution) surrounding the works and at a height of 1.5 m above local ground level.

5.5 Results of Dispersion Calculations

Drawing STAM/1 shows the 98th percentile odour concentrations in the neighbourhood of the Works for Run 1 (Existing Scenario).

The highest 98th percentile odour concentrations are predicted to lie within the site boundary in the vicinity of the primary settlement tanks where concentrations exceed 75ou_E/m^3. Odour concentrations decrease steadily with increasing distance from the Works. The nearest residential property to the works, at Moat and Springs, is found 250m to the west. At this location the predicted odour concentration is in the region of 15ou_E/m^3. Other properties in the area are to be found further to the west at around 800m distance at the Police House and adjacent properties on Stambridge Road, along Cagefield Road and at a similar distance to the west-south west, and in the area of Ballards Gore to the north west. Odour concentrations at these properties are predicted to be at most 3ou_E/m^3

Odour concentrations are predicted to be somewhat greater in the vicinity of Hampton Barns Cottages and Barton Hall to the south and around Biggins Farm to the north east. Here the predicted values are in excess of 5 ou_E/m^3, and in the case of Biggins Farm in excess of 10ou_E/m^3.

The model output for the existing scenario is quite consistent with the off site observations made on 30 September when intermittent, but distinctive, raw sewage odours where detected at properties on Stambridge Road. The implications from the modelling and the off-site monitoring are that the Works, as assessed in September 2004, has the potential to cause loss of residential amenity at receptor properties in the immediate area.

Computer model dispersion Run 2 (Drawing STAM/2) was similarly constructed but with reduced odour emissions to reflect the level of mitigation and lower emissions from the primary tanks and the activated sludge process, together with reduced emissions from both Peacemeaker units. At all surrounding properties the level of odour exposure is predicted to fall by at least 50%. The highest concentrations are still in the area of the nearest property to the west at Moat and Springs (now $6ou_E/m^3$) while around Biggins Farm the concentrations fall from $8ou_E/m^3$ to $3ou_E/m^3$. At all other properties the predicted odour concentration falls to below $1.5ou_E/m^3$.

6. CONCLUSIONS

The following conclusions are offered:

1. Measured odour emissions from the primary settlement tanks were exceptionally high, and appeared to be caused by infrequent and/or incomplete de-sludging, as evidenced by gassing/bubbling, some sludge inversion and elevated H_2S emissions.

2. Measured odour emissions from the activated sludge plant were also very high, possibly as a result of carry-over of odorous compounds in sewage from the primary tanks.

3. High odour concentrations were measured in air off the two “Peacemaker” odour control units at the site. The large unit dealing with the on-site sludge processing plant was particularly ineffective suggesting that the scrubbing media might be exhausted. The smaller unit at the STW end of the works did not seem to cope well with load peaks.

4. The picket fence thickener tanks are not well sealed and the headspace air is very odorous. There is a significant risk of fugitive odour leakage from these tanks and subjective “sniffing” on site suggested that such leakage does occur.

5. Although highly odorous air is displaced by sludge cake loaded into Ro-Ro covered skip containers these emission are not significant because of the low volumes of air displaced.

6. Dispersion modelling, together with off site odour assessments has demonstrated that the works has the potential to at least cause some loss of amenity, if not a nuisance, at residential properties in the area around the Works. The local sewage treatment facilities at the Works (rather than the sludge processing facilities) seem to be the main cause of off site odours, as perceived during the off-site assessments. The on site measurements demonstrated these processes are very odorous.

7. RECOMMENDATIONS

Anglian Water should be encouraged to review the following aspects of the Works operation and management to help demonstrate Best Practicable Mean controls of odour emissions:

1 The frequency and effectiveness of primary settlement de-sludging regimes. More effective procedures should be put in place. Comparative (before and after) odour or H_2S measurements should be undertaken to assess the effectiveness of improvements in reducing emissions.

2 The effectiveness of the sludge treatment centre Peacemaker should be reviewed and appropriate improvements put in place to reduce emissions. Consideration should be given to some form of pre-treatment to reduce the very high hydrogen sulphide loading, and more thorough routine monitoring procedures should be put in place. Objective odour or H_2S measurements should be undertaken to assess the effectiveness of improvements in reducing emissions.

3 The effectiveness of the sludge treatment centre Peacemaker should be reviewed and appropriate improvements put in place to reduce emissions if necessary.

4 Better sealing of the Picket Fence Thickener tanks to reduce fugitive odour loss.

5 Site, boundary and off site mapping of hydrogen sulphide concentrations in the summer or late spring, after appropriate improvements have been made to the works, to demonstrate the effectiveness of these measures.

6 Some covering of the inlet works facilities, although this is not a high priority in comparison to other potential odour sources at the Works.

References

1. Carney PG and Dodd VA (1989) A comparison between predicted and measured values for the dispersion of malodours from slurry. J Agric Eng Res. Vol 44, pages 67-76.
2. Olesen, H.R. (1997) Pilot Study: Extension of the Model Validation Kit. Int. J. Environment and Pollution, Vol. 8, Nos 3-6, pp 378-387.
3. Royal Met. Soc., 1995. Atmospheric dispersion modelling: guidelines on the justification of choice and use of models, and the communication and reporting of results. Meteor Appl. 2, pp 83-88.

APPENDIX 1 - SAMPLING DATA

Sampling Location	Sampling Times	Sample Identities	Odour Concentrations - ou_E/m^3 (Hydrogen Sulphide ppm)			Me
Primary Settlement Tanks on 20/09/04	12:17 to 12:34	A1, A2, 13	6,057 (2.50)	6,439 (3.63)	3,830 (2.50)	**5,3 (2.8**
STW Peacemaker Stack on 20/09/04	13:11 to 13:21	B1, B2	72,921 (8.8)	48,316 (13.0)		**59, (10**
Aeration Lanes (ASP) on 20/09/04	14:40 to 15:05	C1, C2, C3	762 (0)	905 (0)	993 (0)	**88 (0**
STW Inlet Works on 21/09/04	10:34 t0 10:42	D1	4,867 (0.69)			**4,8 (0.**
RoRo Sludge Cake Skip Air on 21/09/04	11:39 to 13:06	E1, E2, E3	2,516,348 (N/R)	2,831,717 (N/R)	2,508,180 (N/R)	**2,614 (N**
Large Peacemaker Outlet Air 21/09/04	13:23 to 13:43	F1, F2, F3	31,969 (33)	23,682 (36)	26,650 (37)	**27, (3**
Picket Fence Thickn. Headspace 21/09/04	13:53 to 14:13	G1, G2, G3	26,650 (47.5)	52,457 (36.5)	43,217 (31.0)	**39, (38**
Sludge Cake Hopper 14:28 to 14:33		H1	30,088 (29)			**30,**
STW Peacemaker Inlet Air 14:53-14:58		J1	28,317 (N/R)			**28,**

*Mean odour concentrations calculated as geometric means.

APPENDIX 2

The Effect of Atmospheric Stability on the Dispersion of Odour Plumes

When the atmosphere is said to be "stable" there is little turbulence and vertical movement of air. Hence odours released at ground level will not dissipate quickly (mainly in the horizontal) and plumes will maintain relatively high surface concentrations as they meander downwind. These conditions are exclusively confined to the hours between sunset and sunrise and require light winds and little turbulence causing vertical movement of air.

Over the whole year stable conditions account for around 17% of all hours, but this varies from around 14% in the spring to 21% in the late summer.

"Unstable" atmospheric conditions are confined to the daytime when, primarily due to surface heating, there is considerable vertical air movement, thus dissipating odour plumes in both the horizontal and vertical. Hence odour concentrations near ground level will decrease rapidly away from the source. Unstable conditions are most frequent under strong to moderate sunshine levels and are biased towards light wind conditions.

Over the whole year unstable conditions account for around 25% of all hours, but this varies from around 9% in the winter to 43% in mid summer.

There is a third category called "neutral" stability which is by far the most frequent. Neutral stability occurs by day when the weather is cloudy and wind speeds rise to 5 m/s or more. By night, partly cloudy or cloudy weather again leads to neutral conditions even when wind speeds are lower. Odour plume concentrations under neutral conditions disperse quite quickly with stronger wind speeds, but will maintain higher near surface concentrations with low wind speeds.

APPENDIX 3

The Gaussian Atmospheric Dispersion Model - ISC-PRIME

The dispersion model chosen for this analysis is one which is used in air quality regulation studies for the US Environmental Protection Agency. Called "ISC-PRIME" (Industrial Source Complex Model), the model calculates down wind pollutant concentrations in the surrounding area each hour of the day and night, each hour at a time.

A grid referencing system within the computer model allows both the location of the sources and receptors to be specified to within 1m resolution. The model also incorporates the effects of the building itself on the plume, better known as building downwash. This is achieved through the application of a sister program called BPIP.

The model requires detailed meteorological records. To obtain reliable statistics, hourly weather records of wind speed, direction, air temperature and atmospheric stability from a Met Office recording station are used over a period of several years. Statistics on the frequency and concentration of pollutant at the receptor sites are based upon the hourly calculations.

The models are not good at predicting a concentration for any particular event and can be a factor of 2 in error. This is because the pollutant plume is often narrow and a 5° difference in the wind direction can often give erroneous results.

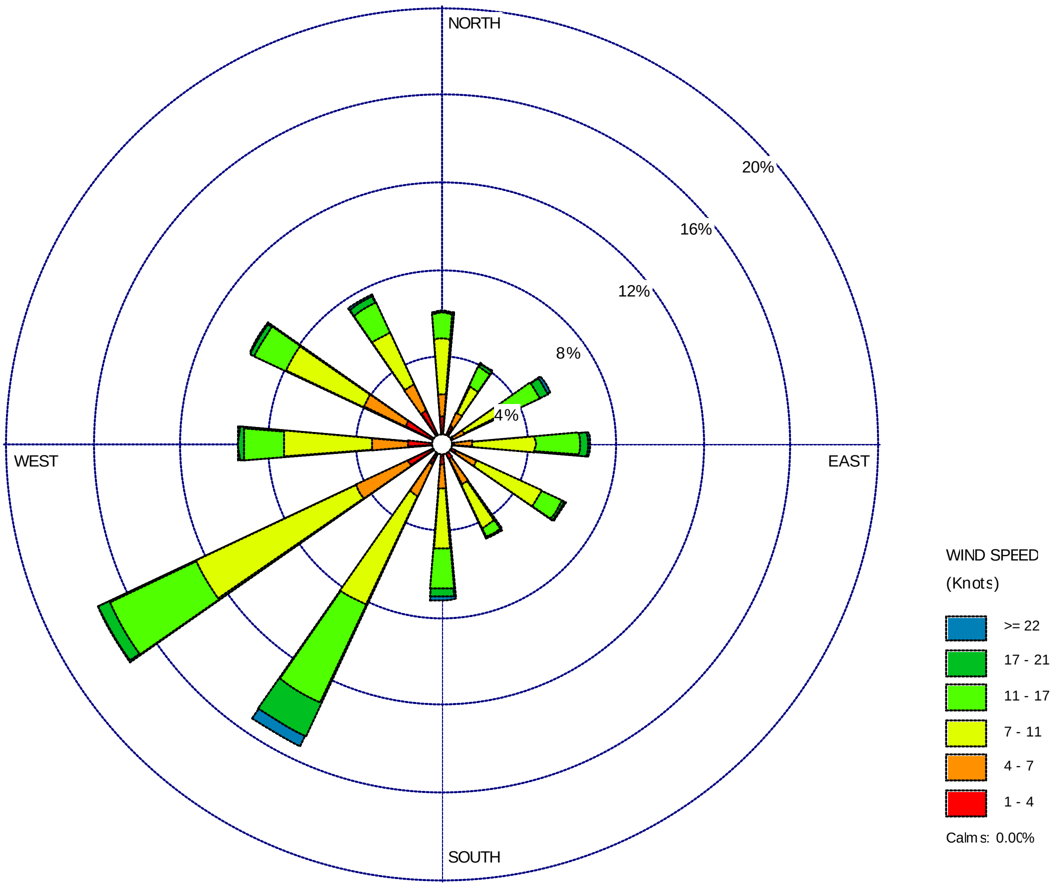
Alternatively one can consider a large sample of measured data and compare with the corresponding modelled data. Again the direct correlation between each measured and modelled event could be in error by a factor of 2. A more accurate assessment is possible if both the measured and modelled samples are treated as statistical distributions.

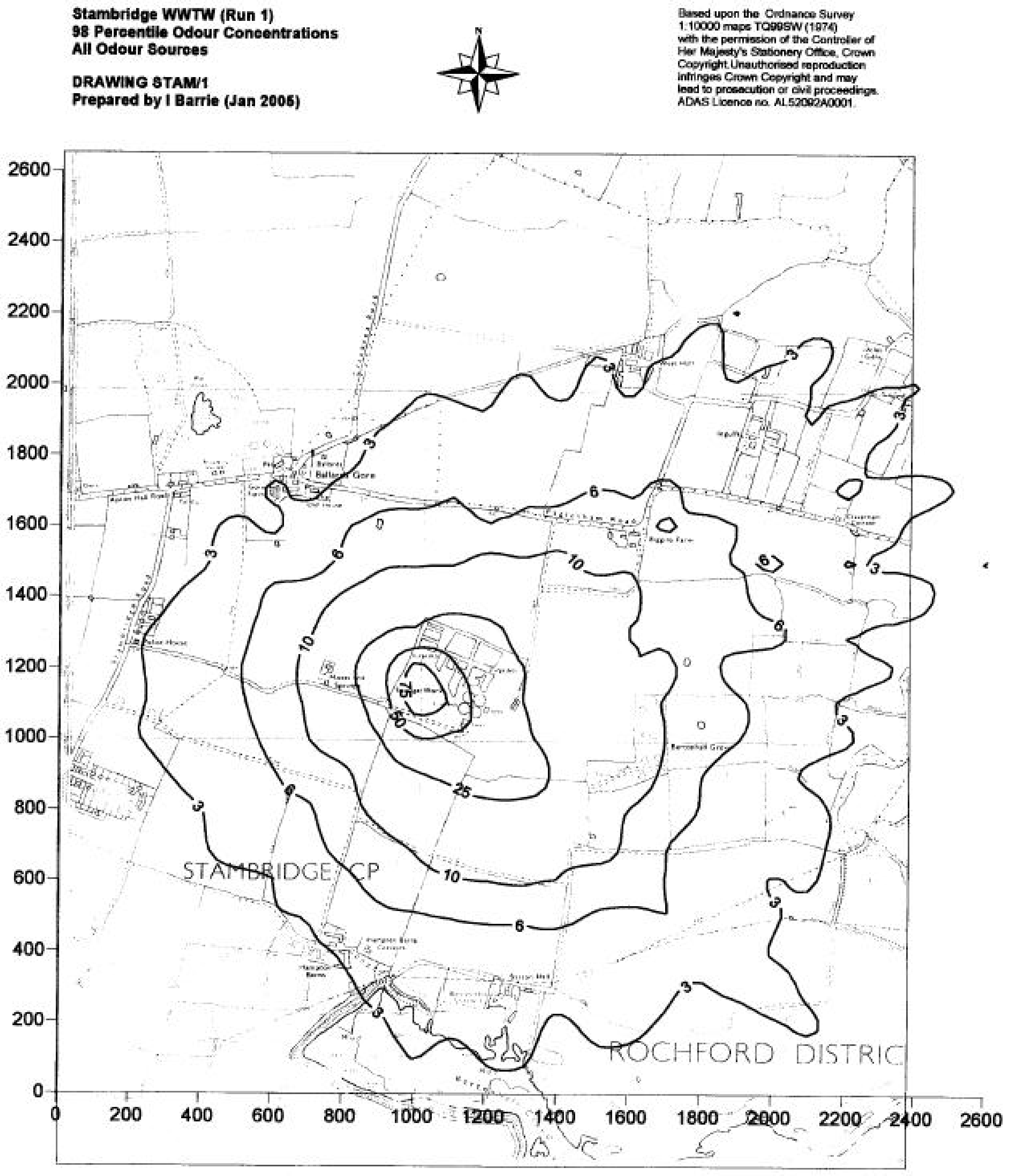
If the lowest measured concentration is plotted against the lowest modelled concentration and the second lowest concentrations are plotted against each other and so on then a much greater degree of correlation is achieved. The resultant plot is termed a quantile-quantile plot. This procedure is outlined in a paper by H.R. Olesen.

This improvement in accuracy is evident when the ISC-PRIME model is run on 5 years of hourly meteorological data, i.e. 43,800 hours. The aim is to provide a long and representative sample of the wind climatology of the area so that a full range of conditions is accounted for. A large sample of modelled values is therefore derived which can be treated as described above.

APPENDIX 4

Shoeburyness Wind Rose from Meteorological Input File




Stambridge WWTW (Run 1)
98 Percentile Odour Concentrations
All Odour Sources
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Prepared by I Barrie (Jan 2005)
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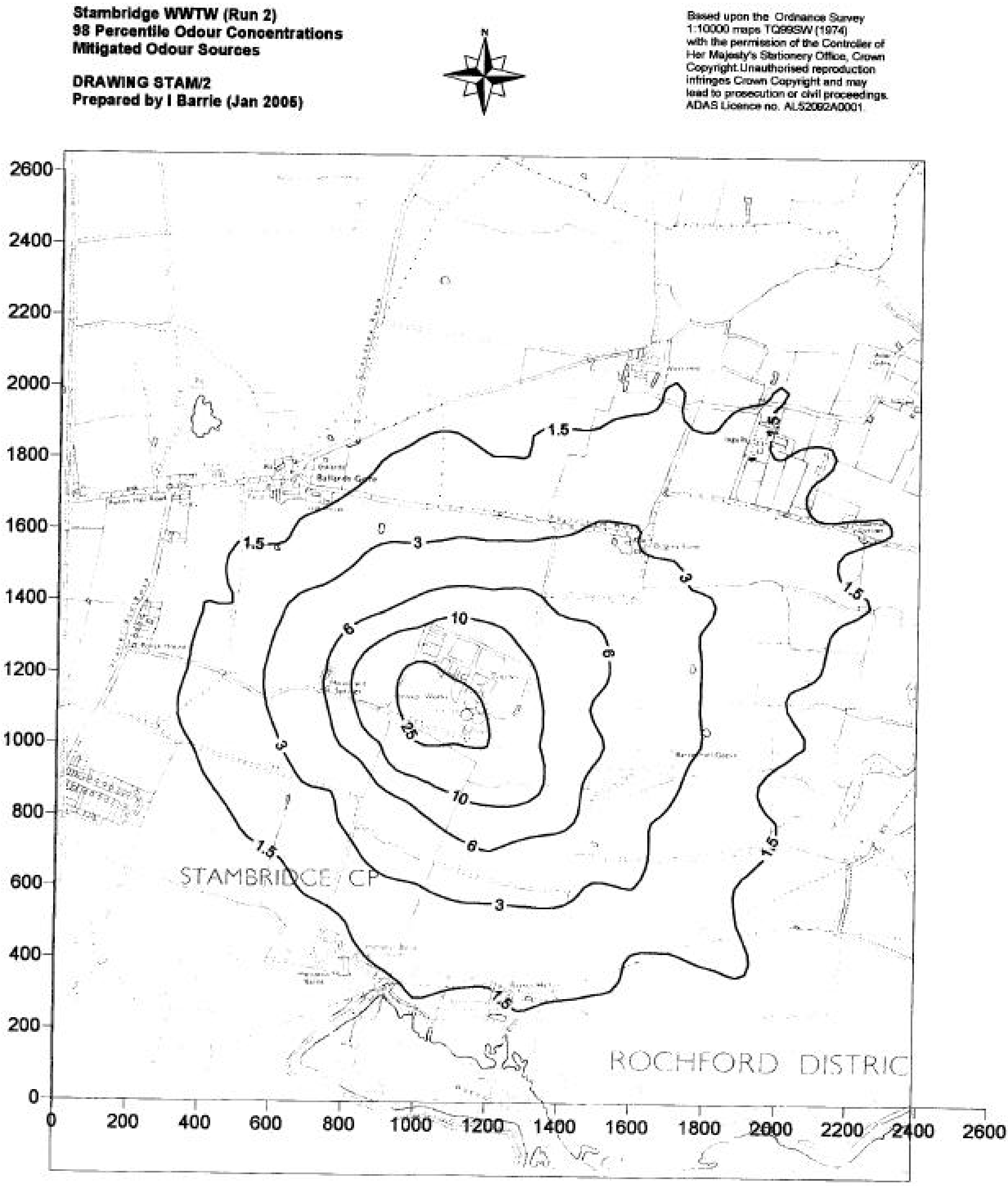
Stambridge WWTW (Run 2)
98 Percentile Odour Concentrations
Mitigated Odour Sources
DRAWING STAM/2
Prepared by I Barrie (Jan 2005)
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