Nenthead Mine Water Treatment Scheme

Outline Design Assessment
Odour Dispersion Modelling Report

The Coal Authority

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Table of Contents

Figures

Tables

1. Introduction

Overview

1.1 This dispersion modelling assessment has been prepared at the request of the Coal Authority (TCA) to evaluate the potential odour impact of the proposed mine water treatment scheme (MWTS) at Nenthead, UK. The use of biological material within the MWTS design means that it is possible for odours to be emitted during the commissioning and normal operation of the treatment system. Such odours could lead to perceptible odour impacts at off-site locations in the absence of appropriate control measures. In particular, experience from prototype Compost Treatment Pond (CTP) schemes indicates that hydrogen sulphide (H2S), to which the human nose is particularly sensitive, can be emitted from the water following treatment within the CTP.

1.2 At Nenthead MWTS odour emissions are likely to be one of the main constraints with regards to planning permission for the MWTS. The potential for H_2S generation through the scheme has been considered within an addendum to the TN (07) document[1] and these figures have been used as inputs to the odour dispersion model.

1.3 At this present time, the outline design of the Nenthead scheme is approaching completion and current odour modelling data has not been fed into the outline design plans for the treatment system. It is expected that any potential changes to the scheme design that follow the current odour modelling will occur after AECOM have submitted the outline design. The odour model used is therefore a further development of the model used in the preparation of the Environmental Statement for the Nent Haggs scheme.

1.4 This assessment considers emissions from the process during commission / early operation and under normal operation of the CTP system, with operational mitigation to remove H_2S from the treated mine water. At the current time, the mitigation proposed for the scheme is a hydrogen peroxide (H_2O_2) dosing system. Odour concentrations have been predicted as the 98th percentile of annual hourly mean values, to enable a comparison with guideline values to assess potential effects on amenity to be made.

Scope

1.5 Three emission scenarios have been evaluated in the assessment, based on information provided, based on the work carried out to produce the TN (07) Addendum.

1.6 The scenarios adopt the following source terms:

- an ‘early operation’ scenario, based on a conservative assumption of the proportion of the excess sulphate in the feed water which would be reduced by the system and then go on to form H_2S. This case assumes a flow rate through the system of 5 litres/second and a H_2S concentration in the water of 1.35 mg/l, prior to dosing.
- A ‘worst-case operation’ scenario, based on an upper range estimate of the level of sulphate to H_2S conversion in the system. This scenario assumes a flow rate through the system of between 10 and 20 litres/second and a H_2S concentration in the water of 1.27 mg/l, prior to dosing.
- A ‘typical normal operation’ scenario, based on the likely level of sulphate to H_2S conversion in the system. This scenario assumes a flow rate through the system of between 10 and 20 litres/second and a H_2S concentration in the water of 0.48 mg/l, prior to dosing.

1.7 Observations and monitoring carried out at the Force Crag pilot project site have indicated that the H_2S emissions are liberated from the water at locations downstream of the treatment ponds where there is turbulence in the water flow. At Force Crag, H_2S odours are most noticeable in the immediate vicinity of the flow control chambers and at the inlet to the wetland where there is turbulent flow. A number of design options are under consideration for the Nent Haggs and Nenthead scheme to attenuate emissions from

[1] AECOM (2021) Addendum to TN07 – Hydrogen Sulphide Odour Generation Assessment for Nenthead Mine Water Treatment Scheme

key points, such as slatted / solid covers on the flow control chamber grids and carbon filtration. For this assessment, however, it is assumed that the residual H_2S in the water after dosing would be released to atmosphere at some point during the treated water's passage through the system.

2. Assessment Criteria

2.1 There is no statutory guidance on the method by which an odour impact assessment should be undertaken. For this assessment, a methodology has been used based on techniques set out within IAQM guidance on the assessment of odour for planning[2].

2.2 The IAQM odour guidance describes the sensitivity of receptors to odours:

- A highly sensitive receptor is one where users can reasonably expect enjoyment of a high level of amenity and people would reasonably be expected to be present continuously, such as residential properties
- A medium sensitivity receptor is where users would expect to enjoy a reasonable level of amenity but wouldn't reasonably expect to enjoy the same level of amenity as in their home, or where people wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land.
- A low sensitivity receptor is where the enjoyment of amenity would not reasonably be expected, or there is transient exposure where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. In this study this includes public rights of way such as footpaths and roads.

2.3 Most odours are due to a mixture of substances and the capability of individual people to detect, recognise or reach a judgement as to the character of an odour varies considerably. Therefore, the regulation of emissions of odorous substances from industrial and agricultural installations in the United Kingdom is based not on the concentration (i.e. mass of odorous substances per unit volume of air) of the odour, but on the idea of Odour Units as determined by a technique called dynamic dilution olfactometry.

2.4 An odour unit is defined as 1 OU_E (European Odour Unit), where 1 OU_E/m^3 is the threshold of detection, i.e. the concentration at which half of the population can just detect the odour. The basic principle is that a sample of odorous air is collected and diluted, before a panel of people sniff the air. The panel sniff the same sample at a series of progressively smaller dilutions until 50% of the panel can detect its presence. This is the threshold of detection for the odour and is equivalent to 1 odour unit (OU).

2.5 As an odour becomes more intense our perception of it changes, such that for most people:

- 1 OU is the threshold of detection;
- 3 OU is the point at which an odour could be recognised;
- 5 OU is the point at which an odour might be noticeable; and
- 10 OU is a distinct smell which may be intrusive.

2.6 If an odorous substance is diluted into 1 m^3 of odourless air at standard conditions such that it has the same odour strength as 1 OU, then this can be expressed as 1 OU_E/m^3.

2.7 Some odour events only last a few seconds, but if they frequently reoccur or are perceived to be particularly offensive the experience may cause annoyance. Dispersion models and most monitoring techniques are not readily or reliably able to predict concentrations with an averaging period of less than one hour. In the case of odour modelling this is partly because the meteorological data used in regulatory models is hourly average data and partly due to assumptions made about dispersion by the models.

2.8 The 98th percentile of hourly mean concentrations represents an odour level that would be achieved 98% of the time, which equates to 8,584 hours out of 8,760 hours in a non-leap year. Using the 98th percentile of hourly values as the assessment criteria gives a more representative account of the fluctuating and often transient nature of odour events than can be obtained from using either the maximum or annual mean value and is the approach adopted to regulate the risk of odour impacts within the UK.

2.9 The ADMS model has been used to simulate the dispersion of odour emissions from the treatment site. The model output is given as a 98th percentile of hourly values for a calendar year. The IAQM odour

[2] IAQM (2018) Guidance on the assessment of odour for planning, Version 1.1, July 2018

guidance proposes odour effect descriptors for impacts predicted by modelling, which has been used as the basis for the assessment of effect significance in this study.

2.10 The model output at each receptor location is compared against the sensitivity of that receptor to establish the potential odour effect there, as set out in Table 1. It has been assumed in deriving the criteria within the table that the odour in question is at the offensive end of the spectrum, which is consistent with the classification of odours containing H_2S within Environment Agency guidance.

Table 1. Matrix to Assess Odour Effect at Individual Receptor Locations

Odour Exposure Level C_{98}, OU_E/m^3	Low Sensitivity Receptor	Medium Sensitivity Receptor	High Sensitivity Receptor
>10	Moderate	Major	Major
5 - 10	Moderate	Moderate	Major
3 - 5	Minor	Moderate	Moderate
1.5 - 3	Negligible	Minor	Moderate
0.5 – 1.5	Negligible	Negligible	Minor
<0.5	Negligible	Negligible	Negligible

The IAQM labels of 'Substantial' and 'Slight' are replaced with 'Major' and 'Minor' respectively, for consistency with the Haggs Environmental Statement

2.11 If the overall effect is described as moderate or major, the effect is considered to be significant. This does not mean that the development proposal is unacceptable, rather it is an indication that careful consideration should be given to the consequences of the emissions, the scope for mitigation, and the balance of other benefits the proposal would bring.

2.12 Where the overall effect is judged to minor adverse or negligible, this would be considered to be not significant.

3. Assessment Methodology

Odour Sensitive Receptors

3.1 A number of odour sensitive receptors have been identified and these are shown on Figure 1. They are also listed in Table 2, below. The locations chosen include residential properties and other points in close proximity to the site boundary (where people could be expected to be present for significant periods of time). These receptors have been selected as being representative of other sensitive receptors in their vicinity.

Table 2. Odour Sensitive Receptors

Receptor	Description	Sensitivity to Odour	Grid Reference (X,Y)	
R1	Hilltop Cottages	High	378423	543423
R2	Mill Cottage	High	378393	543362
R3	Eastern House	High	378388	543589
R4	Thornleigh	High	378448	543616
R5	Granary Cottage	High	378547	543630
R6	Cherry Tree Cottage	High	378325	543633
R7	Heritage Centre	High	378412	543317
R8	Bevan Terrace	High	377901	543529
R9	Nenthead PO	High	378144	543733
R10	Road 1	Low	379142	543371
R11	Road 2	Low	378933	543415
R12	Road 3	Low	378759	543503
R13	Public Right of Way 1	Low	378678	543506
R14	Public Right of Way 2	Low	378651	543426
R15	Public Right of Way 3	Low	378560	543368
R16	Public Right of Way 4	Low	378518	543242
R17	Public Right of Way 5	Low	378631	543123
R18	Public Right of Way 6	Low	378739	543006
R19	Public Right of Way 7	Low	378817	542866
R20	A point midway between the flow control chambers and reed-bed.	Low	378748	543268

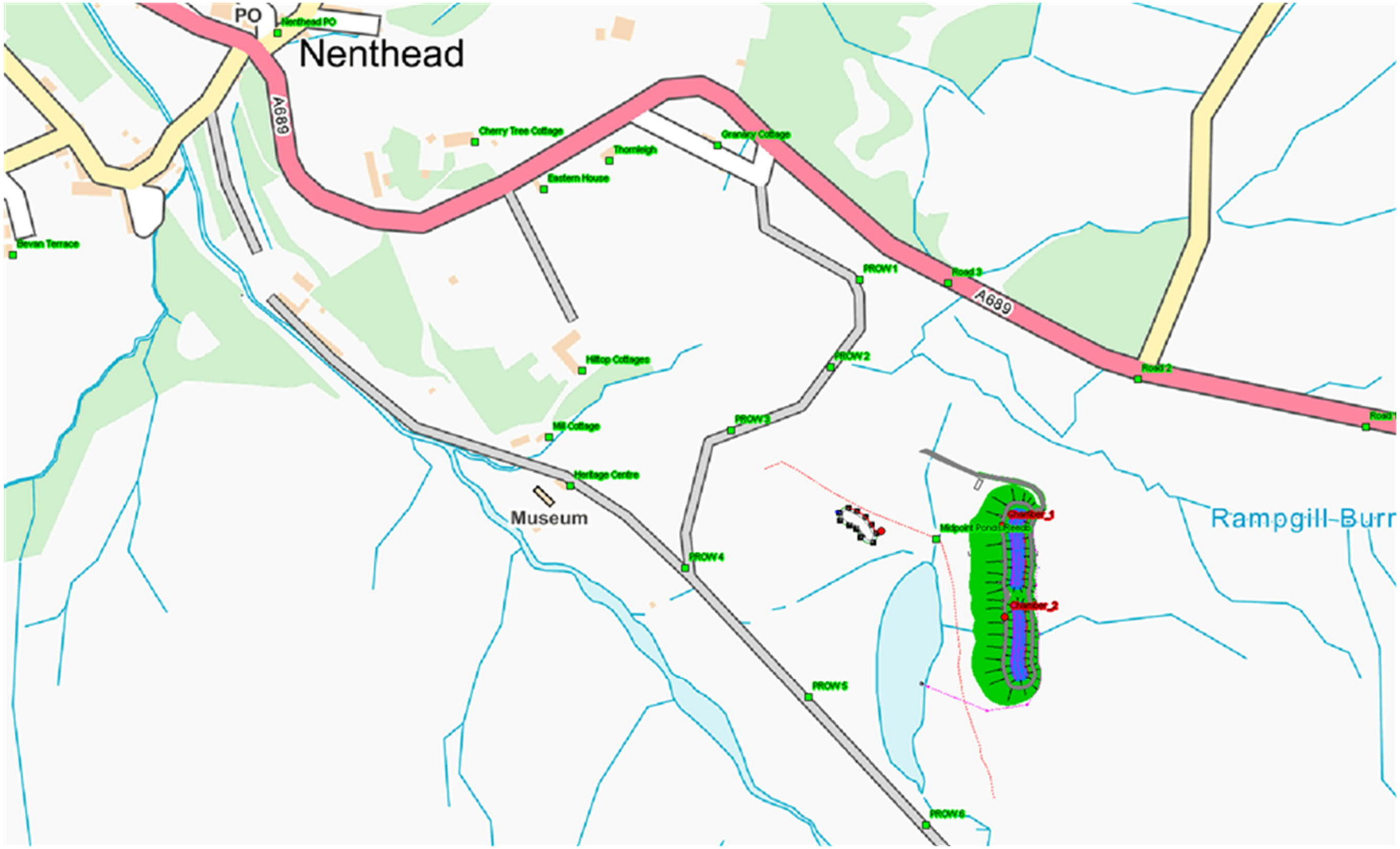


Figure 1. Odour Sensitive Receptors

Dispersion Modelling Methodology

3.2 Odour concentration values have been predicted using the advanced dispersion modelling software ADMS (v5.2.4), supplied by Cambridge Environmental Research Consultants Limited (CERC). ADMS is modern dispersion model that has an extensive published validation history in the UK (CERC, 2017). This model has been extensively used throughout the UK to demonstrate regulatory compliance.

3.3 The general model conditions used in this assessment are summarised in Table 3. Other more detailed data used to model the dispersion of emissions is considered below.

Table 3. ADMS 5 General Model Conditions

Variable	Input
Surface Roughness at Source	0.3 m
Surface Roughness at meteorological site	0.3 m
Receptor Location	x, y co-ordinates, z=1.5m
Source Location	x, y co-ordinates, ground level
Emissions	Emissions in Table 4
Sources	Flow control chamber vents Inlet to reed-bed
Meteorological Data	Five years hourly sequential meteorological data from Warcop Range Meteorological Station (2010-2014)
Terrain Data	Complex terrain
Building Downwash Effects	None considered

Inventory of Odour Emissions

3.4 Emission source terms for the MWTS system have been calculated from information supplied by AECOM in the TN (07) Addendum. Three source terms have been evaluated in the assessment, as follows:

- an 'early operation' scenario, based on a conservative assumption of the proportion of the excess sulphate in the feed water which would be reduced by the system and then go on to form H_2S. This case assumes a flow rate through the system of 5 litres/second and a H_2S concentration in the water of 1.35 mg/l, prior to dosing. Following the dosing and removal of between 50% and 90% of the H_2S, the remainder is assumed to be emitted to atmosphere prior to discharge of the treated water to the River Nent.
- A 'worst-case operation' scenario, based on an upper range estimate of the level of sulphate to H_2S conversion in the system. This scenario assumes a flow rate through the system of between 10 and 20 litres/econd and a H_2S concentration in the water of 1.27 mg/l, prior to dosing. Following dosing, removal of between 90% and 95% of the H_2S is anticipated.
- A 'typical normal operation' scenario, based on the likely level of sulphate to H_2S conversion in the system. This scenario assumes a flow rate through the system of between 10 and 20 litres/second and a H_2S concentration in the water of 0.48 mg/l, prior to dosing. Following dosing, removal of between 90% and 95% of the H_2S is anticipated.

3.5 In calculating the H_2S mass emission rate, the mass of H_2S released has been converted to an odour emission rate (OU_E/m^3), by multiplying the odour threshold value of 0.76 µg/m^3 (which corresponds to 1 OU_E/m^3) by the mass of H_SS which is released by the system.

3.6 The total emission rate for each scenario is then split between different points within the treatment pond system, at points downstream where disturbance of the flow is likely to occur. Based on a consideration of the design, the total emission has been represented as occurring from within the site as follows:

- 25% of the total emission from the vents situated on the lid of each of the two flow control chambers. Although the chamber would be mostly enclosed at this point, there would be a vent to atmosphere in which a H_2S sensor linked to the dosing control system is positioned.
- The remaining 50% of the total emission has been modelled as occurring from the exit of the enclosed channel as it emerges at the entry point to the aerobic reedbed.

3.7 The calculation of the emission split is shown in Table 4.

Table 4. Odour Emission Split for the Modelled Scenarios (Unabated Emissions)

Section of Design	Percentage of Odour Emissions	OU_E/s		
		Scenario 1 (Early Operation)	Scenario 2 (Worst Case Normal Operation)	Scenario 3 (Typical Normal Operation)
Flow Chamber 1 Vent	25	2,220	4,178	1,579
Flow Chamber 2 Vent	25	2,220	4,178	1,579
Channel End at Entry to Reedbed	50	4,441	8,355	3,158
Total	100	8,882	16,711	6,316

3.8 The physical properties of the odour emission sources for each of the two emission scenarios, as represented within the model, are presented in Table 5. Emissions have been assumed to occur at ground level, ambient temperature and with a nominal upwards momentum. The position of the emission sources within the model domain are shown in Figure 2. It should be noted that the position of the reedbed is indicative only as this was not decided at the time of the assessment.

Table 5. Physical Properties, Modelled Sources

Parameter	Unit	Value
Source positions	(NGR) m	Chamber_1: 378809, 543280
		Chamber_2: 378811, 543196
		Channel_3: 378698, 543275
Emission height	m	Chambers: 0.2
		Channels: 0.1
Effective internal diameter	m	Chambers: 0.1
		Channels: 0.5
Exit velocity (all sources)	m/s	0.001 (nominal)
Emission temperature (all sources)	^oC	Ambient

3.9 The model inputs described above have been calculated based on no removal of dissolved H_2S from the treated water by the peroxide dosing system. Based on information gained from dosing trials at the Force Crag pilot project, the dosing system is likely to remove at least 50% of the H_2S from the system in the early operation phase and between 90% and 95% in the normal operation phase. The results presented later in this report have therefore been factored to consider removal efficiencies within this range.

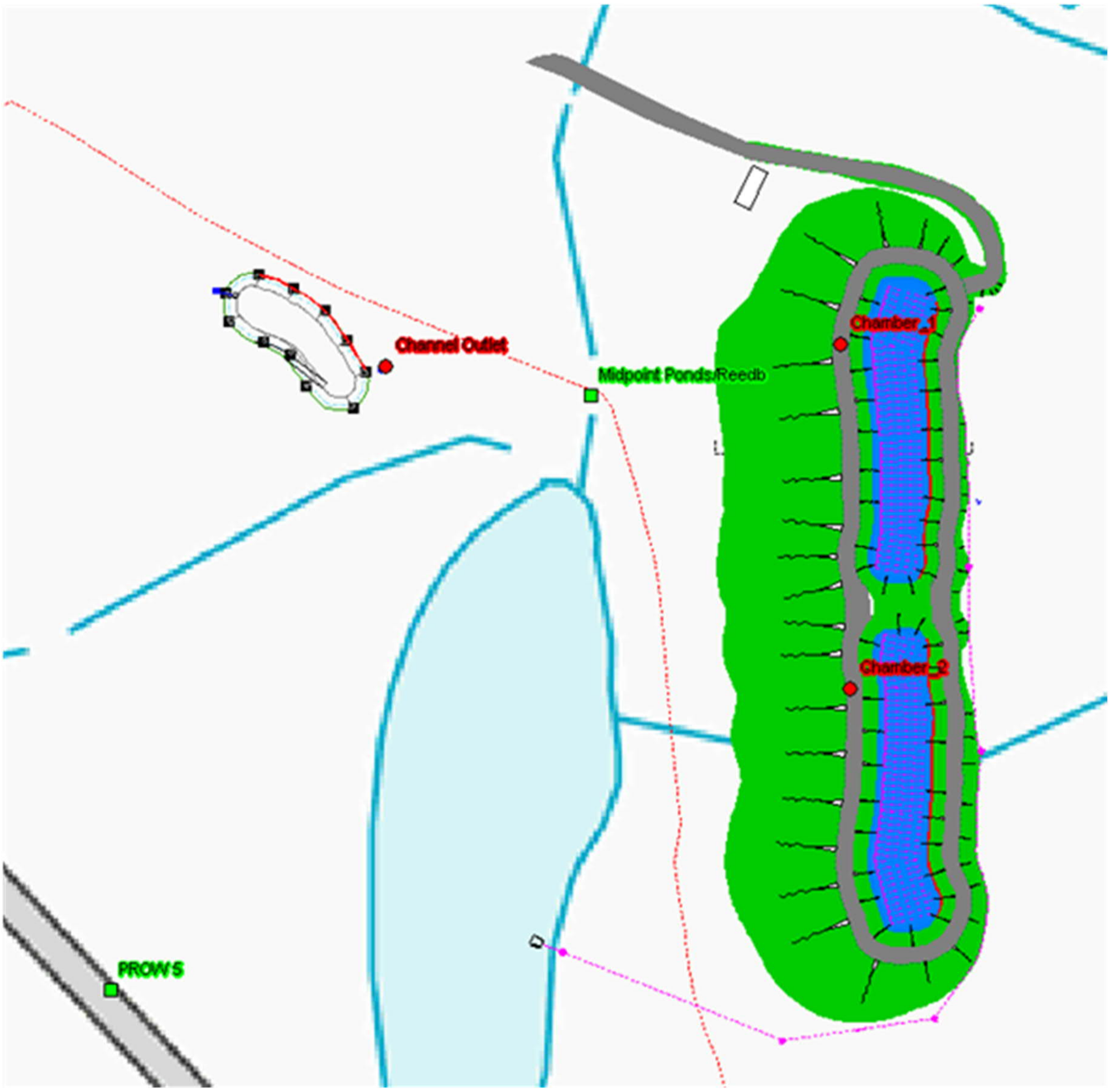


Figure 2. Modelled Source Layout

Meteorological Data

3.10 Five years of hourly sequential meteorological data (2010, 2011, 2012, 2013 and 2014) from Warcop Range Meteorological Station has been used to model the dispersion of odour from the facility across the proposed development site and surrounding area. This meteorological station site is approximately 27 km south of the site and is considered to be representative of the region around the site.

3.11 Figure 3 displays the wind roses of the five meteorological years for Warcop Range used in this assessment. The wind roses show that, as is typical for much of the UK, there is a high incidence of winds blowing from the southwestern sector. In the case of Warcop, there are also a high number of hours in the year when winds blow from the north-western and south-eastern sectors, which could be due to the influence of the terrain as the valley in which the meteorological station is situated runs approximately along this axis. The Scheme is also situated in a valley with a north-west to the south-east orientation and it is considered highly likely that the pattern of distribution observed for Warcop would also be seen within the valley in which the Scheme is situated.

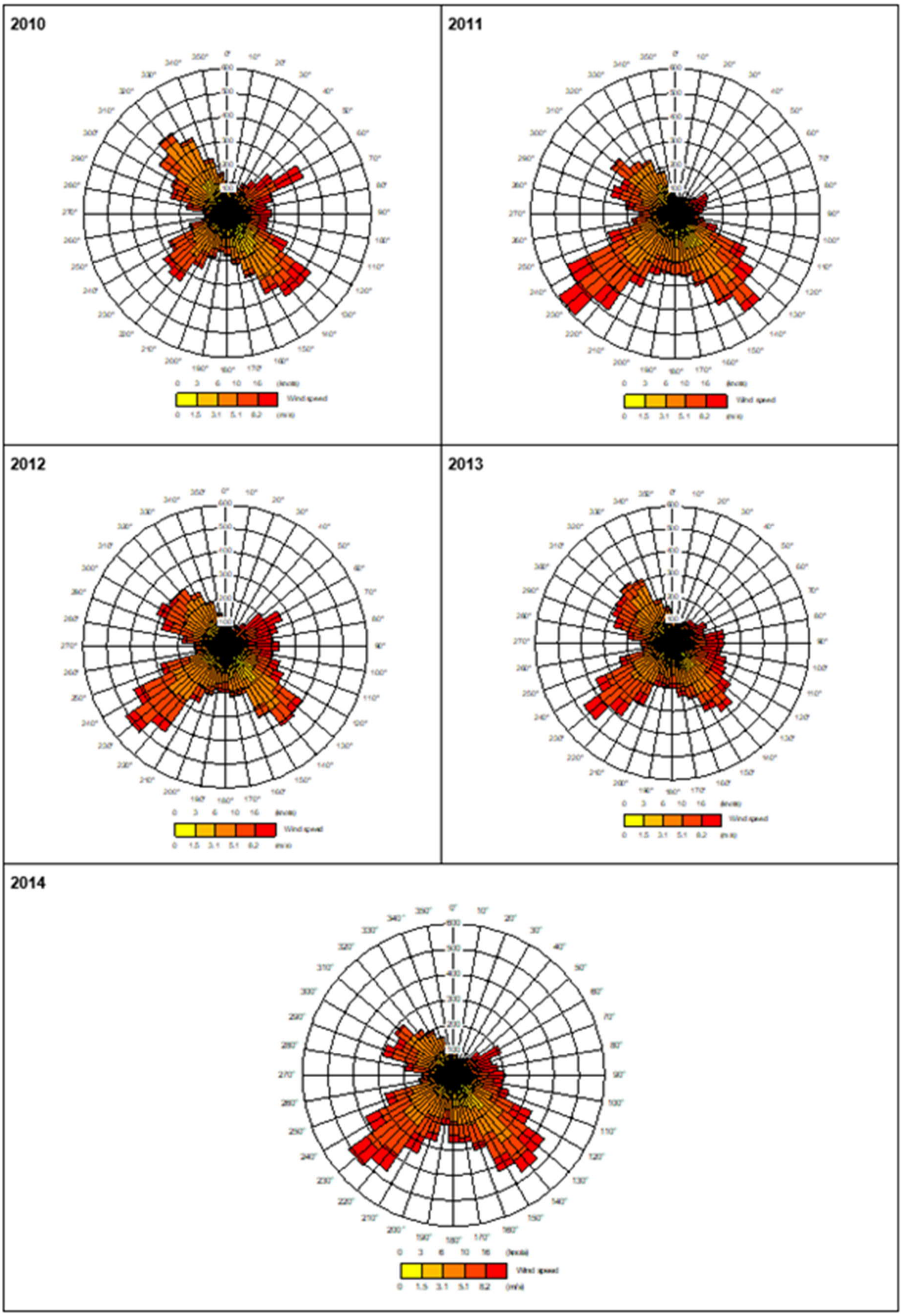


Figure 3. Wind Roses for Warcop Range Meteorological station from 2010 to 2014

Surface Roughness

3.12 A surface roughness of 0.3 m at the dispersion site was used for this assessment. This option is considered representative of the agricultural area around the site. A surface roughness of 0.3 m was also used for the meteorological station site.

Terrain

3.13 The proposed MWTS would be situated at one end of a narrow valley, with sharp changes in gradient and pronounced changes in height. Some of the nearby receptor locations considered by the modelling are situated lower down and within the valley bottom, below the MWTS site. For this reason, a consideration of terrain effects has been included within the modelling assessment.

3.14 A terrain grid was prepared by the AECOM design team, of sufficient detail to capture terrain features which would potentially affect the flow of air within the model domain. The terrain file included the landform proposed for construction upon the main treatment site.

3.15 The model runs within ADMS were undertaken with the high grid resolution (64x64) option selected.

Building Downwash Effects

3.16 The modelled emission sources were assumed to be situated at ground level. It was not therefore necessary to incorporate a consideration of building downwash effects as part of the modelling procedure.

4. Dispersion Modelling Results

4.1 This section presents the results of the dispersion modelling, detailing predicted 98th percentile odour concentrations for each of the modelled scenarios. Analysis of the model output shows that there is a variation in the meteorological dataset for which the maximum modelled impact at each receptor is reported. For this reason, the values reported in the tables below are the maximum value obtained from modelling each of the five years meteorological data.

4.2 In addition to the tabulated results in Appendix A, the results are also represented as a series of isopleth plots showing the distribution of predicted odour impacts across the modelled domain. The highest overall 98th percentile values were predicted for the 2010 meteorological dataset so the plots have been created from that model output.

Scenario 1 – Early Operation (5 l/s)

4.3 Modelling results for emission Scenario 1 are presented in Table 6. The values reported for each receptor in the tables represent predicted odour concentrations for four different odour control system removal efficiencies of 0%, 50%, 90% and 95%. The model inputs assume a H_2S concentration in the effluent, prior to the odour control system, of 1.35 mg/l and a mine water flow rate of 5 litres/second.

4.4 The modelling results in this scenario predict that:

- Without any odour control system in operation, there would be a moderate (significant) effect at three locations including one residential property (Granary Cottage). The highest concentration predicted is at the receptor point midway between the reedbed and MWTS ponds.
- With the dosing system operating at 50% H_2S removal efficiency, the only selected receptor where a moderate (significant) effect is predicted is at the receptor point midway between the reedbed and MWTS ponds.
- With the dosing system operating at 90% or greater removal efficiency, no significant effects are predicted at sensitive receptors.

Scenario 2a – Worst-Case Operation (10 l/s)

4.5 Modelling results for emission Scenario 2 are presented in Table 7. The values reported for each receptor in the tables represent predicted odour concentrations for three different odour control system removal efficiencies of 0%, 90% and 95%, assuming a H_2S concentration in the effluent. The model inputs assume a H_2S concentration in the effluent, prior to the odour control system, of 1.27 mg/l and a mine water flow rate of 10 litres/second.

4.6 The modelling results in this scenario predict that:

- There would be a widespread significant effect without the dosing system in operation. Moderate effects are predicted at a number of residential locations and on public rights of way.
- With the dosing system operating at 90% or greater removal efficiency, however, no significant effects are predicted at sensitive receptors.

Scenario 2b – Worst-Case Operation (20 l/s)

4.7 This scenario assumes the same parameters as Scenario 2a, with the exception that the mine water flow rate is doubled to 20 litres per second. The modelling results for emission Scenario 2b are presented in Table 8.

4.8 The modelling results in this scenario predict that:

- There would be an even more pronounced widespread significant effect without the dosing system in operation. Moderate effects are predicted at almost all residential locations and on public rights of way. At Granary Cottage, a major significant effect is predicted.

- With the dosing system operating at 90% removal efficiency, no significant effects are predicted at sensitive receptors.
- With the dosing system operating at 95% removal efficiency, no significant effects are predicted at sensitive receptors

Scenario 3a – Typical Operation (10 l/s)

4.9 Modelling results for emission Scenario 2a are presented in Table 9. The values reported for each receptor in the tables represent predicted odour concentrations for three different odour control system removal efficiencies of 0%, 90% and 95%, assuming a H_2S concentration in the effluent. The model inputs assume a H_2S concentration in the effluent, prior to the odour control system, of 0.48 mg/l and a mine water flow rate of 10 litres/second.

4.10 The modelling results in this scenario predict that:

- Without the dosing system in operation, there would be a negligible or minor (not significant) effect at all the selected receptor locations, with the exception of the receptor point midway between the reedbed and MWTS ponds.
- With the dosing system operating at 90% or greater removal efficiency, no significant effects are predicted at sensitive receptors.

Scenario 3b - Typical Operation (10 l/s)

4.11 This scenario assumes the same parameters as Scenario 3a, with the exception that the mine water flow rate is doubled to 20 litres per second. The modelling results for emission Scenario 2b are presented in Table 10.

4.12 The modelling results in this scenario predict that:

- Without the dosing system in operation, there would be a number of locations where a moderate (significant) effect is predicted. This includes a number of residential properties.
- With the dosing system operating at 90% or greater removal efficiency, no significant effects are predicted at sensitive receptors.

5. Conclusions and Recommendations

5.1 The dispersion modelling assessment of the current design of the MWTS shows that the H_2O_2 dosing system would be capable of controlling odour emissions from the system to an acceptable level, in overall terms. This includes both residential properties and public rights of way.

5.2 In very close proximity to the ponds and reedbed system, there could still be a residual significant effect in the following circumstances:

- In the early operation scenario, if the dosing system is only capable of 50% removal efficiency;
- In the worst-case operation scenario at a flow rate of 20 l/s, if the dosing system is only capable of 90% removal efficiency.

5.3 In all the modelled scenarios, not using the dosing system predicts a significant effect at residential receptors in the case of both worst case operation scenarios and the high flow rate typical operation scenarios.

5.4 Overall, the modelling assessment shows that it should be possible to bring forward a final design with an acceptable impact on odour sensitive receptors in planning terms.

5.5 It is recommended that the modelling assessment is updated in the event that:

- An updated design is brought forward with a different layout (including the location of the reedbed system.
- Further understanding of the technical operation of the system causes the H_2S emission rate assumptions to be revised.
- The design of the mitigation fitted to the system is revised, including enclosure of emission points to air or the fitment of active filtration systems.
- At the time the Environmental Statement to accompany the planning application is prepared, with more recent meteorological data from either a meteorological station or a source of synoptic data.

Appendix A – Odour Modelling Results

Table 6. Dispersion Modelling Results - Scenario 1, Early Operation

Receptor	Description	Receptor Sensitivity	98th %ile Odour 0% Removal	Significance	98th %ile Odour 50% Removal	Significance	98th %ile Odour 90% Removal	Significance	98th %ile Odour 95% Removal	Significance
R1	Hilltop Cottages	High	1.18	Minor	0.59	Minor	0.12	Negligible	0.06	Negligible
R2	Mill Cottage	High	0.82	Minor	0.41	Negligible	0.08	Negligible	0.04	Negligible
R3	Eastern House	High	1.03	Minor	0.51	Minor	0.10	Negligible	0.05	Negligible
R4	Thornleigh	High	1.28	Minor	0.64	Minor	0.13	Negligible	0.06	Negligible
R5	Granary Cottage	High	**1.67**	**Moderate**	0.83	Minor	0.17	Negligible	0.08	Negligible
R6	Cherry Tree Cottage	High	0.86	Minor	0.43	Negligible	0.09	Negligible	0.04	Negligible
R7	Heritage Centre	High	0.68	Minor	0.34	Negligible	0.07	Negligible	0.03	Negligible
R8	Bevan Terrace	High	0.19	Negligible	0.09	Negligible	0.02	Negligible	0.01	Negligible
R9	Nenthead PO	High	0.60	Minor	0.30	Negligible	0.06	Negligible	0.03	Negligible
R10	Road 1	Low	0.47	Negligible	0.24	Negligible	0.05	Negligible	0.02	Negligible
R11	Road 2	Low	2.10	Negligible	1.05	Negligible	0.21	Negligible	0.10	Negligible
R12	Road 3	Low	3.19	Negligible	1.59	Negligible	0.32	Negligible	0.16	Negligible
R13	PROW 1	Low	3.07	Minor	1.54	Negligible	0.31	Negligible	0.15	Negligible
R14	PROW 2	Low	**5.92**	**Moderate**	2.96	Negligible	0.59	Negligible	0.30	Negligible
R15	PROW 3	Low	4.24	Negligible	2.12	Negligible	0.42	Negligible	0.21	Negligible
R16	PROW 4	Low	1.57	Negligible	0.78	Negligible	0.16	Negligible	0.08	Negligible
R17	PROW 5	Low	4.01	Minor	2.00	Negligible	0.40	Negligible	0.20	Negligible
R18	PROW 6	Low	3.35	Negligible	1.67	Negligible	0.33	Negligible	0.17	Negligible
R19	PROW7	Low	1.68	Negligible	0.84	Negligible	0.17	Negligible	0.08	Negligible
R20	Midpoint Ponds/Reedbed	Low	**16.51**	**Moderate**	**8.25**	**Moderate**	1.65	Negligible	0.83	Negligible

Table 7. Dispersion Modelling Results - Scenario 2a, Worst Case Operation, 10 litres/second

Receptor	Description	Receptor Sensitivity	98th %ile Odour 0% Removal	Significance	98th %ile Odour 90% Removal	Significance	98th %ile Odour 95% Removal	Significance
R1	Hilltop Cottages	High	**2.22**	**Moderate**	0.22	Negligible	0.11	Negligible
R2	Mill Cottage	High	**1.55**	**Moderate**	0.15	Negligible	0.08	Negligible
R3	Eastern House	High	**1.93**	**Moderate**	0.19	Negligible	0.10	Negligible
R4	Thornleigh	High	**2.40**	**Moderate**	0.24	Negligible	0.12	Negligible
R5	Granary Cottage	High	**3.14**	**Moderate**	0.31	Negligible	0.16	Negligible
R6	Cherry Tree Cottage	High	**1.62**	**Moderate**	0.16	Negligible	0.08	Negligible
R7	Heritage Centre	High	1.28	Minor	0.13	Negligible	0.06	Negligible
R8	Bevan Terrace	High	0.36	Negligible	0.04	Negligible	0.02	Negligible
R9	Nenthead PO	High	1.13	Minor	0.11	Negligible	0.06	Negligible
R10	Road 1	Low	0.89	Negligible	0.09	Negligible	0.04	Negligible
R11	Road 2	Low	3.95	Minor	0.39	Negligible	0.20	Negligible
R12	Road 3	Low	**6.00**	**Moderate**	0.60	Negligible	0.30	Negligible
R13	PROW 1	Low	**5.78**	**Moderate**	0.58	Negligible	0.29	Negligible
R14	PROW 2	Low	**11.13**	**Moderate**	1.11	Negligible	0.56	Negligible
R15	PROW 3	Low	**7.97**	**Moderate**	0.80	Negligible	0.40	Negligible
R16	PROW 4	Low	**2.95**	**Negligible**	0.29	Negligible	0.15	Negligible
R17	PROW 5	Low	**7.54**	**Moderate**	0.75	Negligible	0.38	Negligible
R18	PROW 6	Low	**6.29**	**Moderate**	0.63	Negligible	0.31	Negligible
R19	PROW7	Low	3.17	Minor	0.32	Negligible	0.16	Negligible
R20	Midpoint Ponds/Reedbed	Low	**31.07**	**Moderate**	3.11	Minor	1.55	Minor

Table 8. Dispersion Modelling Results - Scenario 2b, Worst Case Operation, 20 litres/second

Receptor	Description	Receptor Sensitivity	98th %ile Odour 0% Removal	Significance	98th %ile Odour 90% Removal	Significance	98th %ile Odour 95% Removal	Significance
R1	Hilltop Cottages	High	**4.43**	**Moderate**	0.44	Negligible	0.22	Negligible
R2	Mill Cottage	High	**3.09**	**Moderate**	0.31	Negligible	0.15	Negligible
R3	Eastern House	High	**3.86**	**Moderate**	0.39	Negligible	0.19	Negligible
R4	Thornleigh	High	**4.80**	**Moderate**	0.48	Negligible	0.24	Negligible
R5	Granary Cottage	High	**6.27**	**Major**	0.63	Minor	0.31	Negligible
R6	Cherry Tree Cottage	High	**3.25**	**Moderate**	0.32	Negligible	0.16	Negligible
R7	Heritage Centre	High	**2.56**	**Moderate**	0.26	Negligible	0.13	Negligible
R8	Bevan Terrace	High	0.71	Minor	0.07	Negligible	0.04	Negligible
R9	Nenthead PO	High	**2.27**	**Moderate**	0.23	Negligible	0.11	Negligible
R10	Road 1	Low	1.78	Negligible	0.18	Negligible	0.09	Negligible
R11	Road 2	Low	**7.90**	**Moderate**	0.79	Negligible	0.39	Negligible
R12	Road 3	Low	**12.00**	**Moderate**	1.20	Negligible	0.60	Negligible
R13	PROW 1	Low	**11.57**	**Moderate**	1.16	Negligible	0.58	Negligible
R14	PROW 2	Low	**22.26**	**Moderate**	2.23	Negligible	1.11	Negligible
R15	PROW 3	Low	**15.95**	**Moderate**	1.59	Negligible	0.80	Negligible
R16	PROW 4	Low	**5.89**	**Moderate**	0.59	Negligible	0.29	Negligible
R17	PROW 5	Low	**15.09**	**Moderate**	1.51	Negligible	0.75	Negligible
R18	PROW 6	Low	**12.59**	**Moderate**	1.26	Negligible	0.63	Negligible
R19	PROW7	Low	**6.34**	**Moderate**	0.63	Negligible	0.32	Negligible
R20	Midpoint Ponds/Reedbed	Low	**62.13**	**Moderate**	**6.21**	**Moderate**	3.11	Minor

Table 9. Dispersion Modelling Results - Scenario 3a, Typical Operation, 10 litres/second

Receptor	Description	Receptor Sensitivity	98th %ile Odour 0% Removal	Significance	98th %ile Odour 90% Removal	Significance	98th %ile Odour 95% Removal	Significance
R1	Hilltop Cottages	High	0.84	Minor	0.08	Negligible	0.04	Negligible
R2	Mill Cottage	High	0.58	Minor	0.06	Negligible	0.03	Negligible
R3	Eastern House	High	0.73	Minor	0.07	Negligible	0.04	Negligible
R4	Thornleigh	High	0.91	Minor	0.09	Negligible	0.05	Negligible
R5	Granary Cottage	High	1.19	Minor	0.12	Negligible	0.06	Negligible
R6	Cherry Tree Cottage	High	0.61	Minor	0.06	Negligible	0.03	Negligible
R7	Heritage Centre	High	0.48	Negligible	0.05	Negligible	0.02	Negligible
R8	Bevan Terrace	High	0.13	Negligible	0.01	Negligible	0.01	Negligible
R9	Nenthead PO	High	0.43	Negligible	0.04	Negligible	0.02	Negligible
R10	Road 1	Low	0.34	Negligible	0.03	Negligible	0.02	Negligible
R11	Road 2	Low	1.49	Negligible	0.15	Negligible	0.07	Negligible
R12	Road 3	Low	2.27	Negligible	0.23	Negligible	0.11	Negligible
R13	PROW 1	Low	2.19	Negligible	0.22	Negligible	0.11	Negligible
R14	PROW 2	Low	4.21	Minor	0.42	Negligible	0.21	Negligible
R15	PROW 3	Low	3.01	Minor	0.30	Negligible	0.15	Negligible
R16	PROW 4	Low	1.11	Negligible	0.11	Negligible	0.06	Negligible
R17	PROW 5	Low	2.85	Negligible	0.29	Negligible	0.14	Negligible
R18	PROW 6	Low	2.38	Negligible	0.24	Negligible	0.12	Negligible
R19	PROW7	Low	1.20	Negligible	0.12	Negligible	0.06	Negligible
R20	Midpoint Ponds/Reedbed	Low	**11.74**	**Moderate**	1.17	Negligible	0.59	Negligible

Table 10. Dispersion Modelling Results - Scenario 3b, Typical Operation, 20 litres/second

Receptor	Description	Receptor Sensitivity	98th %ile Odour 0% Removal	Significance	98th %ile Odour 90% Removal	Significance	98th %ile Odour 95% Removal	Significance
R1	Hilltop Cottages	High	**1.68**	**Moderate**	0.17	Negligible	0.08	Negligible
R2	Mill Cottage	High	1.17	Minor	0.12	Negligible	0.06	Negligible
R3	Eastern House	High	1.46	Minor	0.15	Negligible	0.07	Negligible
R4	Thornleigh	High	**1.81**	**Moderate**	0.18	Negligible	0.09	Negligible
R5	Granary Cottage	High	**2.37**	**Moderate**	0.24	Negligible	0.12	Negligible
R6	Cherry Tree Cottage	High	1.23	Minor	0.12	Negligible	0.06	Negligible
R7	Heritage Centre	High	0.97	Minor	0.10	Negligible	0.05	Negligible
R8	Bevan Terrace	High	0.27	Negligible	0.03	Negligible	0.01	Negligible
R9	Nenthead PO	High	0.86	Minor	0.09	Negligible	0.04	Negligible
R10	Road 1	Low	0.67	Negligible	0.07	Negligible	0.03	Negligible
R11	Road 2	Low	2.99	Negligible	0.30	Negligible	0.15	Negligible
R12	Road 3	Low	4.54	Minor	0.45	Negligible	0.23	Negligible
R13	PROW 1	Low	4.37	Minor	0.44	Negligible	0.22	Negligible
R14	PROW 2	Low	**8.41**	**Moderate**	0.84	Negligible	0.42	Negligible
R15	PROW 3	Low	**6.03**	**Moderate**	0.60	Negligible	0.30	Negligible
R16	PROW 4	Low	2.23	Negligible	0.22	Negligible	0.11	Negligible
R17	PROW 5	Low	**5.70**	**Moderate**	0.57	Negligible	0.29	Negligible
R18	PROW 6	Low	4.76	Minor	0.48	Negligible	0.24	Negligible
R19	PROW7	Low	2.40	Negligible	0.24	Negligible	0.12	Negligible
R20	Midpoint Ponds/Reedbed	Low	**23.48**	**Moderate**	2.35	Negligible	1.17	Negligible

Appendix B Odour Isopleth Plots

Figure 4. 98th Percentile Odour Concentrations, Scenario 1 - Early Operation, 5 litres /sec flow, 0% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

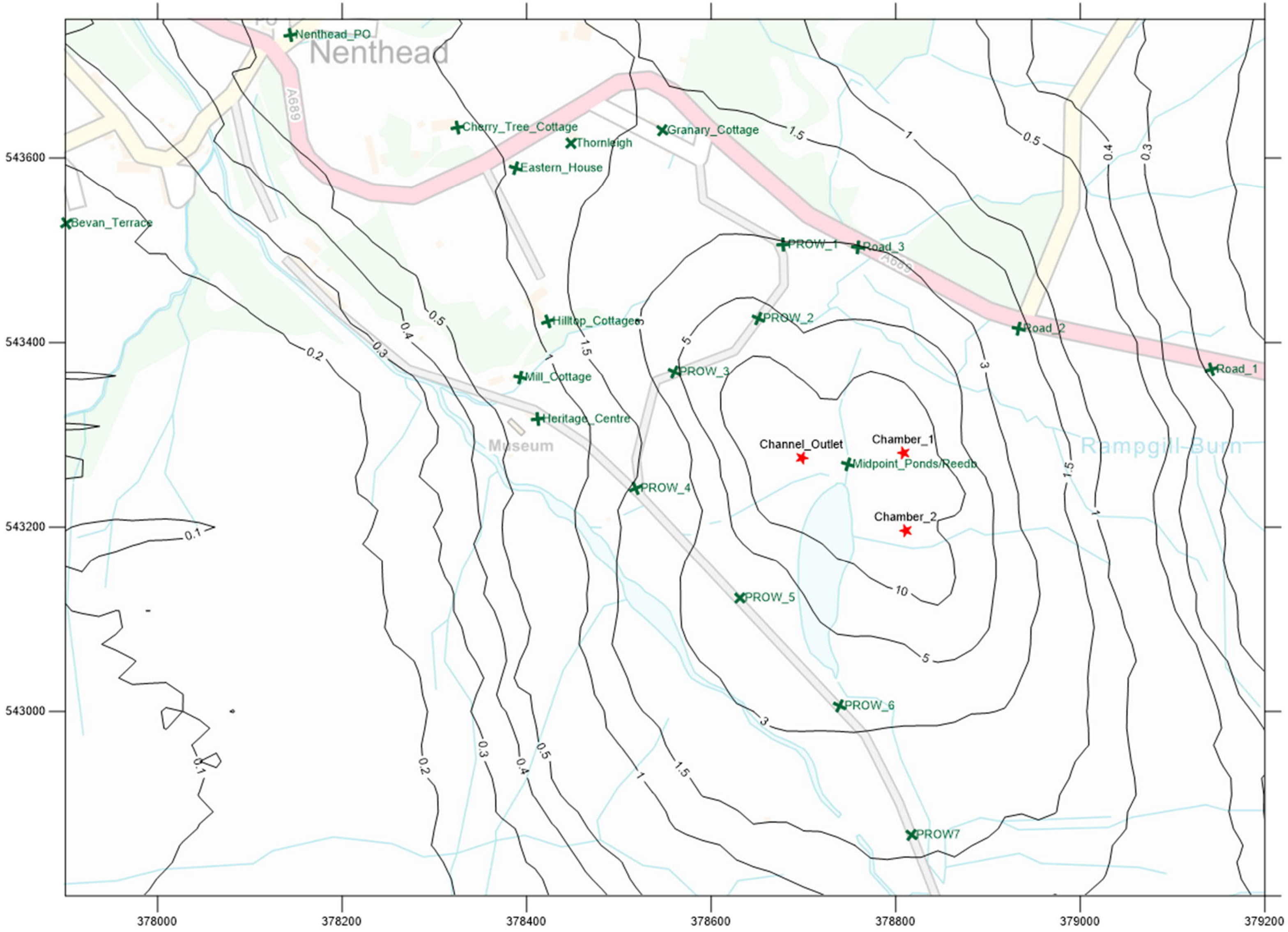


Figure 5. 98th Percentile Odour Concentrations, Scenario 1 - Early Operation, 5 litres /sec flow, 50% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

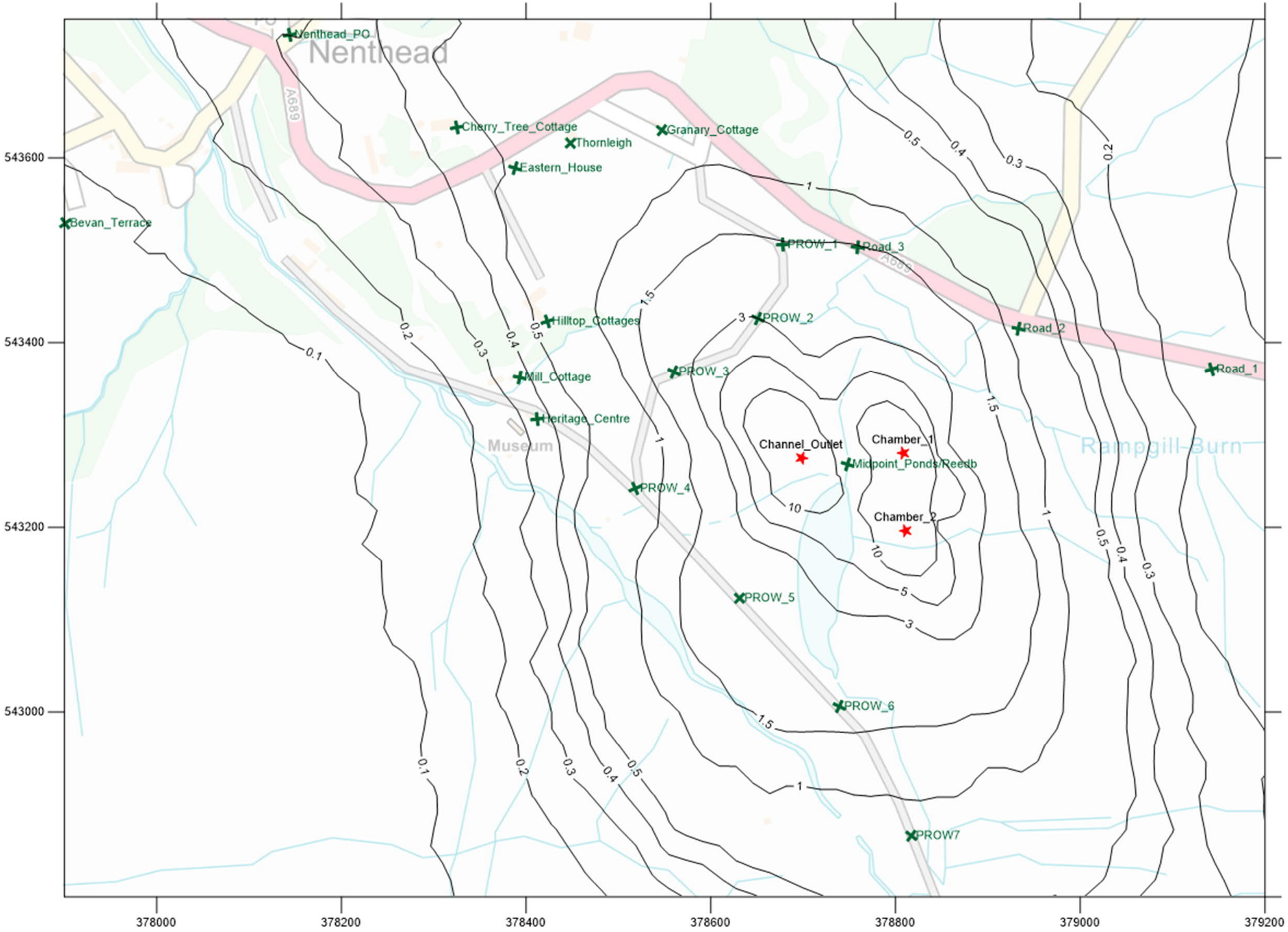


Figure 6. 98th Percentile Odour Concentrations, Scenario 1 - Early Operation, 5 litres /sec flow, 90% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

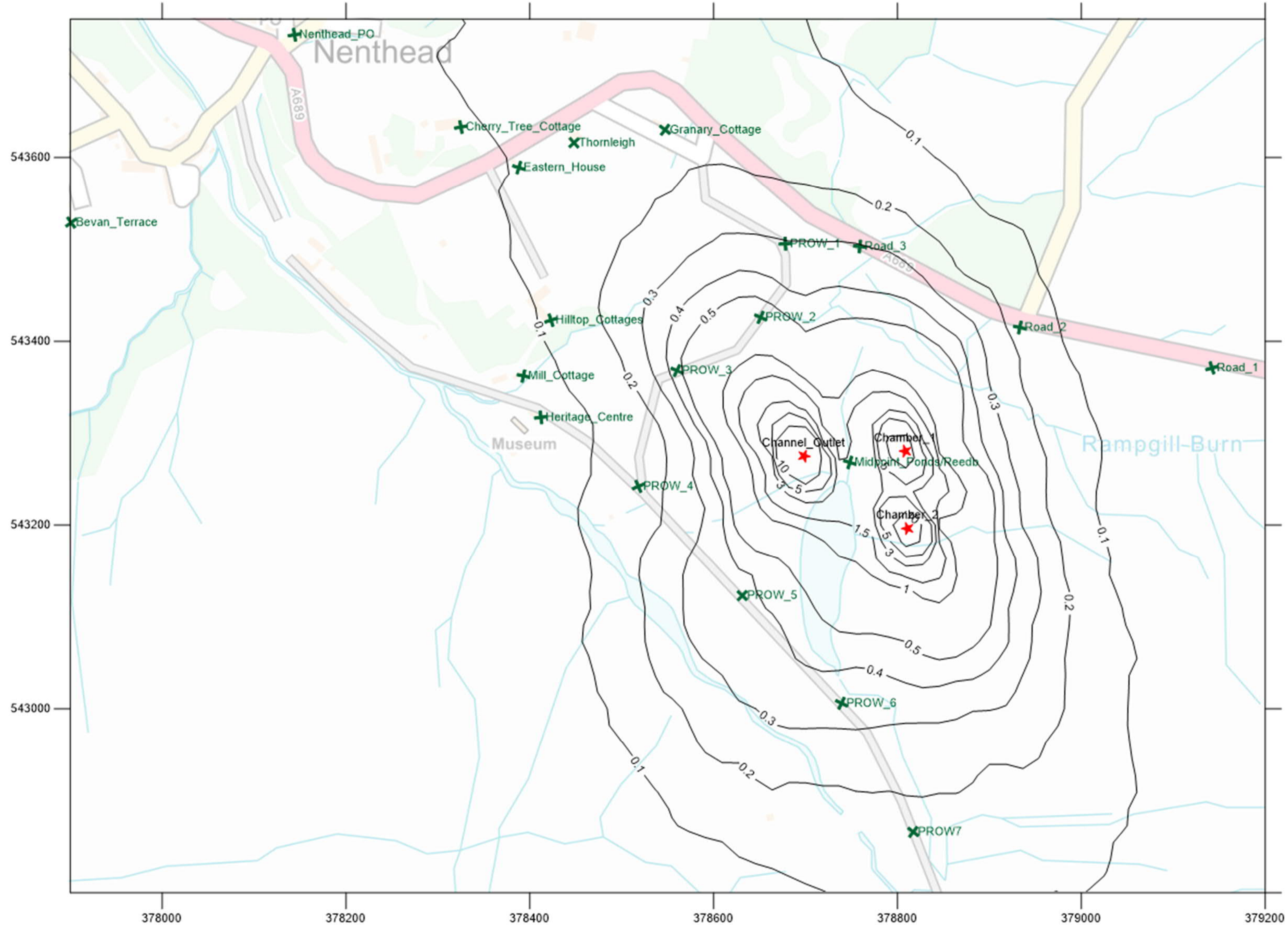


Figure 7. 98th Percentile Odour Concentrations, Scenario 1 - Early Operation, 5 litres /sec flow, 95% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

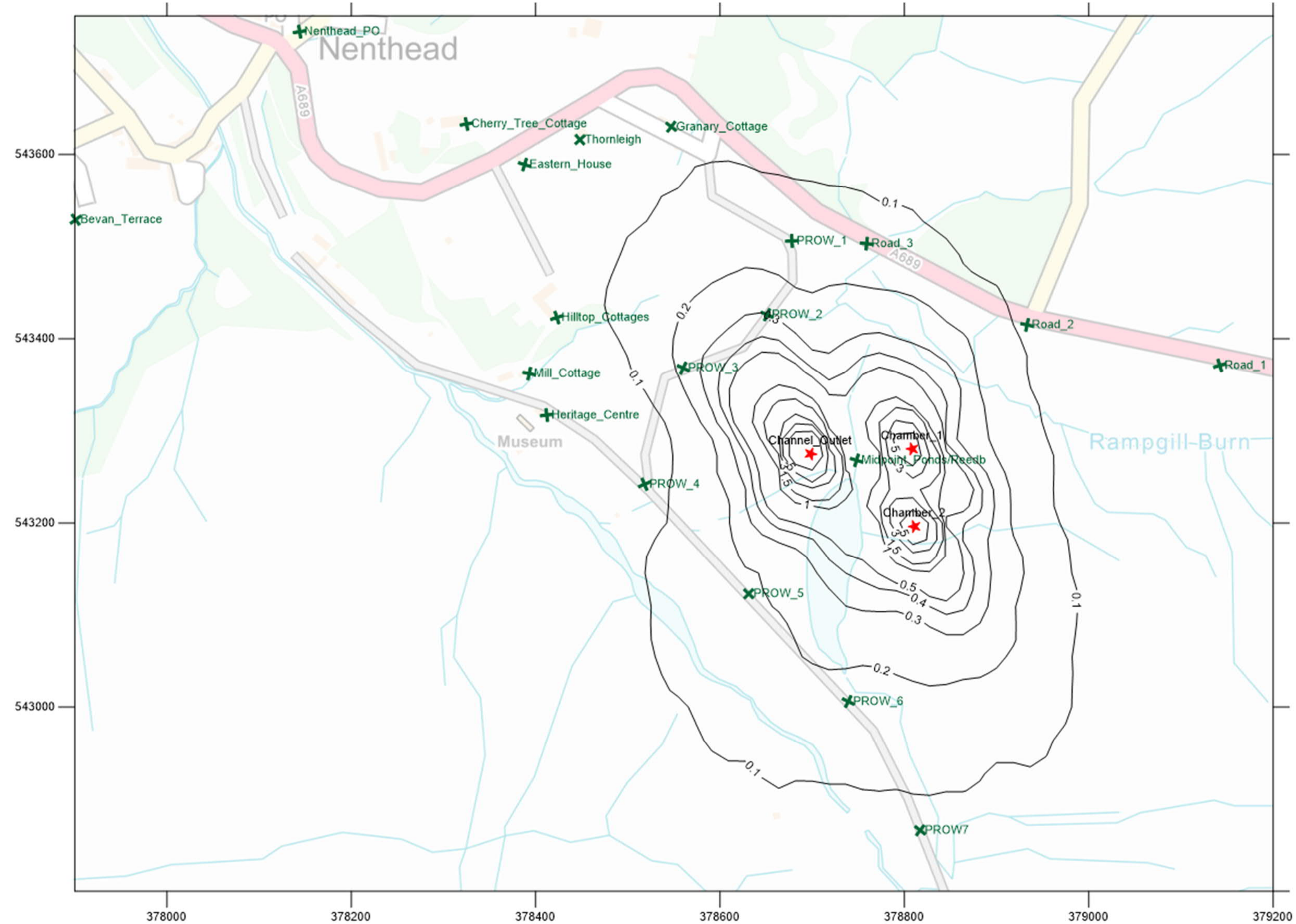


Figure 8. 98th Percentile Odour Concentrations, Scenario 2a - Worst Case Operation, 10 litres /sec flow, 0% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

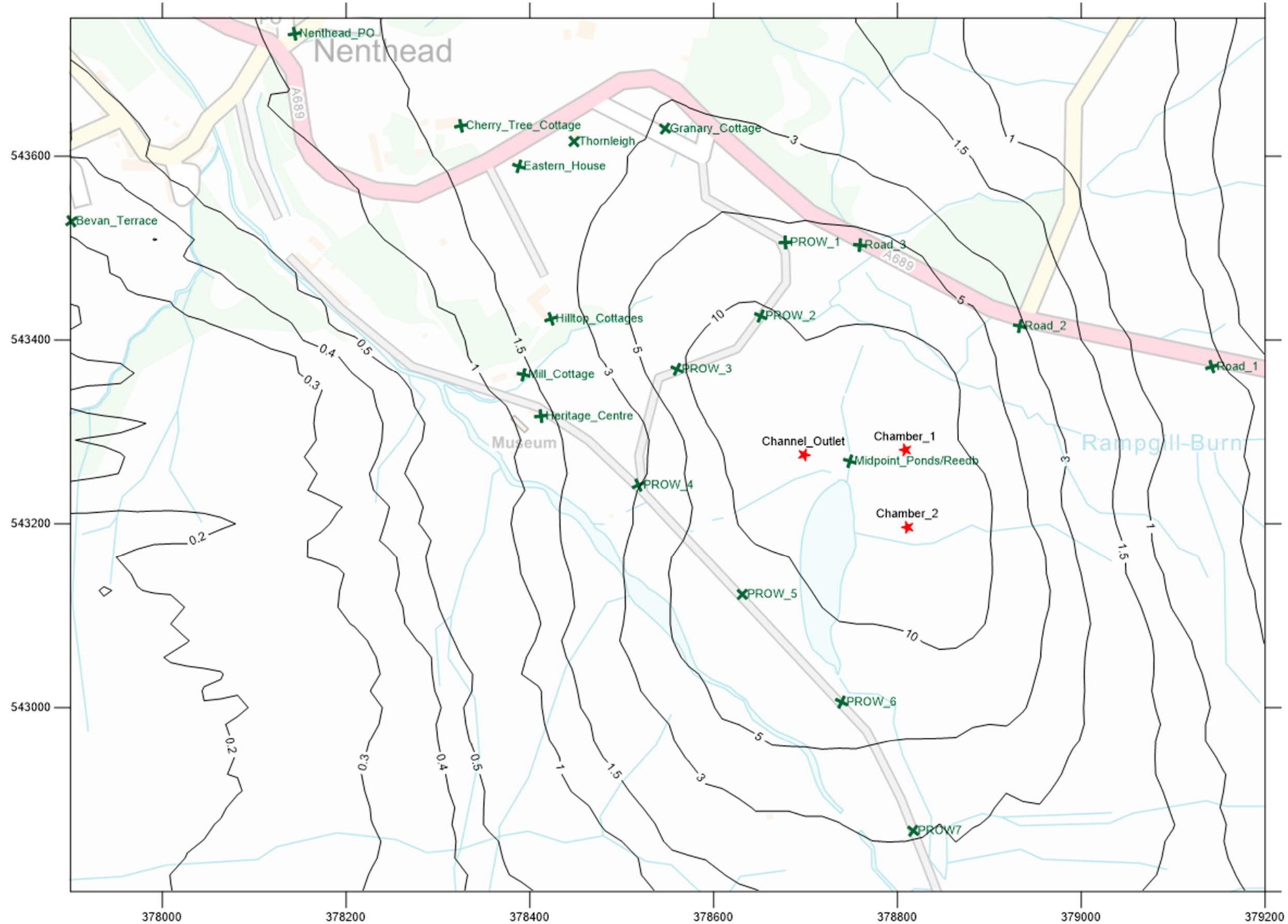


Figure 9. 98th Percentile Odour Concentrations, Scenario 2a - Worst Case Operation, 10 litres /sec flow, 90% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

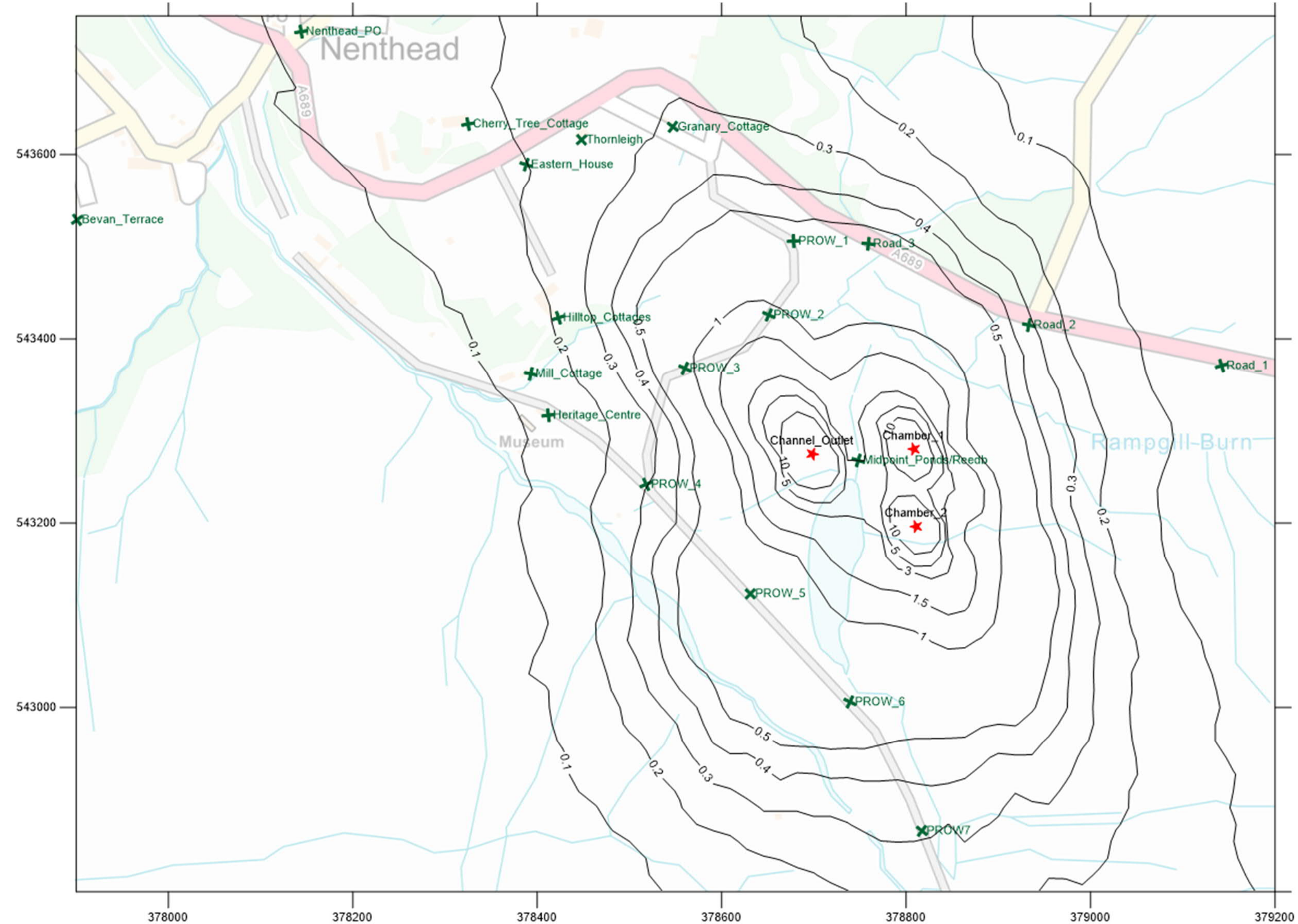


Figure 10. 98th Percentile Odour Concentrations, Scenario 2a - Worst Case Operation, 10 litres /sec flow, 95% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

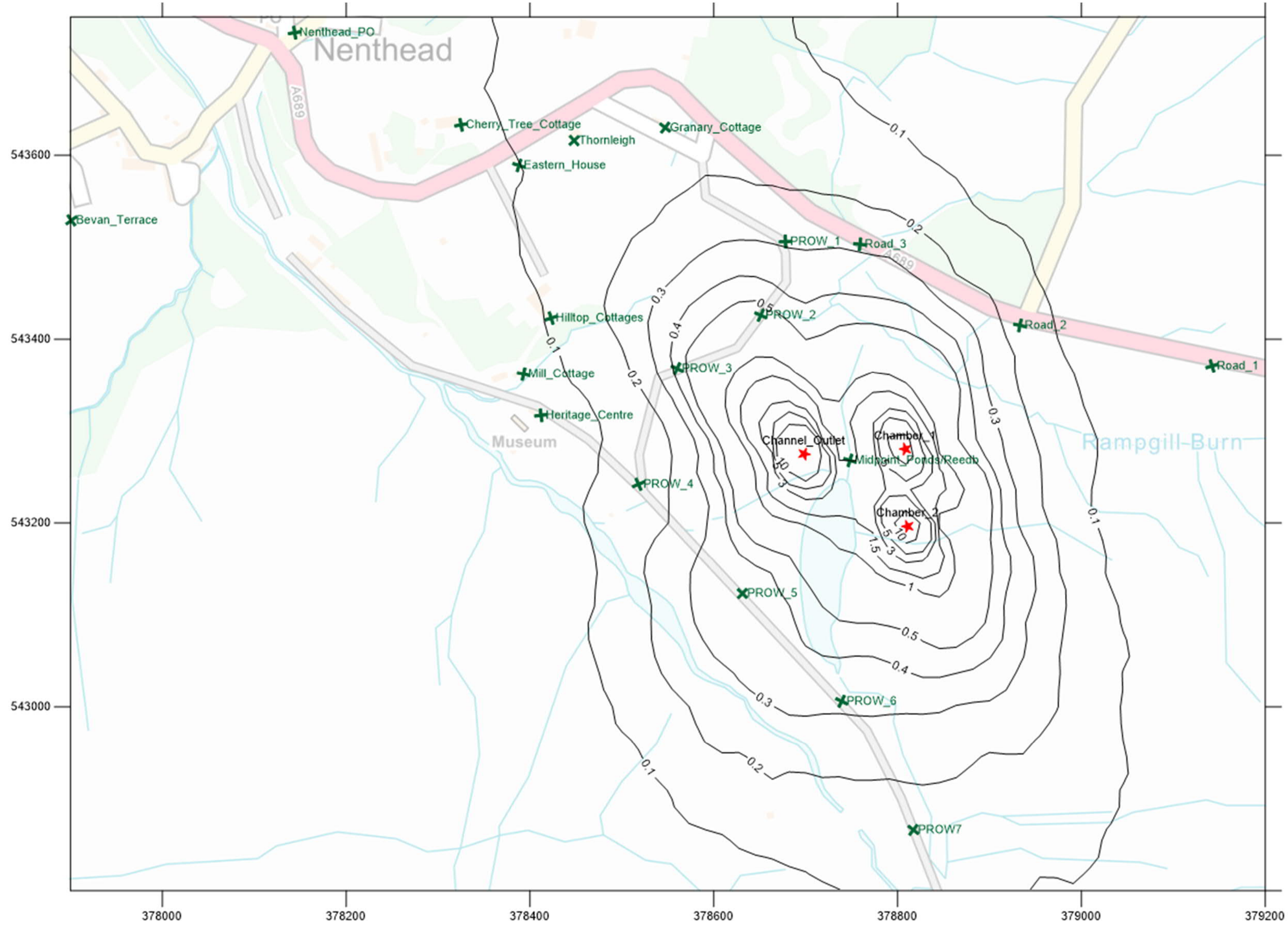


Figure 11. 98th Percentile Odour Concentrations, Scenario 2b - Worst Case Operation, 20 litres /sec flow, 0% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

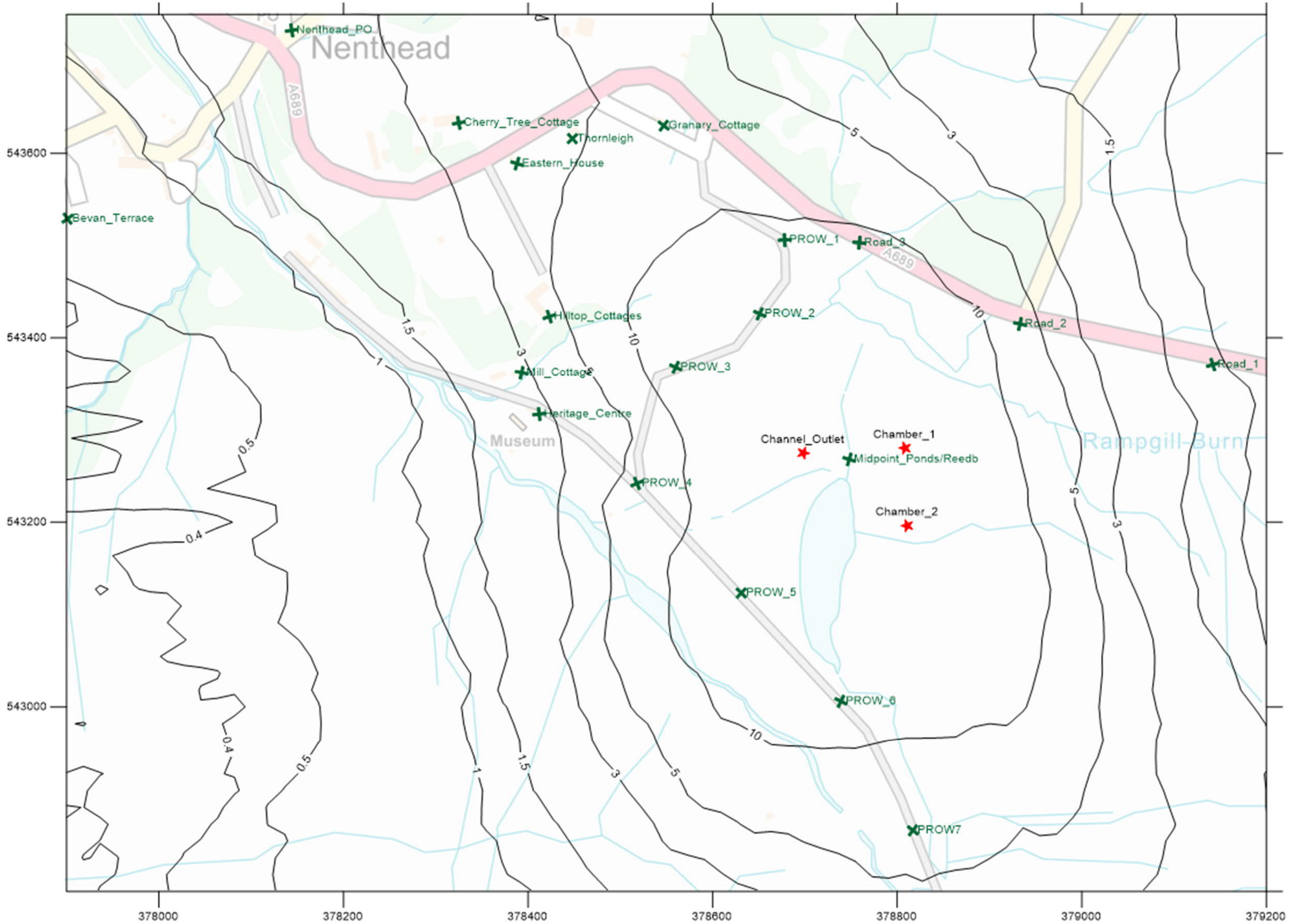


Figure 12. 98th Percentile Odour Concentrations, Scenario 2b - Worst Case Operation, 20 litres /sec flow, 90% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

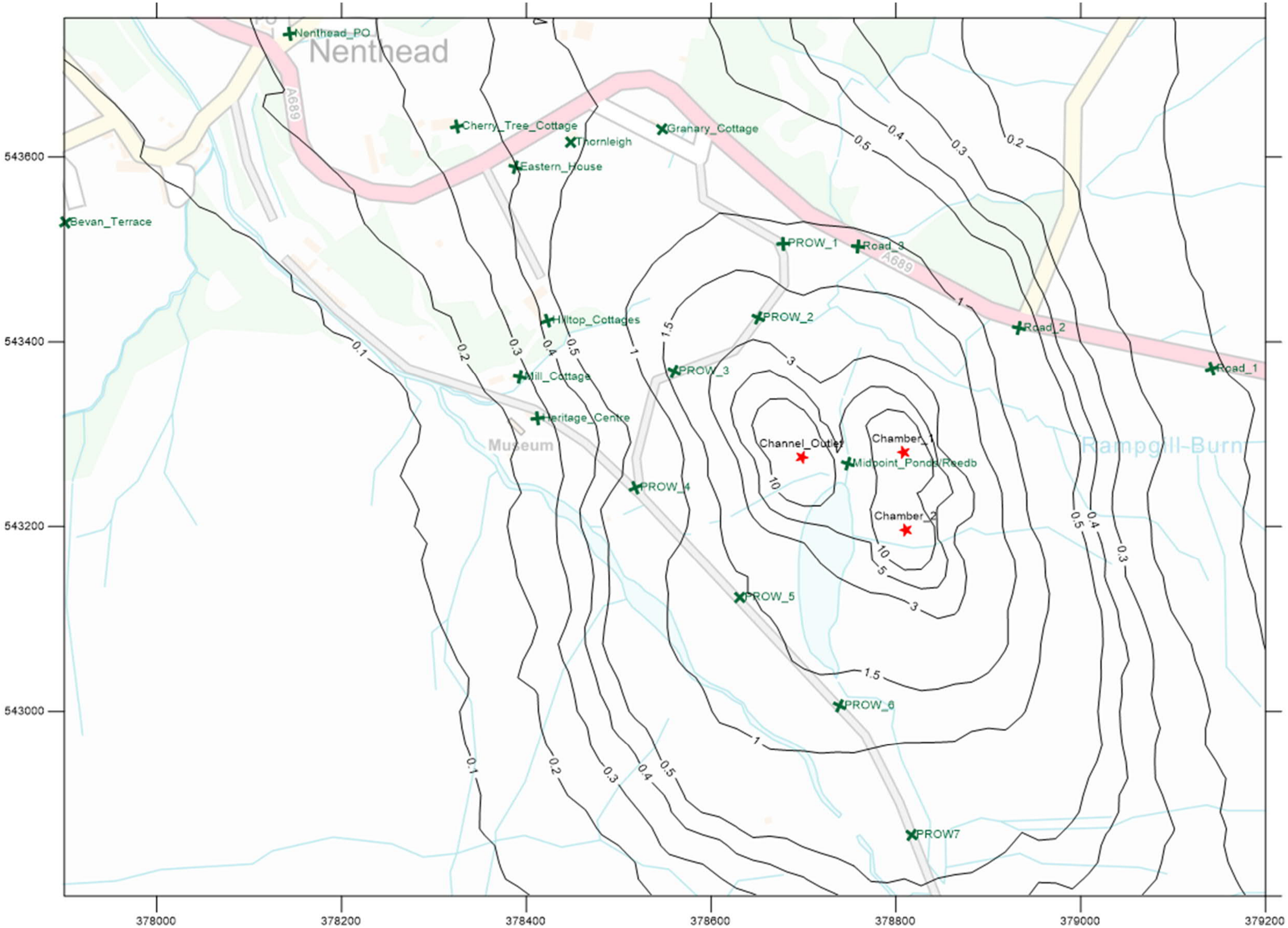


Figure 13. 98th Percentile Odour Concentrations, Scenario 2b - Worst Case Operation, 20 litres /sec flow, 95% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

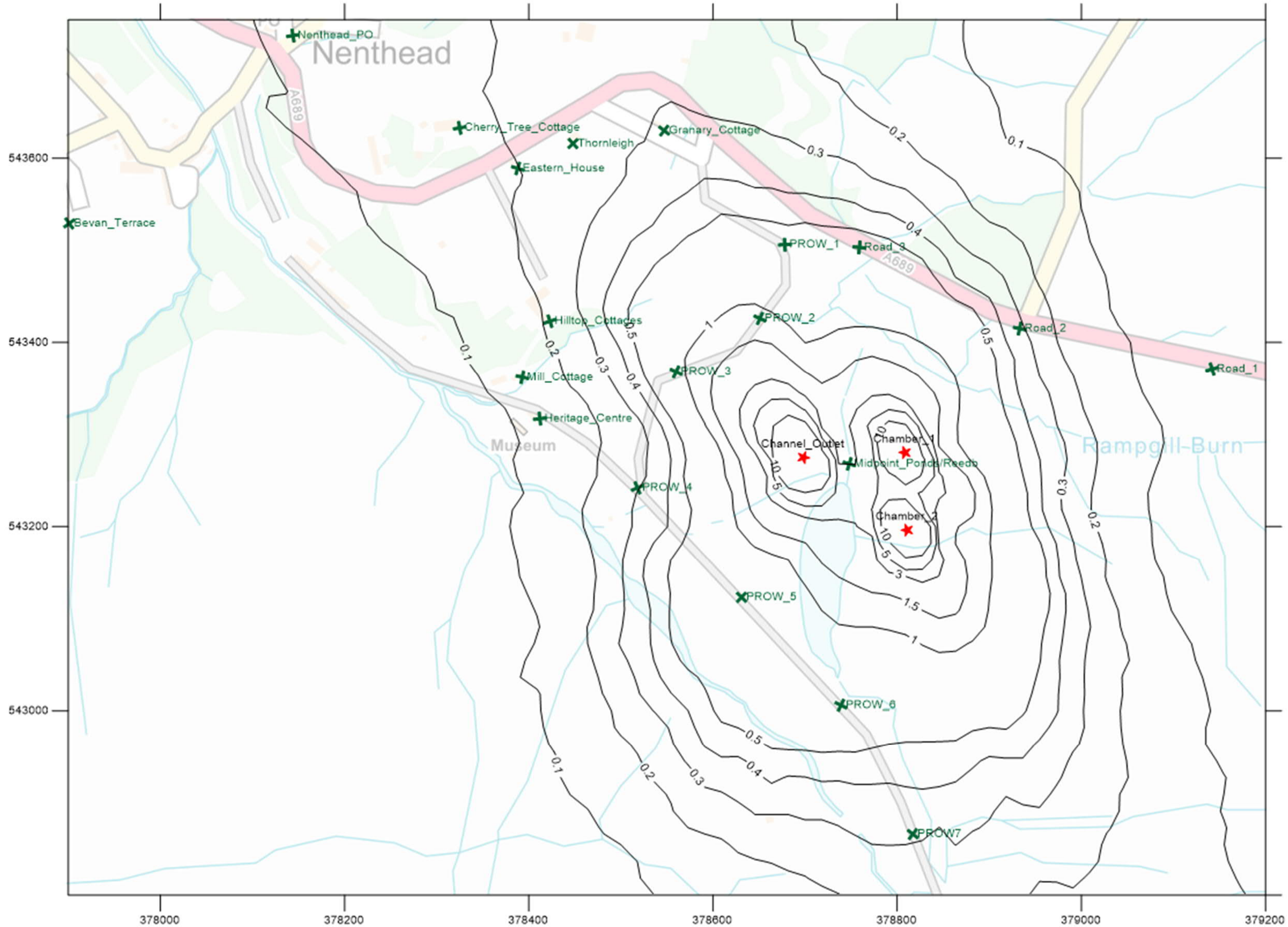


Figure 14. 98th Percentile Odour Concentrations, Scenario 3a - Typical Operation, 10 litres /sec flow, 0% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

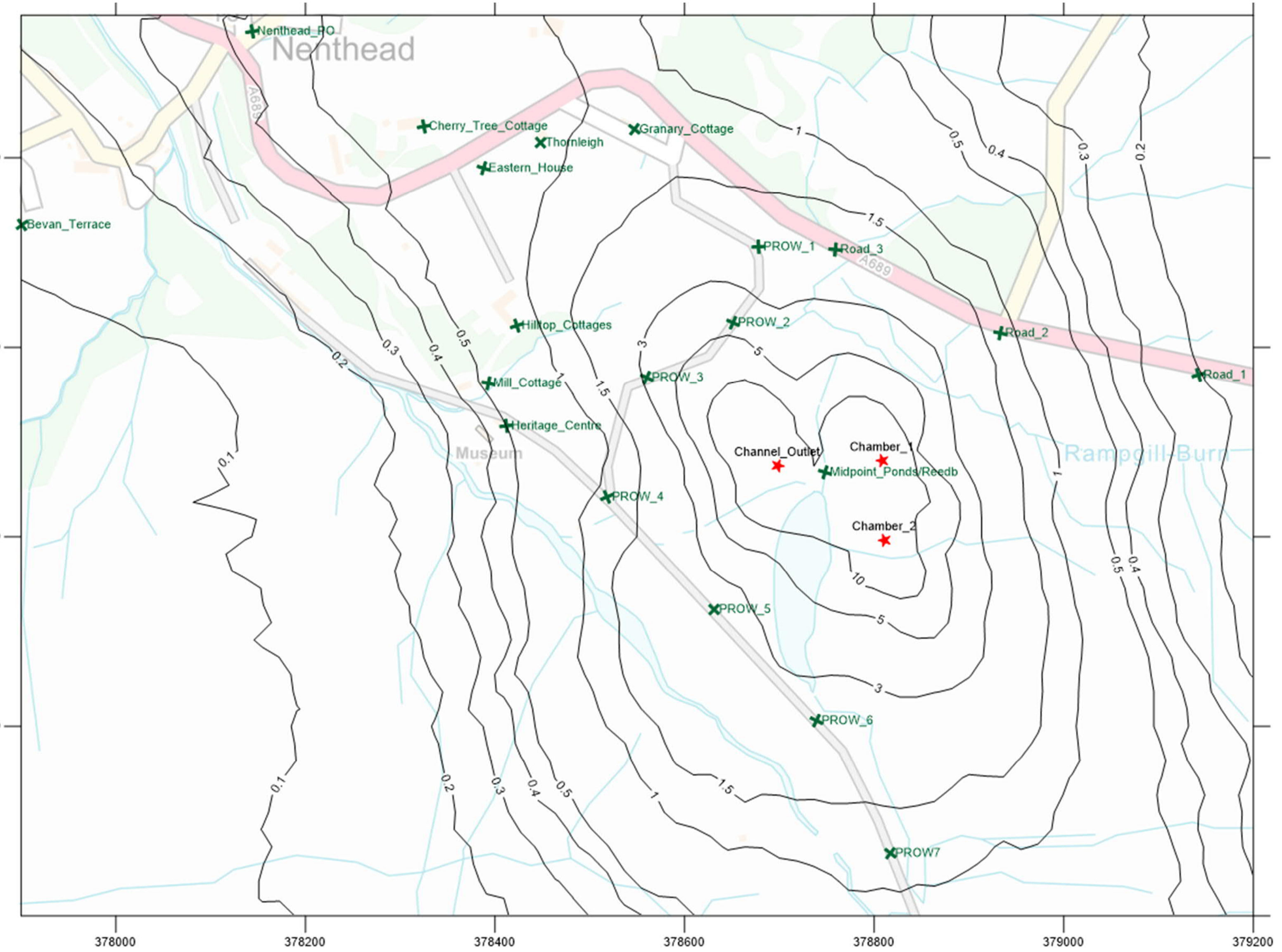


Figure 15. 98th Percentile Odour Concentrations, Scenario 3a - Typical Operation, 10 litres /sec flow, 90% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

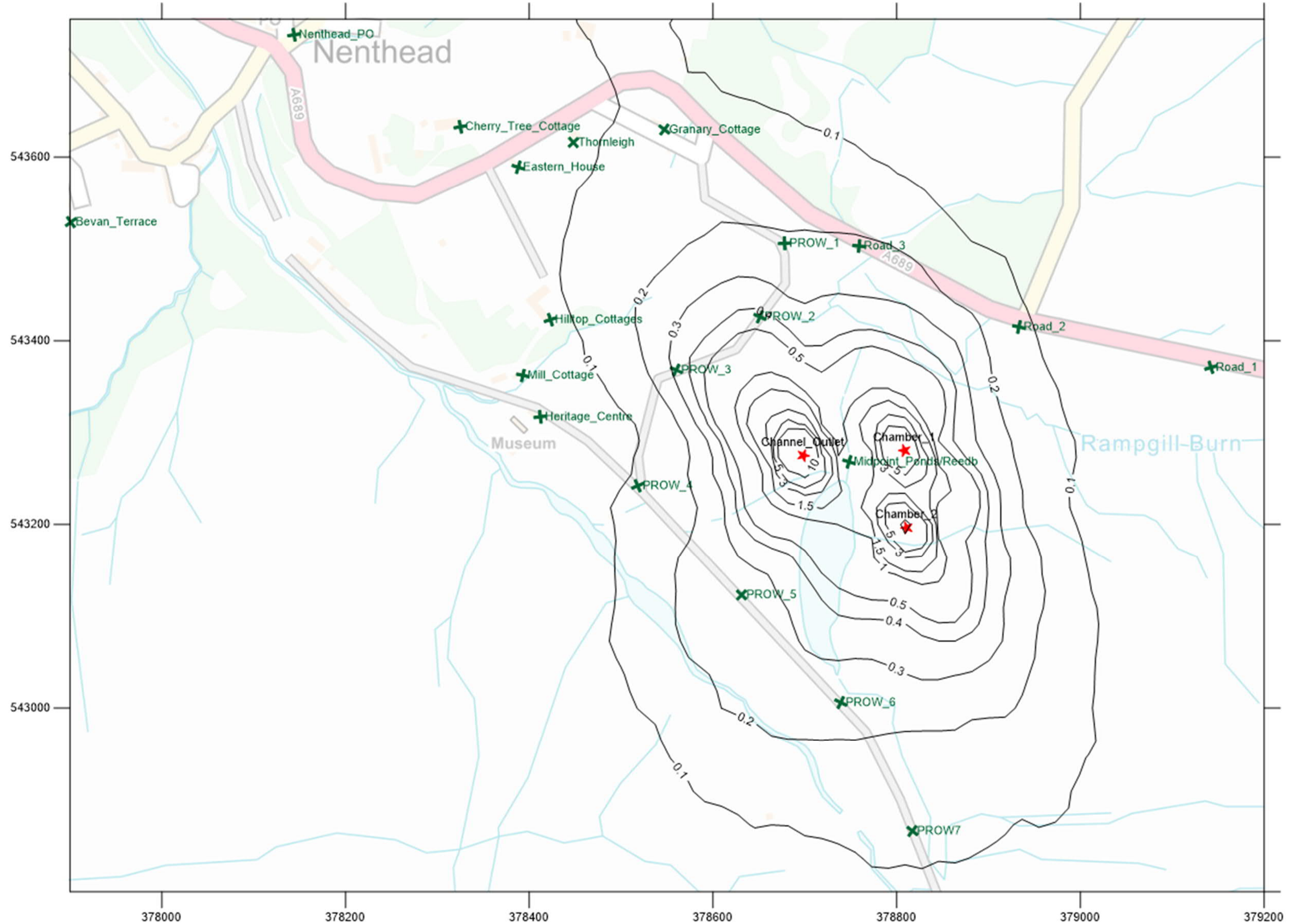


Figure 16. 98th Percentile Odour Concentrations, Scenario 3a - Typical Operation, 10 litres /sec flow, 95% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

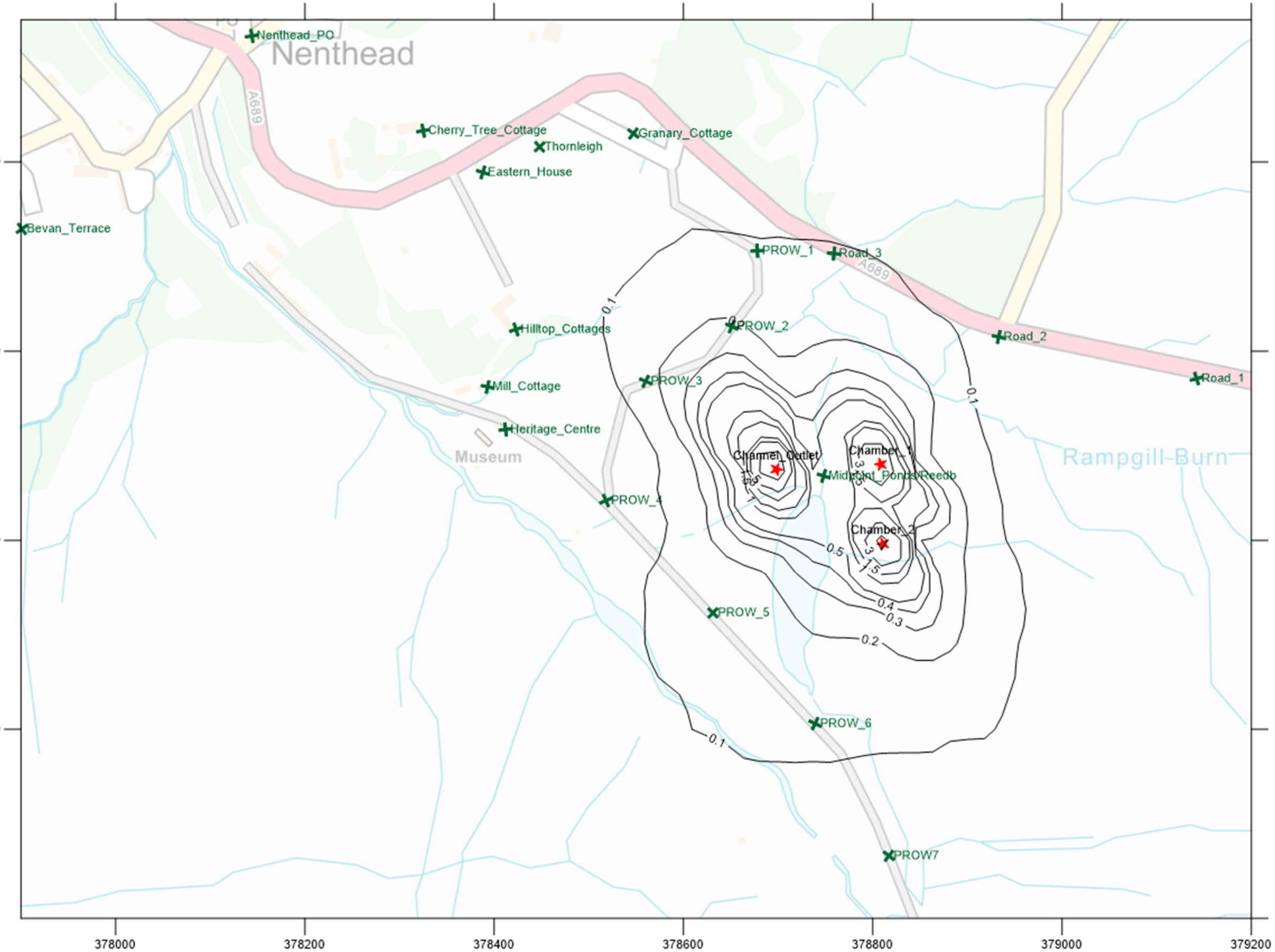


Figure 17. 98th Percentile Odour Concentrations, Scenario 3b - Typical Operation, 20 litres /sec flow, 0% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

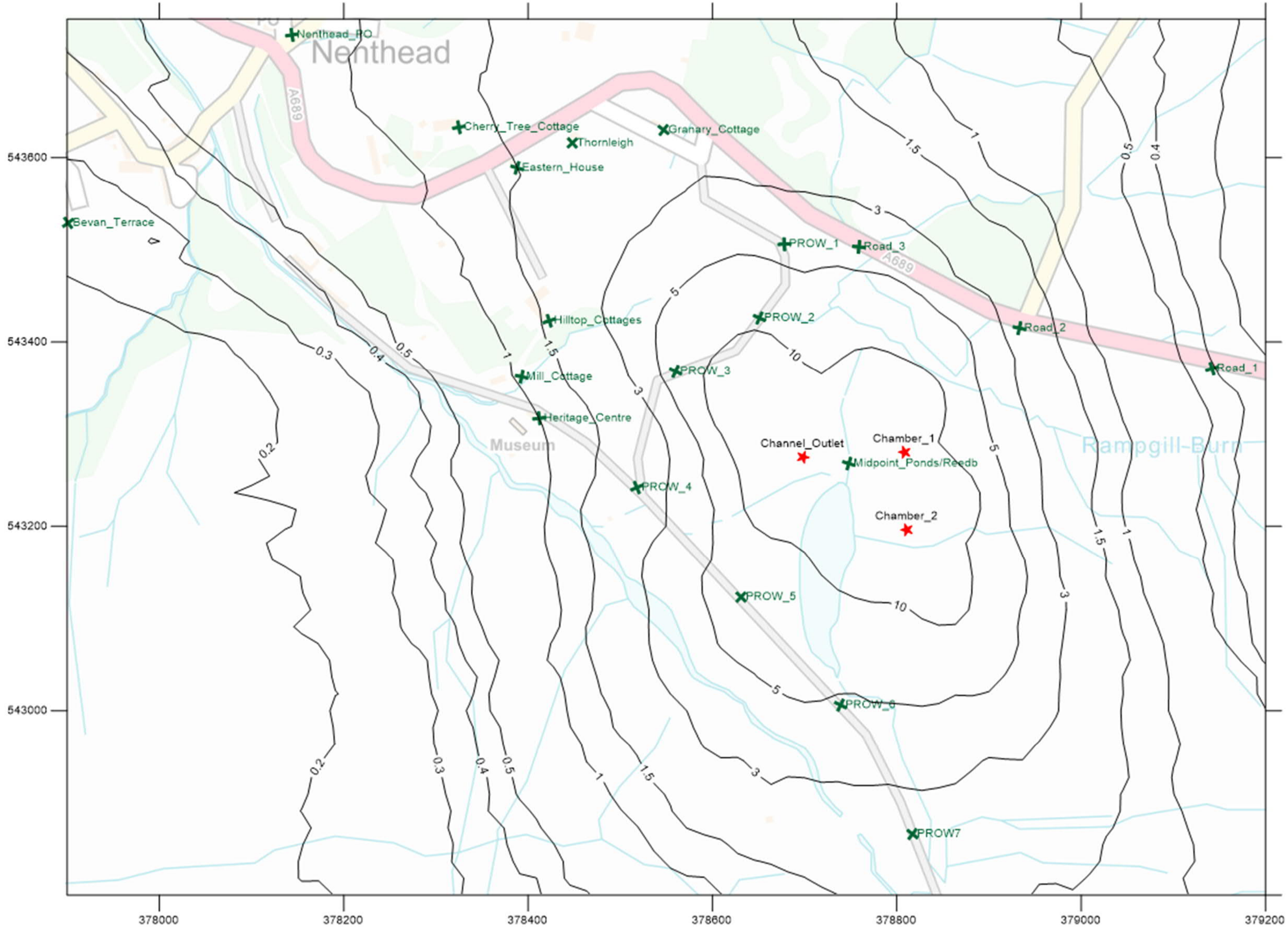


Figure 18. 98th Percentile Odour Concentrations, Scenario 3b - Typical Operation, 20 litres /sec flow, 90% Hydrogen Sulphide Removal, 2010 Meteorological Dataset

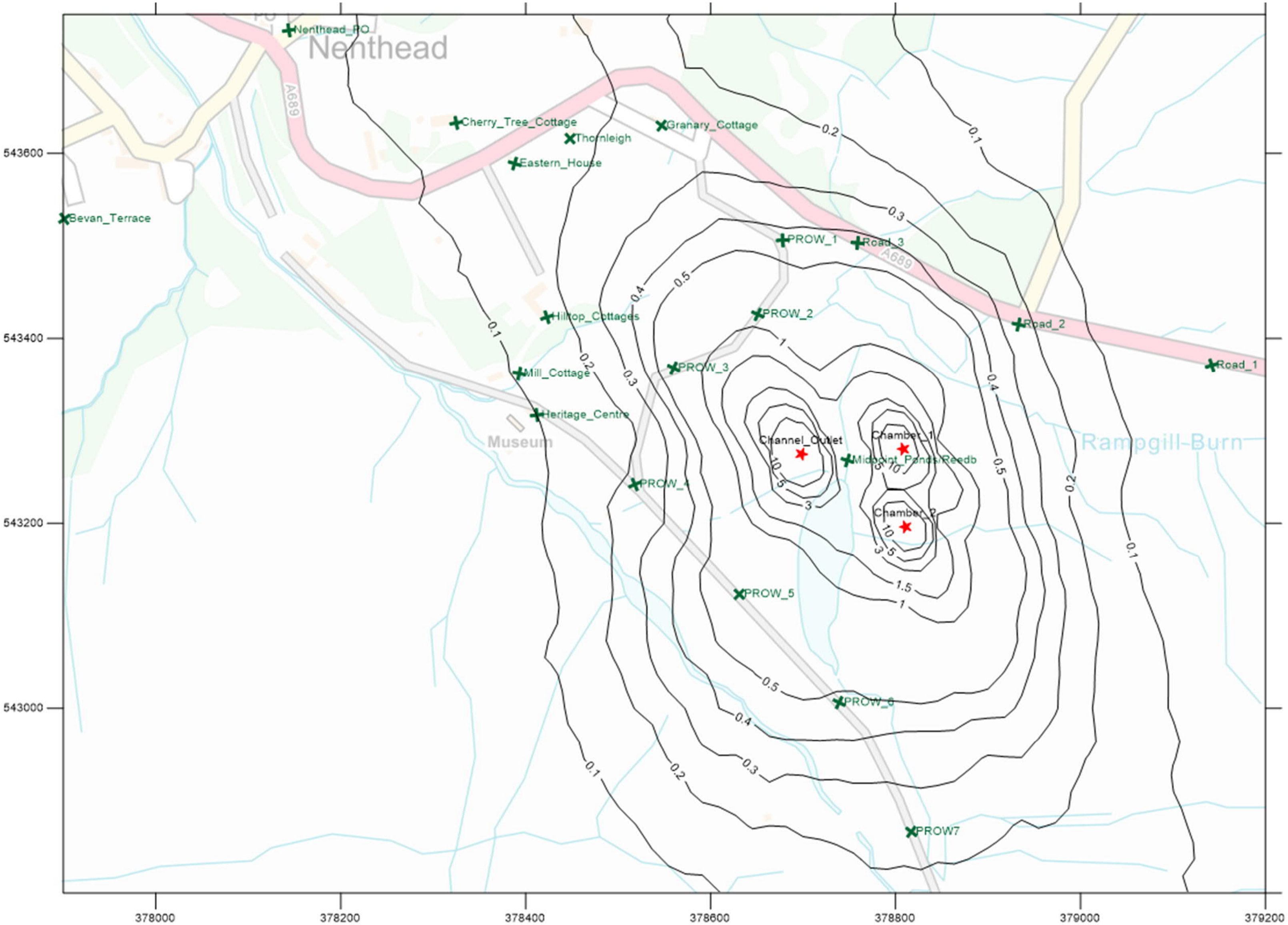
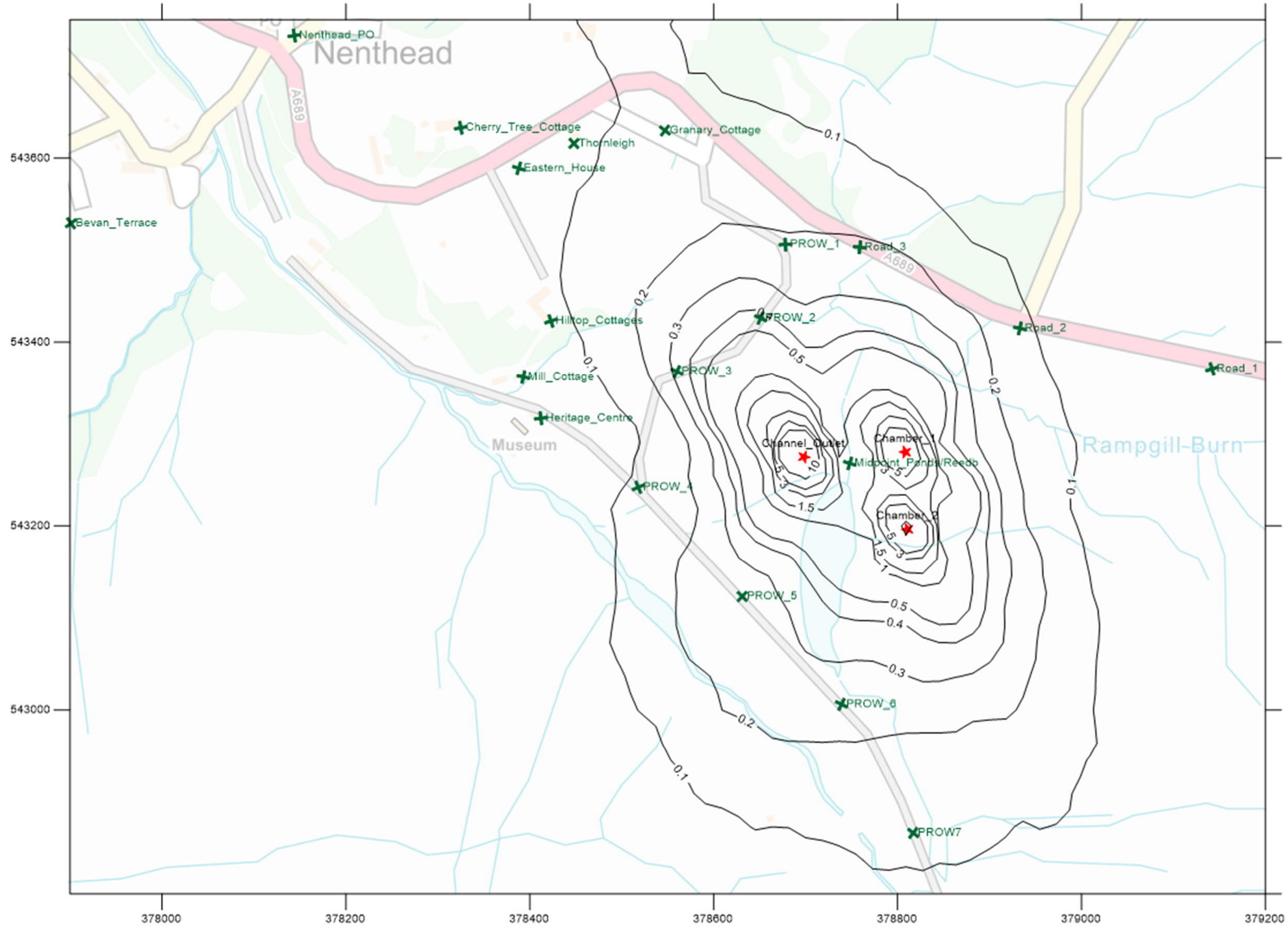


Figure 19. 98th Percentile Odour Concentrations, Scenario 3b - Typical Operation, 0 litres /sec flow, 95% Hydrogen Sulphide Removal, 2010 Meteorological Dataset



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