Public Health Air Quality Board

Devon Wide Personal Exposure Reduction Project Report

May 2016

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Colin Bignall, Alex Bulleid, Alice Burrow, Louise Lewis, Martin White and John Smith for finding time to make the project happen.

Ben Barratt from the Environmental Research Group at Kings College London for all his help for providing and delivering equipment for the project.

Adrian Marsden and Anna Rowan from the Strata GIS team at East Devon Disrtict Council for all their help with the Devon wide mapping requirements.

2 Executive Summary

The project clearly showed the positive impacts of less polluted routes for volunteers in Newton Abbot and showed how monitoring personal air pollution levels can be used successfully as a tool to plan alternative less polluting routes.

The results from Braunton indicate that time and training are vital parts of a project, particularly when working with young children. It also highlighted the issues with successful project management and the need to provide realistic timescales.

However despite the difficulties relating to the Braunton phase of the project, many useful lessons were learnt and some unforeseen benefits were drawn from the project.

Both study areas provided discussion and engagement with young people on other matters including a more detailed knowledge of how modern transportation can affect our health.

The project could be rolled out at other locations but needs to be carefully planned. It would be sensible to targeting any future similar projects at the most polluted areas where schools were present.

This study was successful in showing:

- Daily patterns of exposure are very personal to individuals
- Personal air pollution exposure reductions can be achieved by changing travel habits, even in large mainly rural areas such as Devon, where concentrations are generally low compared with urban areas in the rest of the UK. These changes may not be so great, but even small reductions are of benefit
- New ways of communicating air pollution issues, raise awareness in schools, and encouraging behavioural change

This study was also indicates that Devon wide working offers benefits including:

- Better understanding of issues
- Improved networking
- Improved sharing of knowledge and skills
- Potential for sharing a range of other resources including finance and workforce

The study also presented challenges with the following:

- Facilitating projects across a large geographical area
- Working with people in different organisations
- Providing capacity to facilitate additional relevant public health projects

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4 Introduction

The evidence for the health impacts of air pollution are growing, and are not linked solely to concentrations above the air quality objective levels. A reduction in exposure, particularly to fine particles will deliver health benefits, whatever the initial concentration.

The Environment Section (6.03) of the Devon joint strategic needs assessment Devon overview 2015 states:

Poor air quality negatively affects human respiratory and cardiovascular systems and is strongly linked to asthma and mortality. In the short-term, high pollution episodes, perhaps associated with heat waves for example, can contribute to the premature death of people who are more vulnerable to daily changes in levels of air pollutants. Objectives are set for nine main air pollutants within DEFRA's Air Quality Strategy, and where these objectives are not met, the local authority must declare an Air Quality Management Area (AQMA). There are 12 AQMAs in Devon shown in the map in figure 6.2. All areas are designated as AQMAs for excessive levels of Nitrogen dioxide which is a pollutant from road traffic which can cause increased vulnerability to respiratory infection and may cause infection of the lungs. The Crediton AQMA is also designated for excessive levels of particulate matter below 10 microns in diameter (PM10) which is predominantly emitted from diesel engines without particulate filters. The proportion of mortality attributable to particulate air pollution in Devon is 3.7% which is below the South West average of 4.4% and England average of 5.4%.

The committee on the medical effects of air pollutants (COMEAP) summary from the statement on the evidence for the effects of nitrogen dioxide on health states:

Studies have shown associations of nitrogen dioxide (NO_2) in outdoor air with adverse effects on health, including reduced life expectancy. It has been unclear whether these effects are caused by NO_2 itself or by other pollutants emitted by the same sources (such as traffic). Evidence associating NO_2 with health effects has strengthened substantially in recent years and we now think that, on the balance of probability, NO_2 itself is responsible for some of the health impact found to be associated with it in epidemiological studies.

Studies in London and other cities have shown that daily patterns of exposure are very personal to individuals, and that reductions can be achieved by changing travel habits. For example changing the route used to walk or cycle, or changing from car to bike. In Devon, where concentrations are generally lower and hotspots of pollution are of smaller geographic extent, these changes may not be so great, but even small reductions are of benefit.

Personal exposure provides a new way of communicating air pollution issues, and encouraging behavioural change. For example it may reach those groups who do not engage with messages about climate change. The study will work with school pupils and provide outputs that the schools can use either in the classroom, or to raise awareness in the whole school community.

5 Devon wide project background

Two small air quality projects formed a part of an allocated a district council grant of £20,000 from the Devon Public Health Grant 2015/16. This was part of an arrangement made to support the public health system across the two tier structure of local government in Devon.

The Devon District Local Authorities worked together with Devon County Council on two projects as follows:

- **Ecostars**
  The ECO Stars project is focussed on recruiting companies into the ECO stars scheme For more information on the scheme, please see www.ecostars-uk.com. This project received 100% of the £20,000 funding.

- **Devon Wide Personal Exposure Reduction Project (DWPERP)**
  10% of the grant money was originally planned for this project, in order to cover any “ad hoc” expenses required, as the main resource was existing staff resources within the participating Local Authorities. However, none of the grant funding was finally allocated to this project. It was not intended as an academic study as it eventually received no funding; it was specifically designed to trial a potential harm reduction approach to air pollution. The study involved 6 school pupils from two schools in different Devon Districts.

6 Aims and objectives

6.1 Aims

To use measurements of the personal exposure to $PM_{2.5}$ to develop exposure reduction advice, raise public awareness and support behavioural change with school children.

6.2 Objectives

- To equip school children with personal $PM_{2.5}$ monitors and GPS loggers for 24 hours while they travel to and from school by their usual method.
- To map the exposure of the volunteers by location, and to plot exposure against time.
- To provide personal travel planning advice to the volunteers and to use their monitoring data to suggest changes they could make which would reduce their exposure.
- To repeat exposure measurements and review the effectiveness of the advice given and any changes made.
- To demonstrate that active travel planning can help to reduce personal exposure.

7 Methodology

7.1 Choice of study groups

It was decided that schools within established AQMAs would be the focus of the study. The areas for consideration included Exeter, Honiton, Braunton and Newton Abbot. Exeter was ruled out as work had already been undertaken there. Honiton was ruled out as it was felt that the AQMA may not remain in place or would be likely to reduced considerably in size and consequently raising expectations would be unhelpful given likely future changes. Thus Newton Abbot and Braunton became the target areas for the study. Connections were already in place with these two schools and both schools had expressed an interest in local air pollution problems. Concerns were raised about practical details of providing improved routes to the schools, as it was felt that the routes choices for Braunton were limited. However, the purpose of such studies is to highlight the issues and problems in selecting appropriate target groups with widely differing potential problems and solutions.

7.2 General

Three TSI SidePak AM510 Personal Aerosol Monitors were borrowed from Kings College University London. These were configured to measure $PM_{2.5}$ and to log every 1 minute. The equipment was zeroed by following the manufacturer's instructions before each deployment. Location data was provided by three Garmin GPS devices.

Appendix 1 – Methodology Information Provided to Volunteers, shows the instructions provided to volunteers. They were asked to start the $PM_{2.5}$ monitor and GPS when they left home in the morning. The intake tube for the monitor was to be mounted as close to their mouth as possible, for example on the shoulder strap of a bag. They turned the monitors off during the school day because the equipment was too noisy to leave running in the classroom. It was switched on again before they left school in the afternoon.

After each time of use, the equipment was returned to Exeter City Council where the data was downloaded. The results from the PM2.5 monitor and the GPS watch were combined for each volunteer so that a single spreadsheet showed location and concentration for every minute. After it was downloaded, the equipment was charged and the analyser zeroed ready for the next deployment.

Measurements were taken both during the pupils "normal" travel routes to school and during their new "advised" routes, i.e. after the provision of safer route travel advice.

7.3 Specific - Coombeshead Academy, Newton Abbot

Initial contact was directed to the Head of Science at Coombeshead Academy, Fiona Peters. Despite Fiona's incredibly busy schedule it was important to meet her in person even if only for 20 minutes, to explain the Who, What, and Why about the study. The meeting also proved crucial to reassure Fiona that the study would only need a minimal investment of Fiona's time.

The simple remit agreed was for Fiona to identify and bring together 3 volunteers (could be staff) that regularly walk to and/or from the Academy each day, ideally from a similar direction, and through the Air Quality Management Area, the longer the journey the better. All communication was direct with Fiona Peters, so that all personal details about the volunteers stayed confidential with Coombeshead Academy.

7.4 Volunteer Briefings

At the first volunteer briefing, the equipment was explained, followed by a run through of the protocol information sheet. Despite the interest shown this left little time to expand into the broader subject of local air quality and health effects, so information was forwarded subsequently to Fiona Peters to pass on to the Volunteers.

7.5 Specific - Caen primary school, Braunton

Caen primary school, Braunton was chosen because teachers have previously expressed concerns about air quality in the village. Caen primary school is the oldest primary school in the village of Braunton and is located at the centre on a very busy main road.

7.5.1 Volunteer selection

Three children were chosen by the year six teacher, Mrs Robinson. The three children all walk to school, but on different routes. Although these children were extremely enthusiastic, the knowledge, skills and behaviours of these young people could possibly have an impact on the use of complex measuring equipment for this project.

7.5.1 Volunteer briefing

The briefing given to the children and the class teacher was 30 minutes long. We explained the aims of the study to the three volunteers and teacher. The style was informal and relaxed so as to put them at their ease. Everyone asked questions and we answered them all individually and tried to make things as simple as possible. We ensured that all the equipment was working before they left the school on their first journey home.

7.5.2 Equipment use

Volunteers used the equipment on their way home in the afternoon first, and then on the way back to school the next morning. This was to ensure the equipment was working correctly before it was used for the first time. Our concerns about the use of the equipment included the following:

- Would the monitors work?
- Would the monitors be too difficult hard for the children to use?
  (especially regarding switching off the equipment and re-setting it for their next journey. Although instructions were given verbally and in writing, we were concerned that the children may not fully understand what was required as they were very young.

8 Monitoring results

8.1 Results presentation

The data was obtained from the pollution monitoring and Global Positioning System (GPS) devices in a tabular form. The data is presented in the form of combined time dependant graphs and geographically accurate map plots of the routes taken by the volunteers.

The time dependant graphs plots for before and after the travel planning advice are shown together, whereas the Geographical Interface System (GIS) mapping plots for before and after the travel planning advice are shown separately.

The levels are shown in the form of a series of circles linked to a colour spectrum. These circles also increase in size relative to the measured pollution levels. Because of the large number of results in the form of time dependant graphs and GIS plots, these have been appendicized as follows:

- Appendix 3 – Teignbridge results – Time dependant variations
- Appendix 4 – Teignbridge results – Spatial dependant variations
- Appendix 5 – Braunton results – Time dependant variations
- Appendix 6 – Braunton results – Spatial dependant variations

8.2 Results discussion

8.2.1 Teignbridge

The time dependant graphs and GIS plots for Teignbridge (see Appendix 3 – Teignbridge results – Time dependant variations and Appendix 4 – Teignbridge results – Spatial dependant variations) clearly show how changing the routes produced a much lower level of pollution exposure to the individual volunteers. The data illustrated graphically in Figure 1 - Volunteer 7 – before and after advice and Figure 2 - Volunteer 11 - before and after advice indicates that the volunteers 7 and 11 were exposed to over six times the level of pollution on the most polluted routes compared with the least polluted routes.

8.2.1 Braunton

The time dependant graphs and GIS plots for Braunton do not show any clear trends or indications of the impact of changing routes. Much of the data appears to have been corrupted and is shown to indicate the difficulties in running successful practical monitoring programmes. It was clear that some data was found to be missing where the volunteer had not operated the equipment correctly. Please see section 10 Practical implementation, for further detailed information.

9 Results of the interventions

9.1 Coombeshead Academy, Newton Abbot

The intervention clearly showed the positive impacts of providing less polluting routes to school. The order of magnitude of the reduction achieved for the students attending Coombeshead Academy, Newton Abbot was larger than had been expected.

9.2 Caen primary school, Braunton

9.2.1 Data collection issues

The data for Braunton appears to have been corrupted and there were a number of possible of reasons. In general, the reliability of the data collected was questionable as there were some large gaps in GPS data, zero data (or null data) collection and some very low results.

9.2.2 Positive impacts of the Braunton study

- **Air quality understanding, the impact of transport and travelling on health**

The study provided the children with an opportunity to measure, analyse and assess the impact that air quality can have on them. They engaged in discussions about travel modes and the effects on their health.

We discussed the factors that could influence their air quality such as traffic volumes, types of vehicle, the weather etc. We obtained some free road maps of Braunton from the local tourist information office and the children were very interested in looking at each others' routes.

The children became more aware of how they travel to school and what affects the quality of the air they breathe.

- **The impact of travel and improving school facilities**

On the second visit to the school, we arranged to meet with Mark Donnelley (the North Devon Sustrans Travel Officer), the volunteers and their teacher. We looked at the first set of results and discussed the childrens' school routes. Mark's input was invaluable to all those involved and he will continue to work with the school to support them in financing healthy travel modes, for example a new scooter pod to store their scooters in.

- **Unaccompanied children**

It was noted that one child walked to and from the school un-accompanied on roads with no pavements. This child was recommended an alternative route that was considered less dangerous but not necessarily less polluting.

10 Practical implementation

10.1 Coombeshead Academy, Newton Abbot

10.1.1 Problems regarding implementation

The study highlighted some issues:

- **Recording events on the route**
  Events en route may affect the data.

- **Use of software etc**
  Understanding and using the various required software was initially difficult and time consuming. For example it was difficult to show the difference between outward and return routes taken by two of the volunteers on the same diagram. Also, whilst different scaling was needed on each of the graphs to be able to present the data, this made comparison between the data sets more difficult.

- **Design of alternative routes**
  Designing alternative routes was difficult due to other factors.

- **Time to do the work**
  Block days and half days were “pencilled in” to do the work. This worked well when the project was running on time, but as delays crept in, times were pushed further back and project delays were exacerbated and ultimately some project outcomes were adversely affected.

10.1.2 Proposed improvements to implementation

- **Recording events on the route**

Volunteers to record an account of the journey and route taken. For example, traffic behaviour, weather conditions. Being a subjective record however, the volunteers would have needed some calibration guidance to standardise their responses and minimise variation between them. Maybe a simple “tick box” form could be developed or alternatively a video of the journey may be the most appropriate method.

- **Use of software etc**

Training and testing the various software was done before the data arrived. However, it was only when using the software under time pressure did the cracks show. Better documentation of procedures and processes helped, but it is software and site specific.

- **Design of alternative routes**

When designing alternative routes we tried to keep the overall distance (and therefore time taken) as close to the original route as possible. We actively promoted this point to the volunteers to minimise any misgivings about the time it would take to complete. Although not apparent with these particular 3 volunteers, when designing the alternative route we did consider whether there could be external factors that influenced their original route choice, (for example availability of shop facilities). If

present this would need to have been addressed to make the alternative route sustainable. In the process of designing the alternative routes the professional "fresh eyes" input from the DCC's travel planning officer helped to identify what could be a generic template approach to designing alternative routes that are palatable enough (in terms of overall distance, duration etc) to be a sustainable route choice in the long term. We observed from the town plan that the broad flow from the various catchment areas on the edge of the town towards a school was likely to fall in to one of only a few approach options to get on to the school campus. Given that all 3 of the volunteers at Coombeshead Academy originated from the south eastern side of Newton Abbot rather than produce a unique route for each we decided to design one generic route that could accommodate the broad majority of flow from the south east side of the town to the school.

- **Time to do the work**

This worked well when the project was running on time. Project delays exacerbated delays in work production. Increased levels of contingency may help improve project timing, though working with other teams and with multiple agencies and organisations may inherently impact on such delays.

10.2 Caen primary school, Braunton

Unfortunately the Braunton part of the project was challenging, especially given the unrealistic timescales. The data for Braunton appears to have been corrupted and there are a number of possible of reasons.

10.2.1 General time constraints

The project was due for completion by the end of the financial year 2015-2016. Unfortunately there were delays in equipment acquisition at the start of the project and the project was delayed by some months. This meant that the time constraints were very intense for the Braunton part of the project:

10.2.2 Time constraints - alternative route advice, monitor installation and collection

The officer involved only had one week to arrange to go back to the school, meet the travel officer, plan three alternative routes, deploy and collect the monitors for return to Exeter City Council.

10.2.3 Consulting with parents about alternative routes

Because of the short time scales for the Braunton part of the project, it was very difficult to adjust the participants "after" routes, as parental consent was required beforehand. Unfortunately, this was not possible without delaying the return of the equipment for the second time. Therefore, only small changes to their existing routes could be suggested. This highlighted the need for more time and a detailed local knowledge of the area.

10.2.4 Use of equipment / Equipment failures

The following problems were recorded:

- Unable to operate the GPS smartwatch

- Monitoring equipment failure (possibly caused by equipment not being switched on as no pump or battery failures were identified when the equipment was returned)
- Unable to suggest an alternative route as no original route plotted due to absence of GPS data.

10.2.5 Other Issues

Time also seems to have impacted on the results that have been obtained from individuals. For example, lower levels of fine particles were measured in afternoon recordings as opposed to morning levels.

10.2.6 Knowledge, skills and behaviours

Although all the children chosen were extremely enthusiastic, the knowledge, skills and behaviours of the young people may have had an impact and therefore more time and training would be recommended for any similar future studies.

11 Discussion, conclusions and recommendations

11.1 Measurement, data and transport planning outcomes

The project clearly shows the positive impacts of less polluted routes for the Newton Abbot volunteers.

These results showed how monitoring personal air pollution levels can be used successfully as a tool to plan alternative less polluting routes. A progressive roll out of the approach used in Newton Abbot and described in 6.1 could mean for example that any school could risk assess, approve and publicise sets of “reduced harm” routes in for that school. (A route if approaching the school from the direction of the Bradley or Heel Park estates, another if from the east, then the north, and so on).

11.2 Project management and resource constraint outcomes

The results from Braunton indicate that time and training are all vital parts of a project, particularly with primary age children and how “rushing” a project (in order to meet unrealistic timescales) can lead to the project aims and objectives not being met. It also highlights the issues with successful project management and the need to provide realistic timescales.

However despite the difficulties relating to the Braunton phase of the project, many useful lessons were learnt and some unforeseen benefits were drawn from the project.

11.3 Health promotion and harm reduction outcomes

Both study areas provided discussion and engagement with young people on other matters including a more detailed knowledge of how modern transportation can affect our health. However telling a child that; “We have shown you a way to reduce your pollution exposure by a factor of six” is probably fairly meaningless. To deliver of real change long term it is absolutely critical that the results can be translated into a meaningful context for the children and their families. For example “Do this and it will reduce by 50% the probability of you getting asthma”

11.4 Future project roll outs

The project could be rolled out at other locations but needs to be carefully planned with appropriate levels of contingency as project delays result in unforeseen impacts further on in the life of the project.

Increased numbers of similar projects would benefit from “economies of scale” and would only improve as relevant skills improved in implementing the projects.

It would be sensible to targeting any future similar projects at the most polluted areas where schools were present. In general, this would be likely to mean within AQMAs in built up areas.

12 References

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13 Appendices

Appendix 1 – Methodology Information Provided to Volunteers

Teignbridge District Council - Personal Exposure to Air Pollution Project

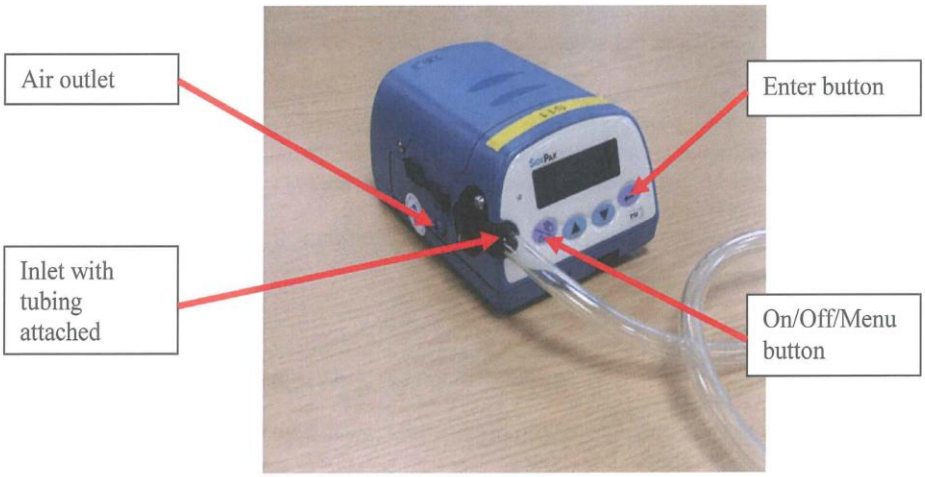
Protocol for Volunteers

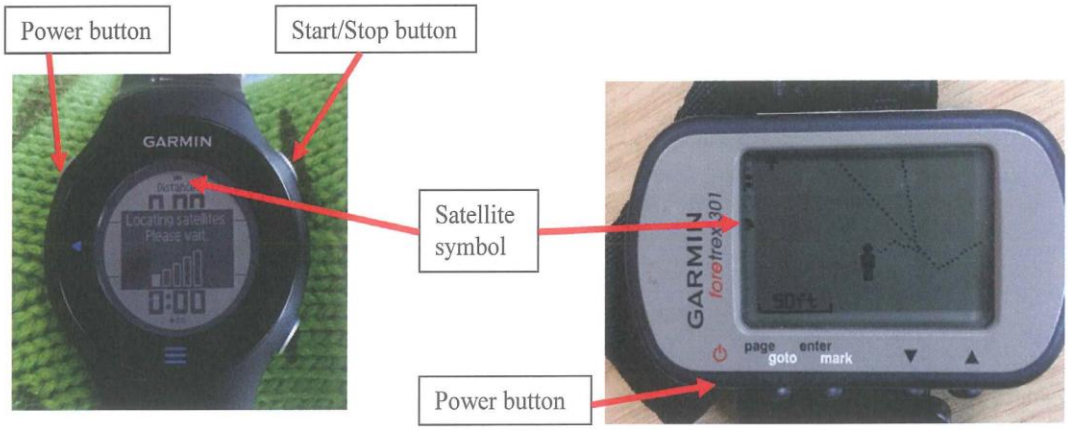
The aim of the project is to test how you can reduce the amount of air pollution you breathe, and have other health and environmental benefits, by changing your travel habits.

To do this, you will be given a pollution monitor and GPS device to wear for a day, while you go about your normal activities. We will use the results, and advice from the school travel planner to give you suggestions about how you could reduce the amount of air pollution that you breathe. You will then spend another day with the equipment, so that we can measure what the effects have been.

How to use the equipment

The pollution monitor has an inlet (black) and an outlet (blue). Please do not block these. It is fairly tough, but please don't drop it or get it wet.





Setting up the equipment:

1. Turn the monitor on. Press and hold the on/off/menu button until the machine beeps.
2. Wait while the machine starts (this takes about 10 seconds) and then warms up (30 seconds) until the screen shows 'survey mode'.
3. Press the on/off/menu so the screen shows 'Main menu Data log'.
4. Press the enter button, and the screen will show 'Run Manual'.
5. Press the enter button again. The screen will read 'logging data'.
6. Check that the inlet and outlet are not blocked.
7. Attach the tube to the inlet. Put the monitor in your bag and bring the end of the tube out of the bag near your shoulder.
8. Put the GPS on your wrist or bag strap, and press the 'power' button until it beeps and switches on. (The watch has buttons and a touchscreen, the larger device only has buttons to control it).
9. Stand outside while the watch finds a satellite. It will tell you that it is searching. If the satellite symbol is flashing, the device has no satellite signal. When it stops flashing, it has found a satellite.
10. If the device asks you whether you want to use it indoors or stop searching for a satellite, select no.
11. Press the start/stop button on the watch. If you have the larger GPS device it will start automatically once you move.
12. If the screen lock symbol appears on the watch, you will not be able to press start/stop until you unlock the screen. Do this by swiping left across the touchscreen.

Travelling:

13. Fix the tube from the monitor to the strap of your bag on your shoulder. If it is raining, please make sure that the end of the tube is pointing downwards, not up. You can use the strap of the GPS, or the velcro strap provided to help fix it in place.
14. Complete your journey.
15. If the GPS beeps because it has lost satellite signal, try to keep it close to a window. It will find a satellite again when it can.

At your destination:

16. When you reach your destination, please press stop if you have the GPS watch, to conserve its battery while you are not moving. If you have the larger GPS it will be fine to keep running.
17. Please leave the monitor somewhere safe (away from heat sources and somewhere it won't be dropped or bumped).
18. If you go out during the day, please take the monitor with you. Please press start on the GPS watch when you are outside. Wait for the GPS device to find satellites.

At home:

19. When you get home in the evening, please stop the GPS watch. Turn off the GPS device using the power button.
20. Please leave the monitor running for half an hour after you get home. Please put it in the room where you spend most time while you are at home.
21. After half an hour, press 'enter' on the monitor, and it will say 'stop?' Press enter again.
22. Press the on/off/menu button and then press and hold the same button until the machine switches off.

The next day:

23. Please bring all the equipment back to school.

Appendix 2 – Methodology Information Provided to School

Personal Exposure Study Equipment

The pack contains:
Three air pollution monitors
Three GPS devices (two larger ones and a watch)
Three straps (two long ones and one short velcro one)
Three clear tubes

I have also put in the following things that you should not need to use:
Chargers and connector cables for all the equipment
A calibrator for the pollution monitor
Manuals for all the equipment
Spare batteries for the larger GPS devices

Please read the instructions for volunteers
Key points for teaching staff are to make sure that each volunteer has a monitor, a GPS and a tube. Please make a note of which monitor has been used with which GPS device (they all have a number on except the watch).
The monitor can go in a rucksack, but the tube will need to be fixed outside their bag and somewhere near their mouth. Please try this before they go home with the equipment. You can use the strap of the GPS, or the straps in the bag to find a way of doing this. (Please make sure that the end of the tube points down in case it rains).

Possible Problems
The equipment is fairly tough, but please do ask the pupils to look after it.
The batteries are all fully charged so should not need charging during the time that they are with you.
If you have any concerns, please speak to Alex Bulleid on 01392 265718.

Appendix 3 – Teignbridge results – Time dependant variations

Figure 1 - Volunteer 7 – before and after advice

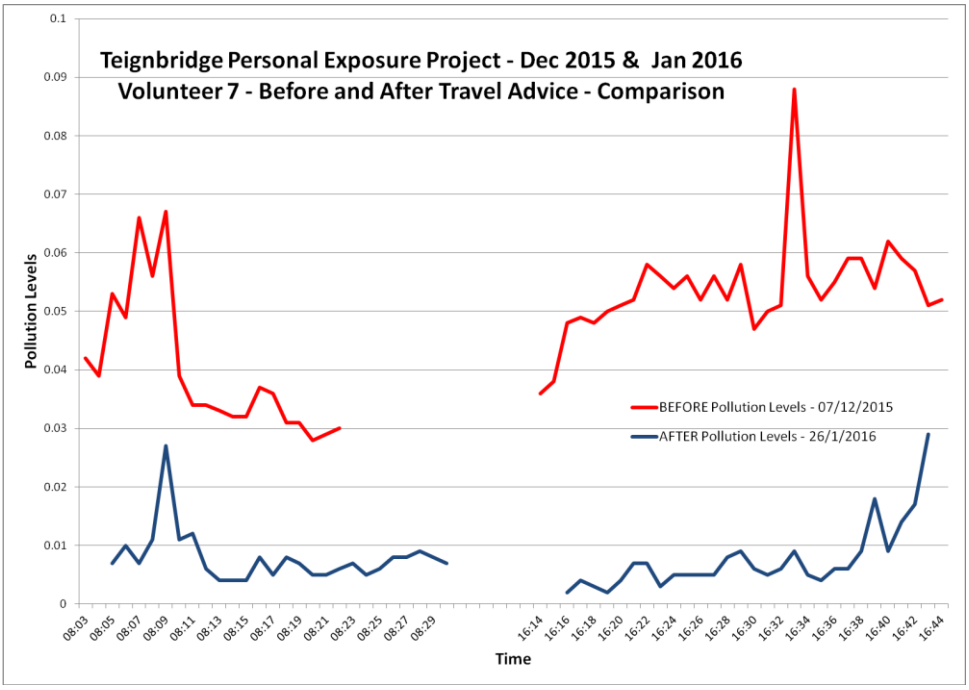
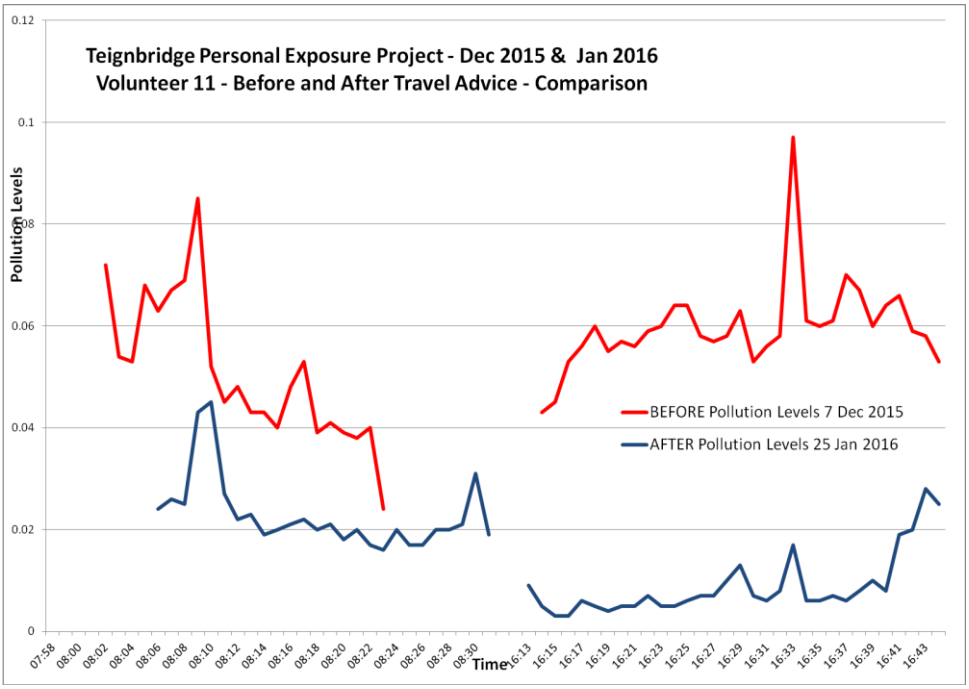


Figure 2 - Volunteer 11 - before and after advice



Appendix 4 – Teignbridge results – Spatial dependant variations

Figure 3 – Volunteer 7 – before advice (AM)

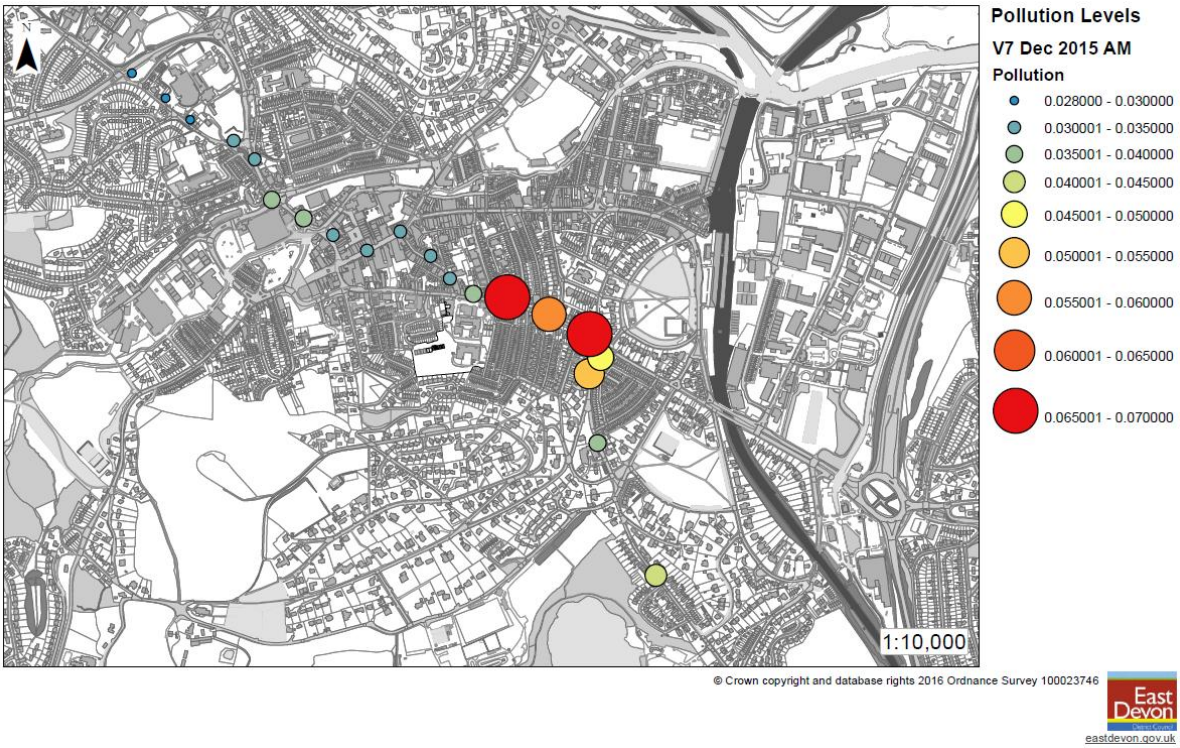


Figure 4 – Volunteer 7 – before advice (PM)

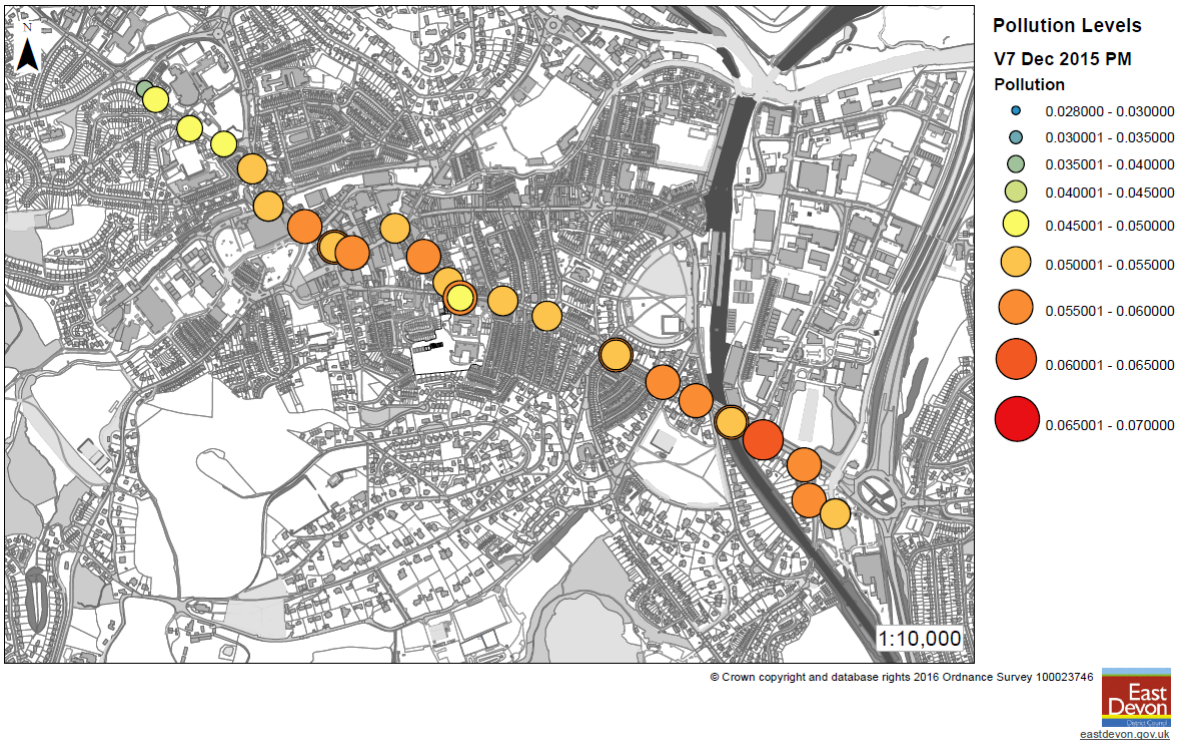


Figure 5 – Volunteer 7 – after advice (AM)

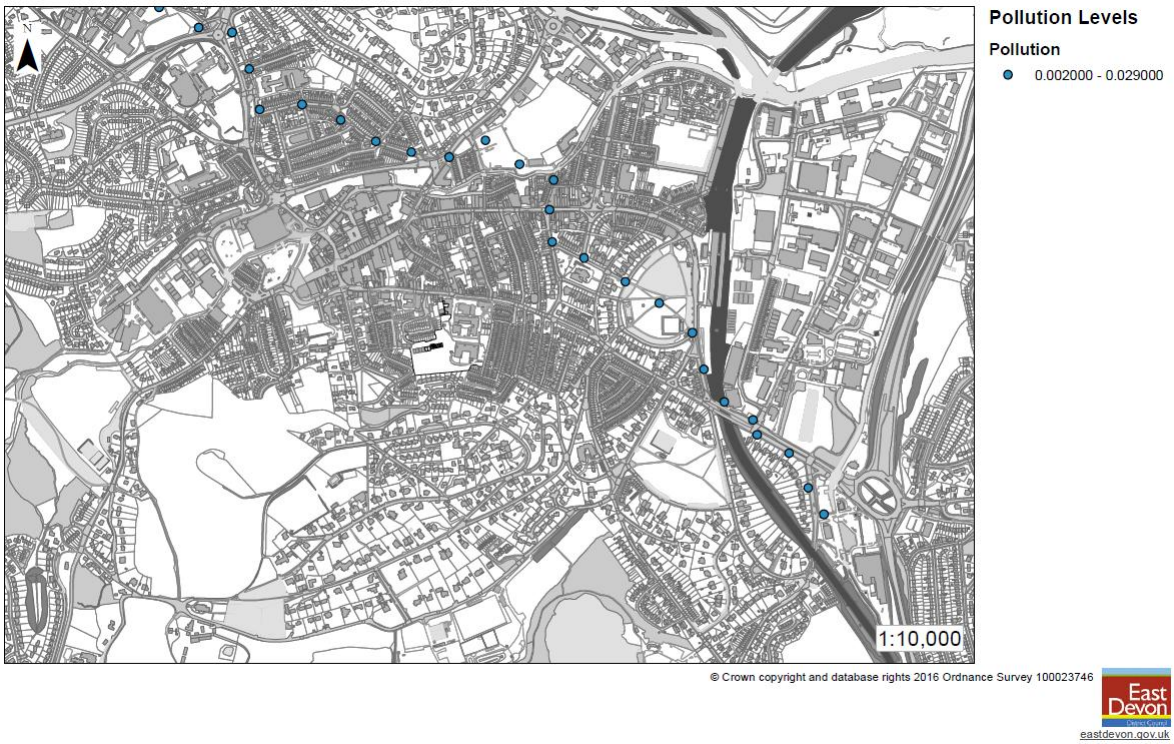


Figure 6 – Volunteer 7 – after advice (PM)

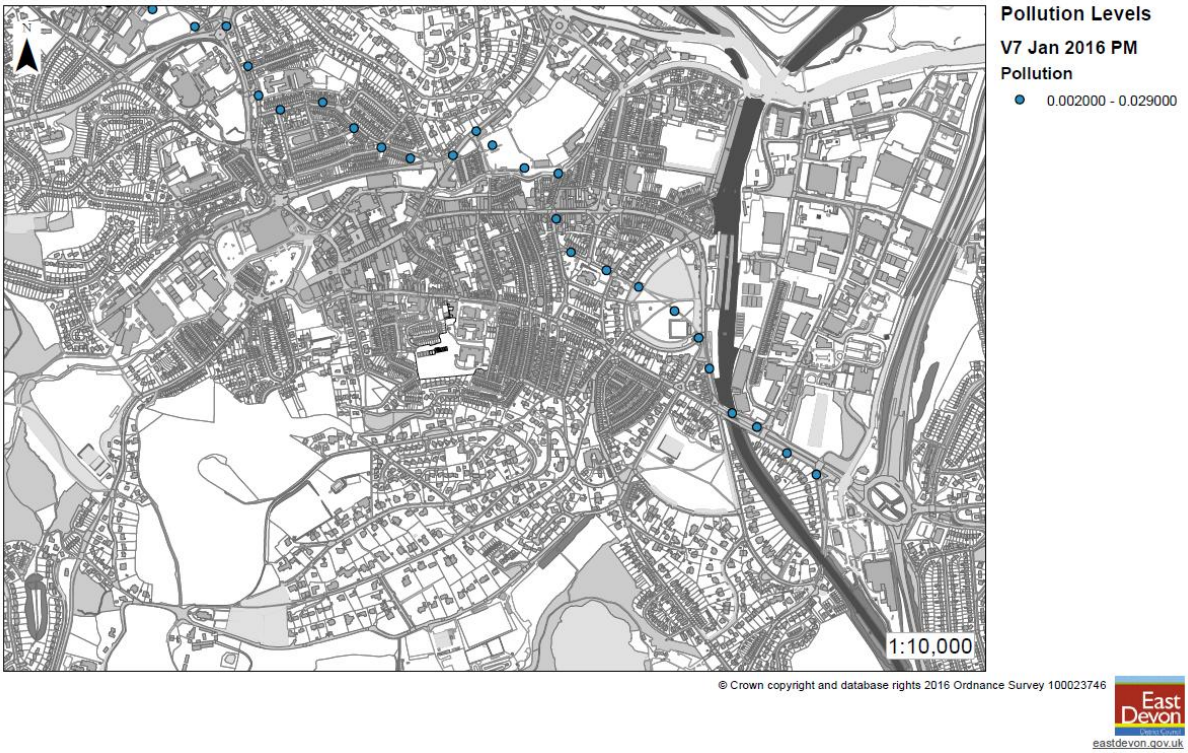


Figure 7 - Volunteer 11 – before advice (AM)

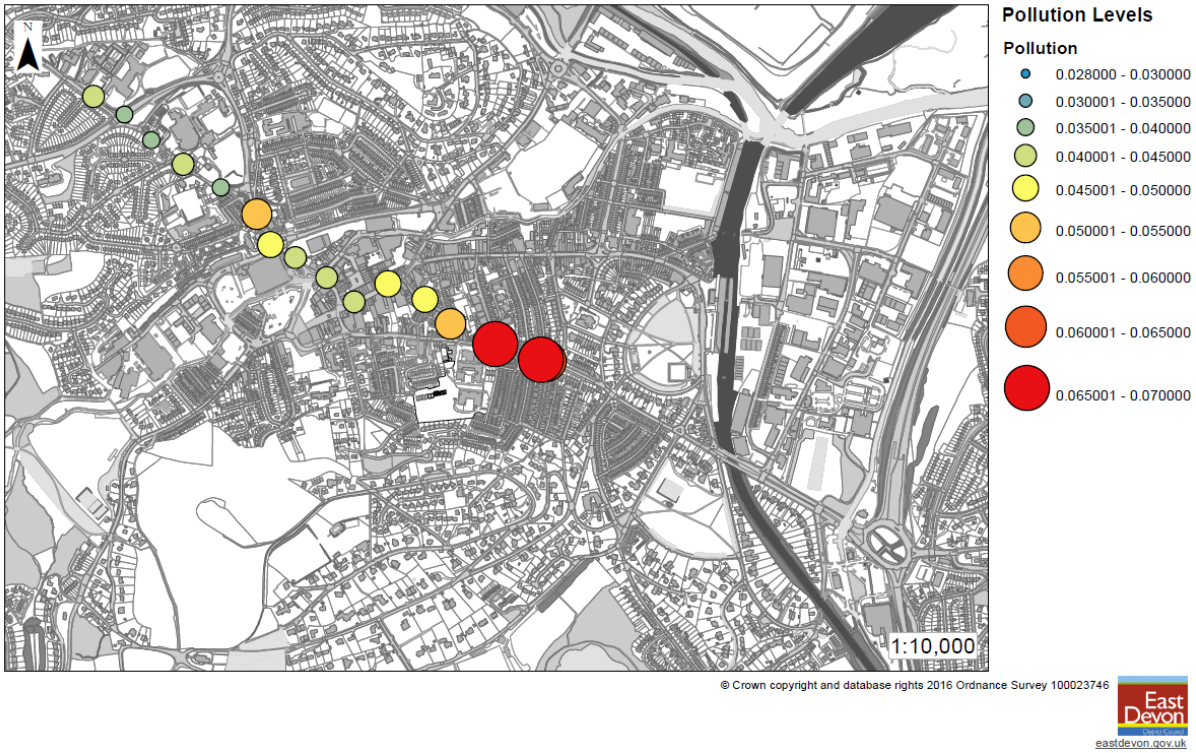


Figure 8 - Volunteer 11 – before advice (PM)

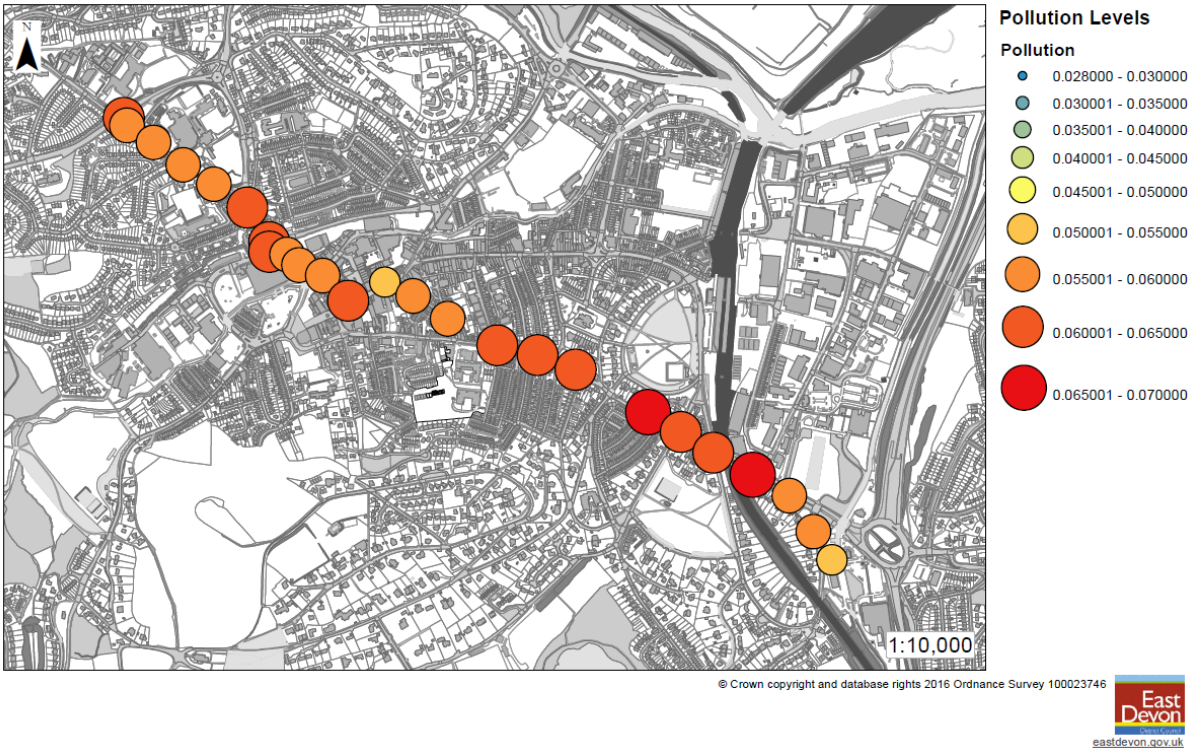


Figure 9 - Volunteer 11 – after advice (AM)

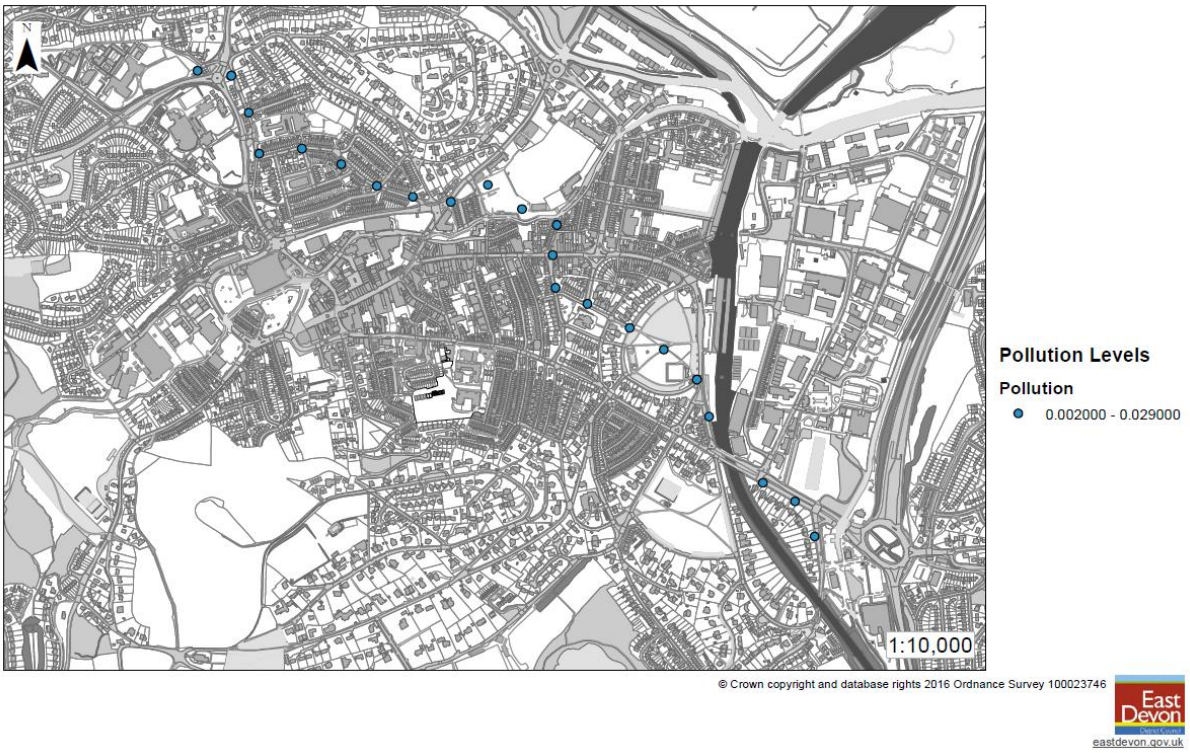
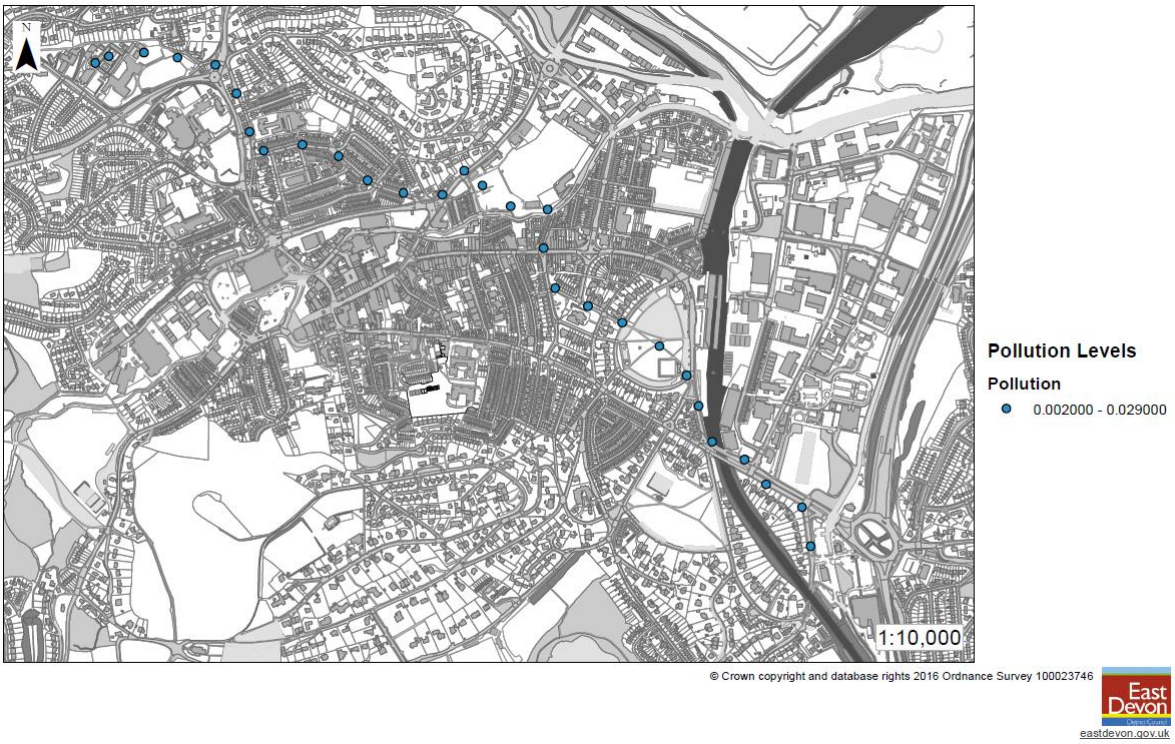


Figure 10 - Volunteer 11 – after advice (PM)



Appendix 5 – Braunton results – Time dependant variations

Figure 11 - Volunteer 1 – before and after advice

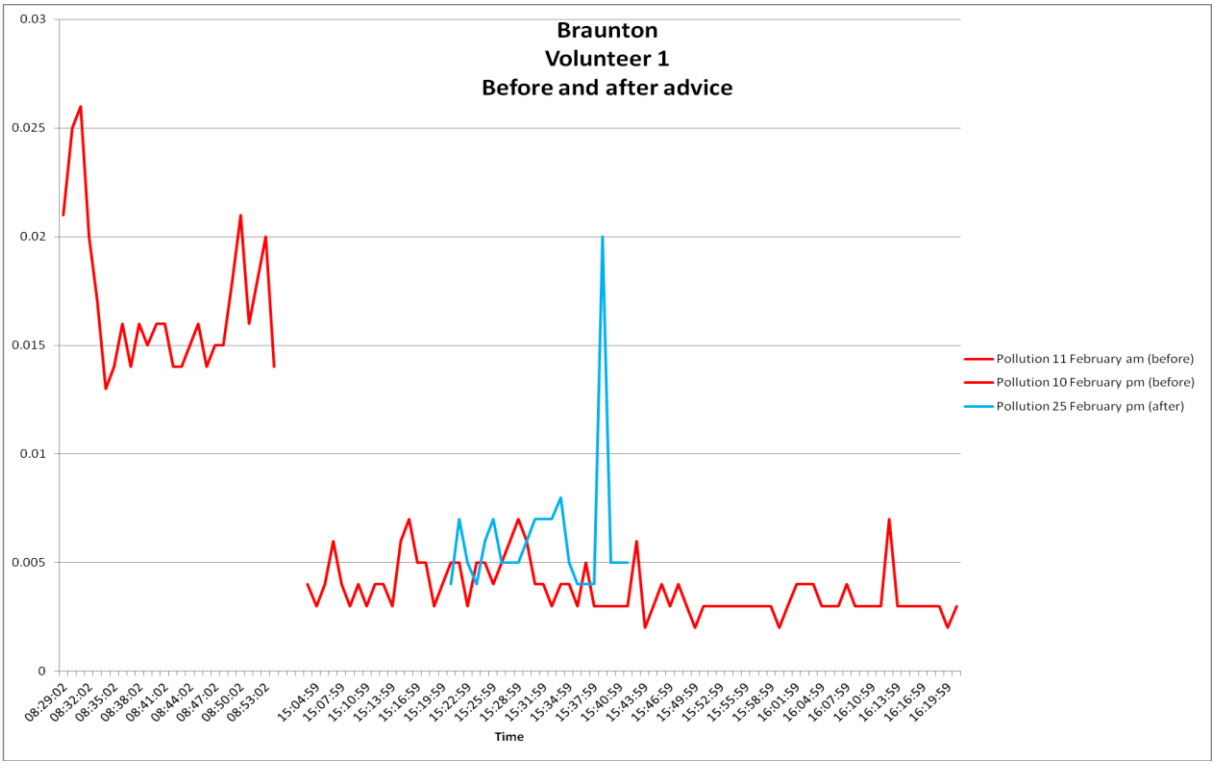


Figure 12 - Volunteer 2 – before and after advice

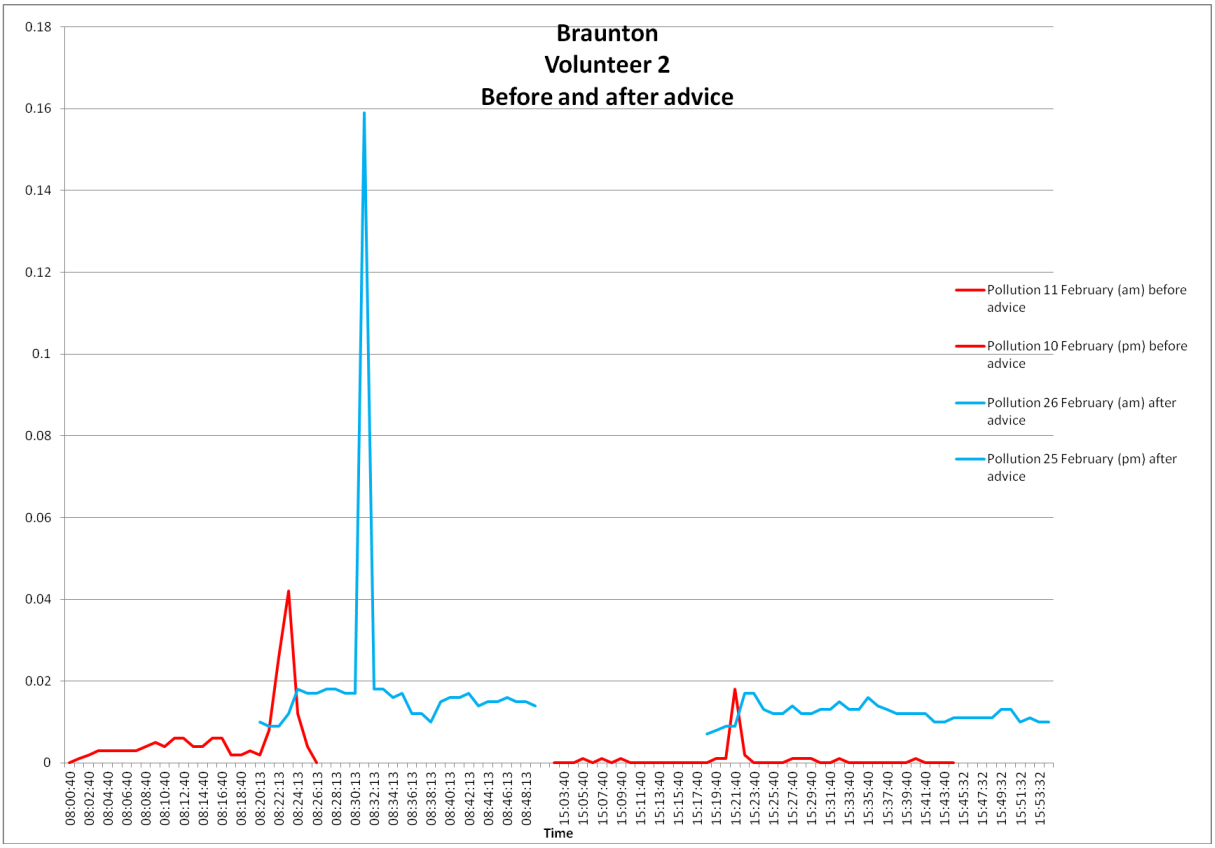
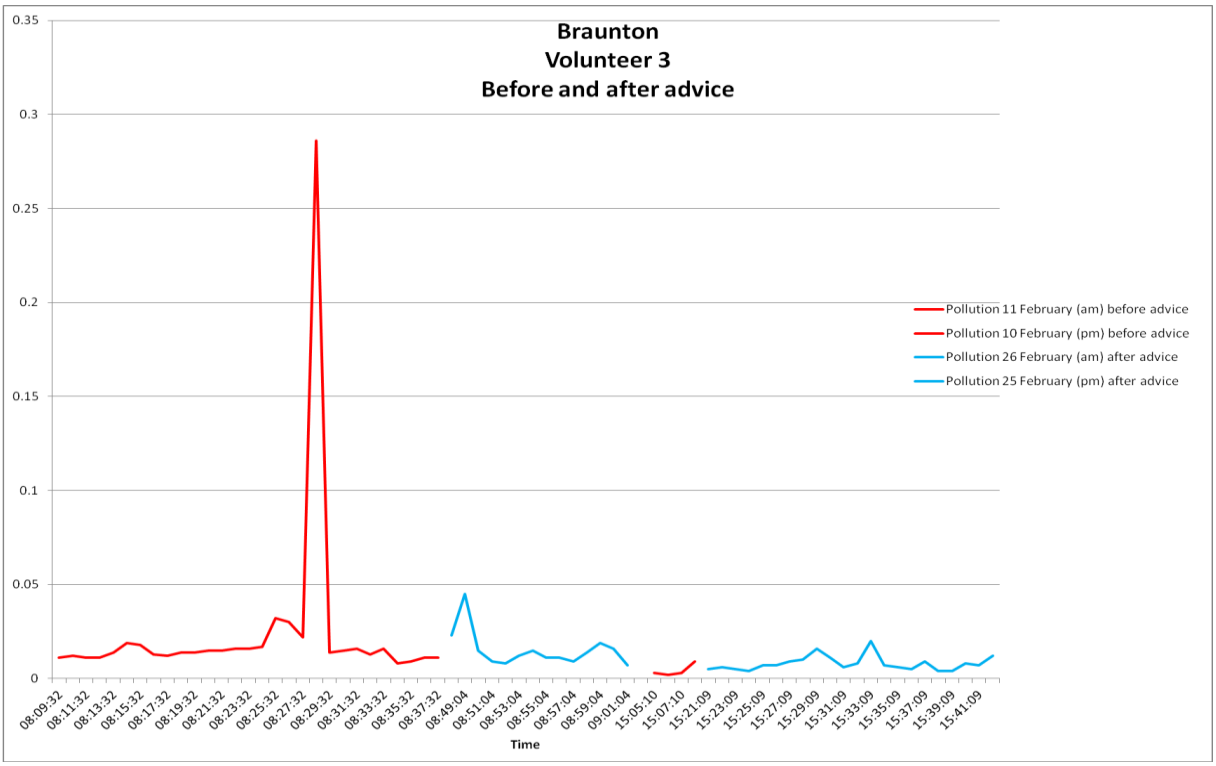


Figure 13 - Volunteer 3 – before and after advice



Appendix 6 – Braunton results – Spatial dependant variations

Figure 14 - Volunteer 1 – before advice (AM)

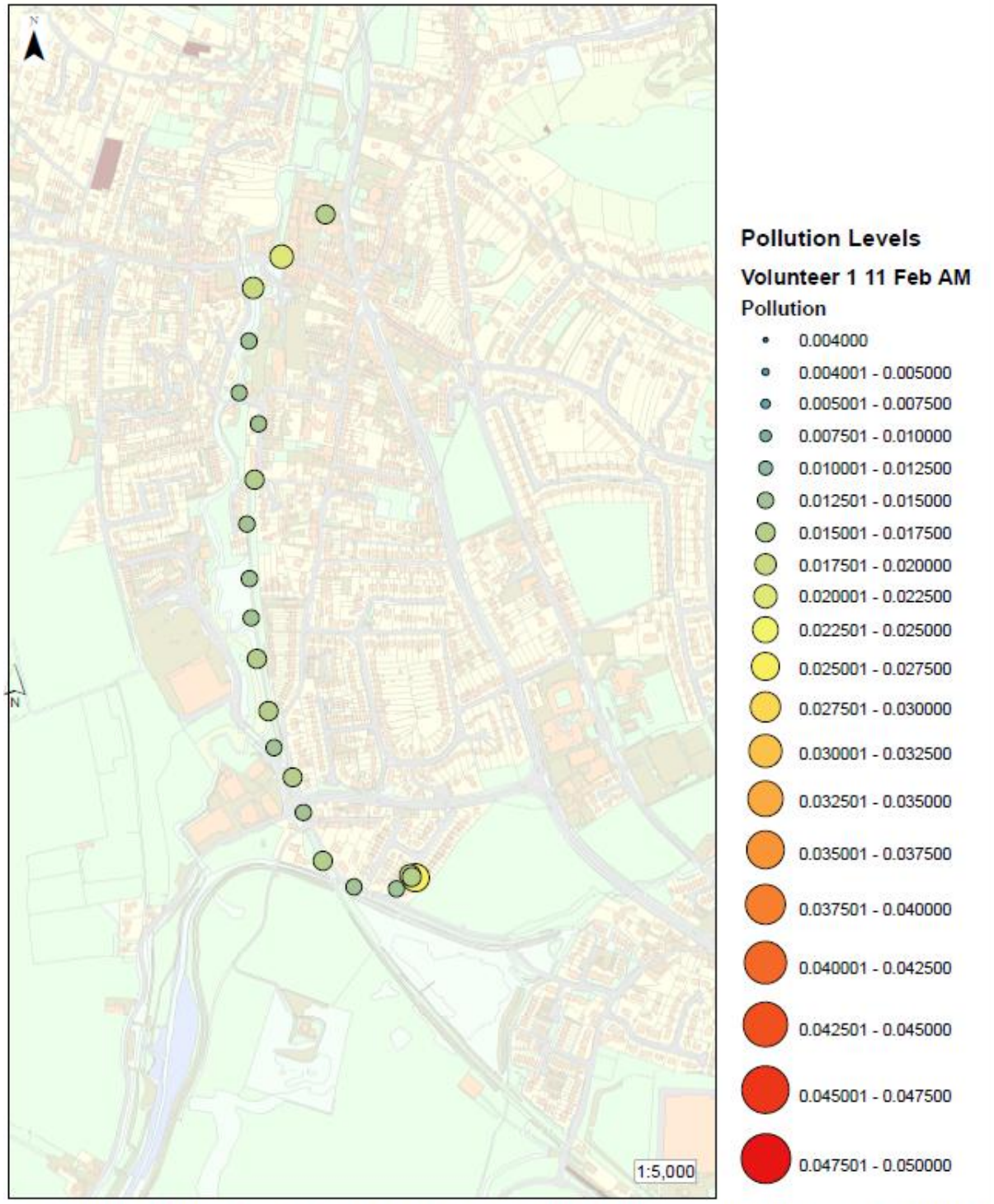


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Figure 15 - Volunteer 1 – before advice (PM)

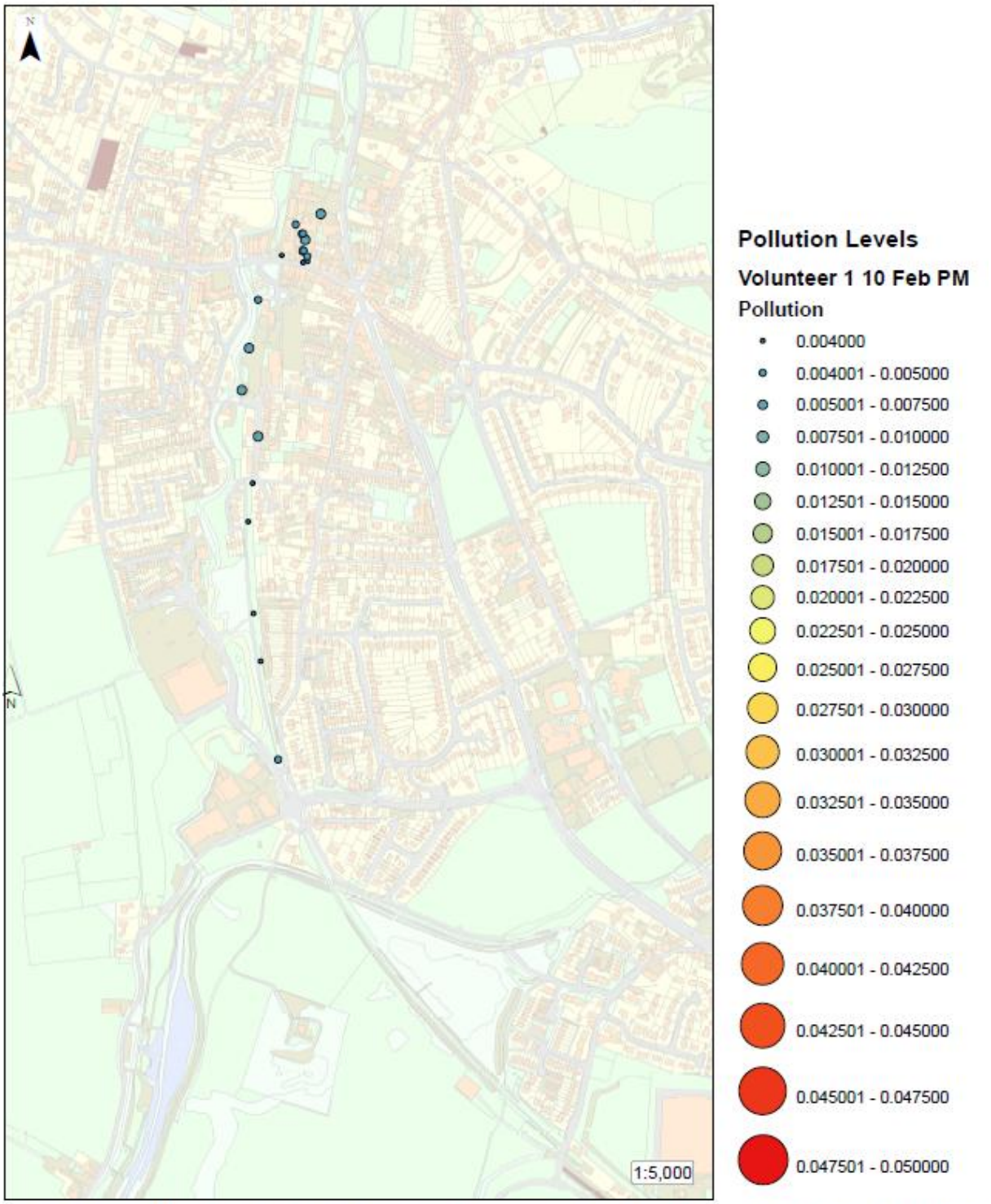

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Figure 16 - Volunteer 1 – after advice (PM)

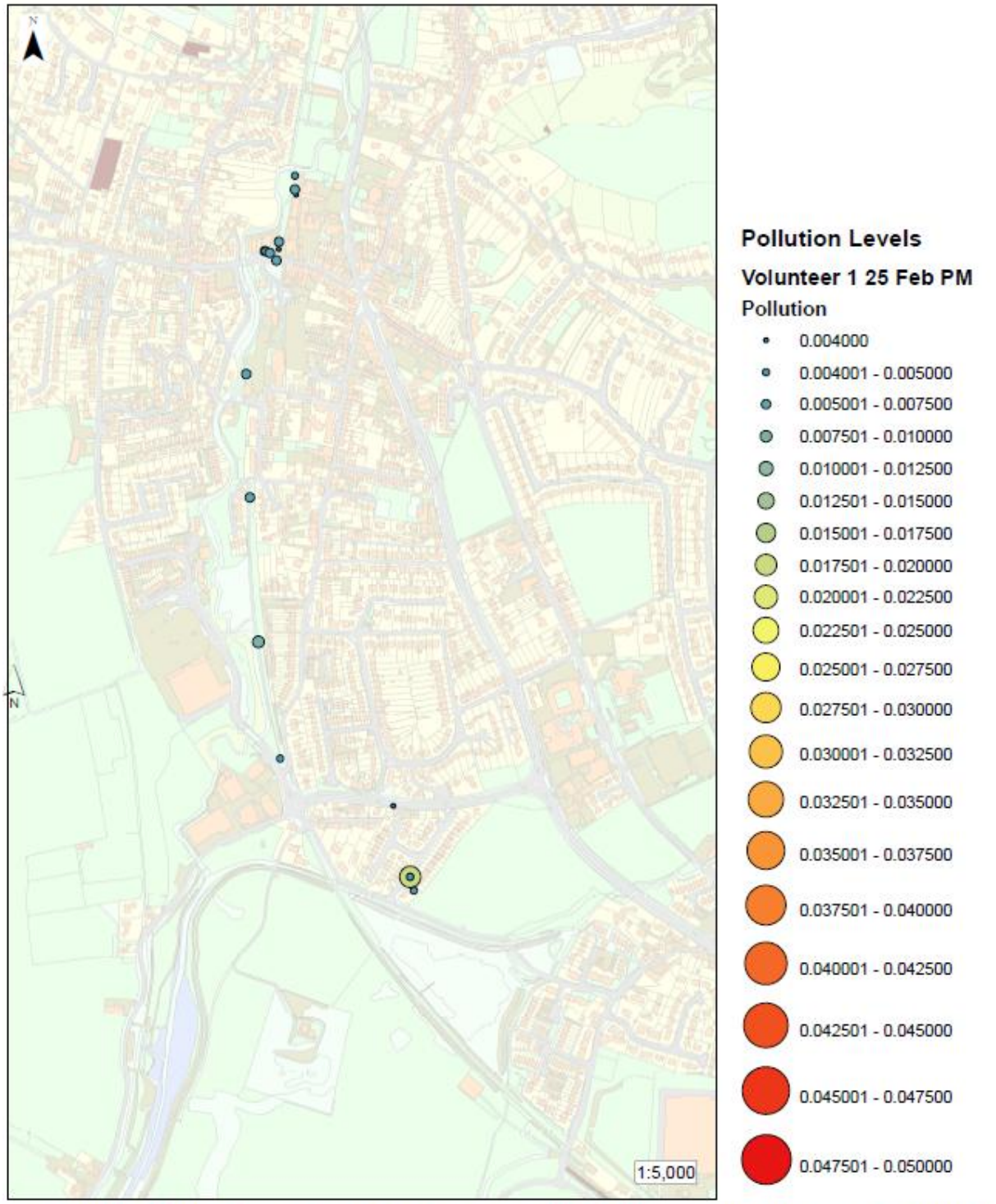

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Figure 17 - Volunteer 2 – before advice (AM)

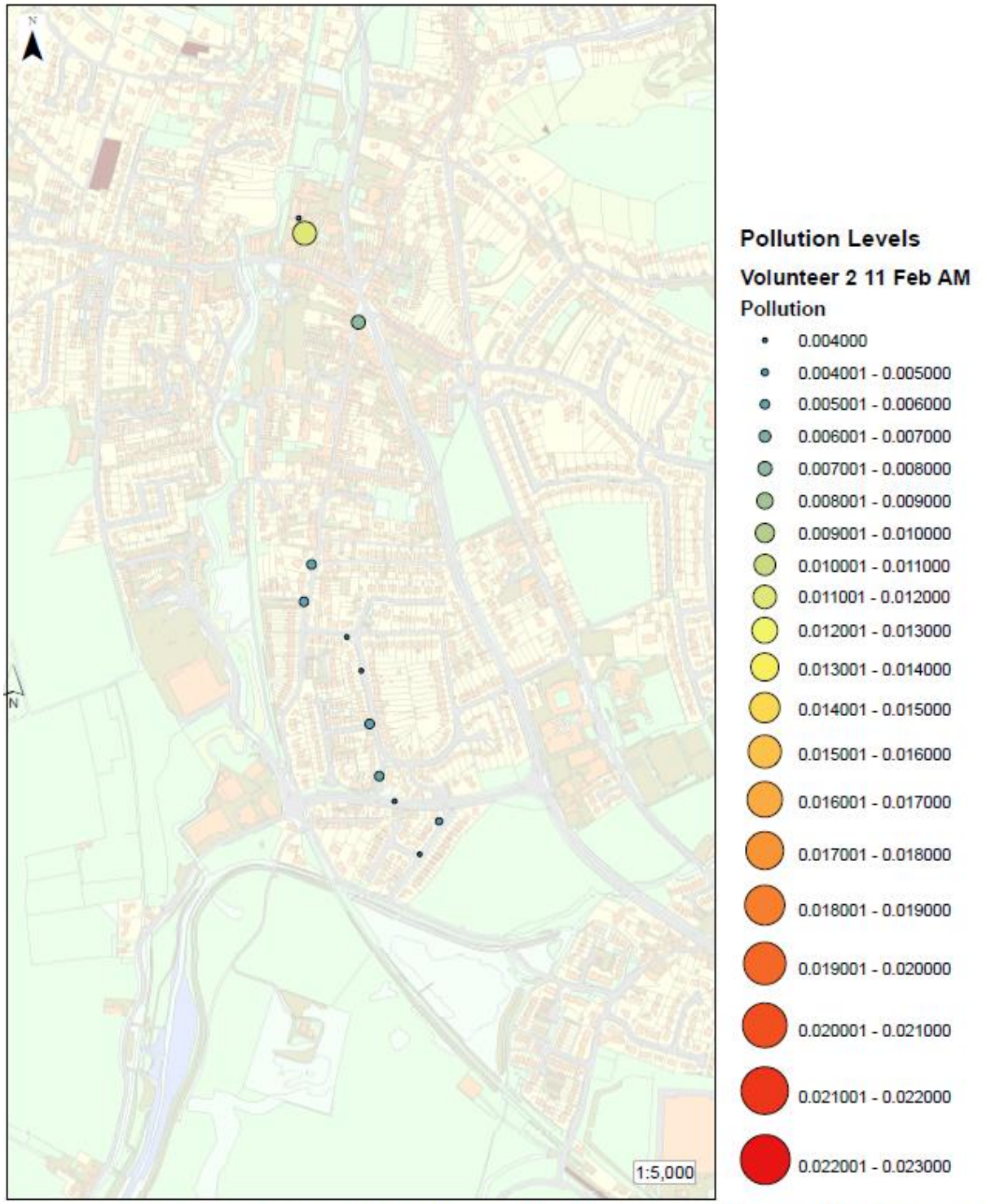

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Figure 18 - Volunteer 2 – after advice (AM)

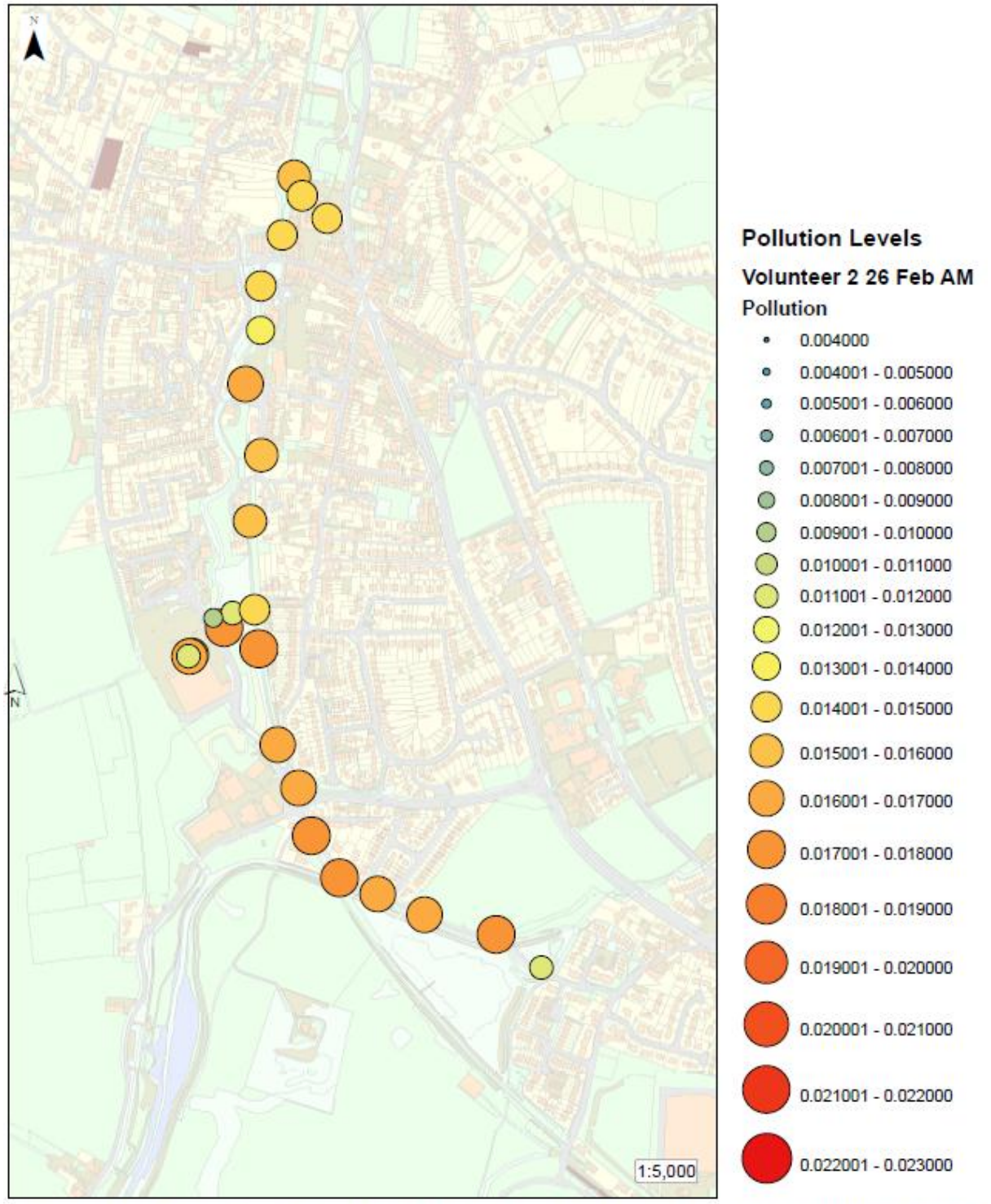

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Figure 19 - Volunteer 2 – after advice (PM)

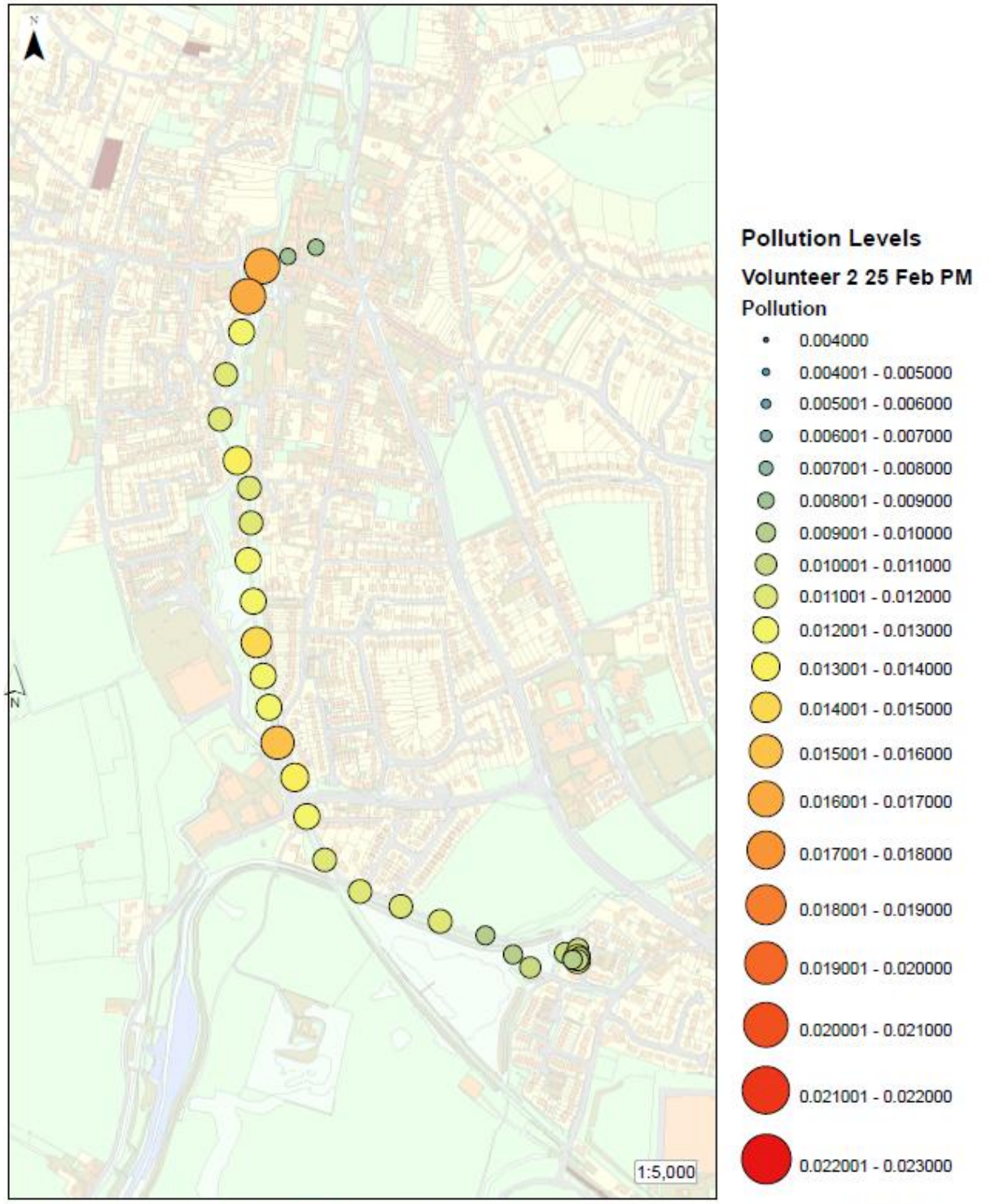

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Figure 20 - Volunteer 3 – after advice (AM)

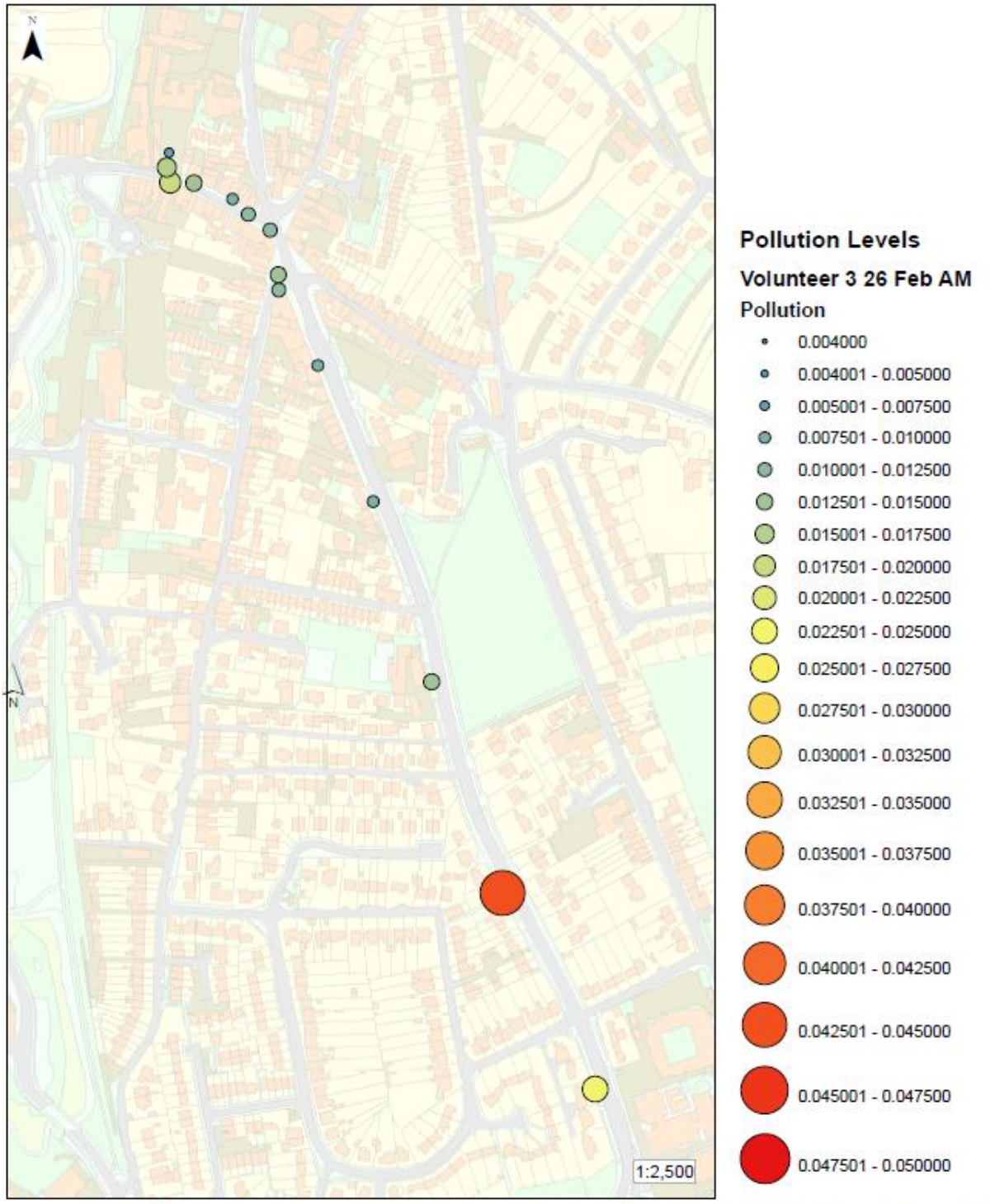

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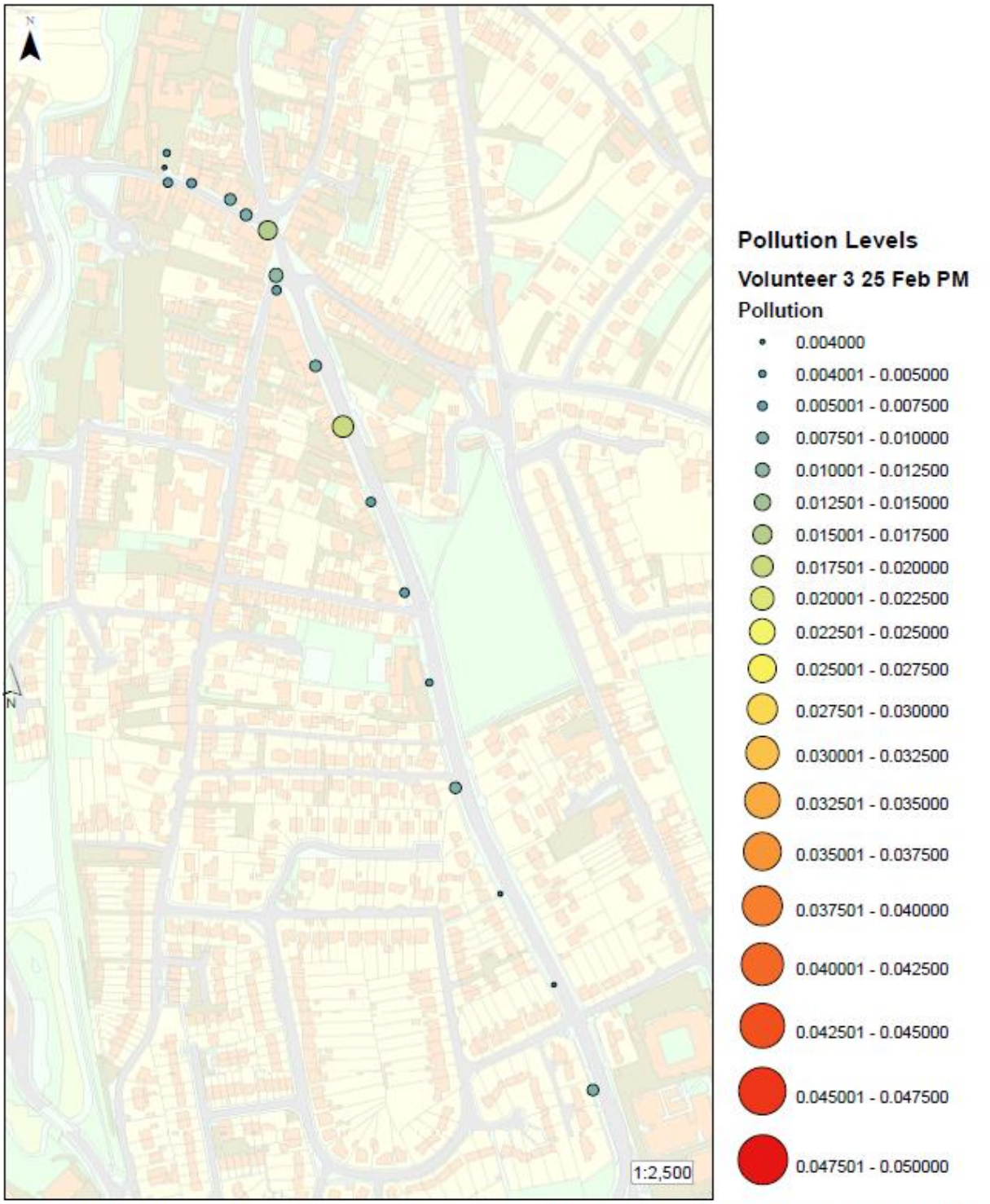
Figure 21 - Volunteer 3 – after advice (PM)



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