Developing metrics and instruments to evaluate citizen science impacts on the environment and society

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Abstract (for dissemination)	Deliverable 4.1 provides a description of the citizen-science activities and case studies in the UK that the MICS impact assessment will be tested in 2021. Across the UK, citizen science plays an important long-term role in data collection and monitoring before, during and after NBS implementation. Citizen-science activities are widespread across the UK and are an accepted method of engagement, stakeholder collaboration, data collection and monitoring. The MICS metrics and tools will be applied to: (i) Outfall Safari citizen science initiative which aims to detect and record pollution from surface water outfalls to gather evidence and report on pollution incidents; (ii) Riverfly Anglers Monitoring Initiative which aims to monitor key macroinvertebrate species (riverflies) that are indicators of river water quality; and, (iii) Work of the Farming Wildlife Advisory Group who encourage farmers and volunteers to detect and manage water quality related problems.				
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Executive Summary

The MICS project is developing an integrated platform of metrics and instruments to measure the impacts of citizen science across five domains: society, environment, economy, science & technology, and governance. The MICS project will test and validate these metrics and instruments in hands-on citizen science activities in four case studies to evaluate the impact of Nature-based Solution(s) (NBS) in Western Europe: (UK); Southern Europe (Italy); and in Central and Eastern Europe (Hungary & Romania). The project, as indicated in the MICS DoA, adopts the definition of Nature-based Solutions by the International Union for Conservation of Nature (IUCN): NBS are …"actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". The MICS case studies represent different types and stages of water related NBS implementation, with some activities in the early planning phase, some underway and others already implemented. Deliverable 4.1 provides a description of the citizen science activities and case studies in the UK. The MICS impact assessment will be tested on these case studies in 2021.

Across the UK, citizen science plays an important role in data collection and monitoring before, during and after NBS implementation. Citizen science activities are widespread across the UK and are an accepted method of engagement, stakeholder collaboration, data collection and monitoring. Many of the citizen science activities enable the assessment and monitoring of environmental problems. We are using established citizen science methods and projects to:

a) Compare different approaches of citizen science set up (in the UK most citizen science activities are scientist led and citizens have a contributory or collaborative roll, this will be compared to the co-design set up of citizen science activities being followed in the other MICS case studies); and,
b) Test the MICS impact assessment method.

The established and long running UK case studies allow the MICS team to investigate the outcomes and longer-term impacts of citizen science on society, the environment, science & technology, governance and the economy.

The UK case studies include the Outfall Safari citizen science project, Riverfly Anglers Monitoring Initiative (ARMI), and Water with Integrated Local Delivery (WILD) citizen science activities. The case studies were selected as collectively, over 3000 citizen scientists have been involved with monitoring and data collection over the last 10 years across the UK.

The Outfall Safari Citizen Science initiative aims to detect and record pollution from surface water outfalls to gather evidence and report on pollution. The citizen science activities have been ongoing for over five years in Greater London, with 179 citizen scientists involved. We are planning workshops with the citizen scientists and regulatory stakeholders involved to identify the impact journey pathways and prioritise the indicators to measure the outcomes and impacts of Outfall Safari in 2021.

The Riverfly Partnership was established in 2004 to monitor key macroinvertebrate species (riverflies) that are indicators of river water quality. The Partnership consists of a network of over 180 organisations, including angling clubs, local conservation groups and wildlife trusts, who coordinate the activities of local volunteers. Currently, there are 3,000 active volunteers who engage with Riverfly monitoring across the UK. There are several monitoring methodologies that have been developed by Riverfly, of which the Anglers' Riverfly Monitoring Initiative (ARMI) is the most widely used, having been successfully applied nationally. We have approached several organisations coordinating local Riverfly activities who have expressed interest in being involved in the testing of the tools and metrics developed by MICS for measuring impact. We plan to hold workshop with coordinators and citizen scientists involved in Riverfly monitoring to identify the impact journey pathways and prioritise the indicators to measure the outcomes and impacts of Riverfly in 2021.

The WILD project, led by the Farmers and Wildlife Advisory Group (FWAG), was initiated in 2016 and looks to improve the water quality of rivers in the Cotswold Water Park located in the Upper Thames River Catchment. Currently, only one third of water bodies in the Upper Thames Catchment meet Good Ecological Status. This is due to a variety of problems, including high phosphate levels, poor aquatic biodiversity, and poor water quality. The WILD project aims to address these issues across the entire Upper Thames River Catchment by engaging with local landowners and farmers, local communities and interest groups in order to improve water quality and biodiversity to meet the requirements of the Water Framework Directive (WFD). Volunteers are engaged in a variety of activities, including site surveying, enhancement activities and monitoring. We plan to hold workshops with coordinators and citizen scientists involved in WILD to measure the outcomes and impacts of WILD in 2021.

In the UK case studies, we are planning workshops with the stakeholders involved in the citizen science activities to understand the key outcomes and impact journeys of the project. This will enable the stakeholders to prioritise indicators to measure the impact of their project. We will then assess the impact of each case study using the indicators selected. This will allow us to measure the impact of

each citizen science activity, and help us test the usability and effectiveness of the MICS impact assessment and platform. The results from these activities will be reported on in the comprehensive evaluation report (Deliverable 4.5) in 2021.

1 Introduction

1.1 Background on MICS

The MICS project develops approaches and tools to assess citizen science impacts. These approaches and tools can help to plan and implement projects in ways that lead to more robust results. The MICS project specifically aims to:

- provide comprehensive, participatory and inclusive metrics and instruments to evaluate citizen science impacts;
- implement an impact-assessment knowledge-base through toolboxes for methods application, information visualisation, and delivery to decision makers, citizens and researchers;
- improve the effectiveness of nature-based solutions through test-site development and citizen-science tool validation;
- generate new approaches that strengthen the role of citizen science in supporting research and development;
- foster a citizen-science approach to increase the extent to which scientific evidence is taken up by policy makers through recommendations and guidelines.

The result is an integrated platform where these metrics and instruments are available for use by anyone involved in a citizen science project wanting to understand its impact, whether at the planning stage or several years after the project's conclusion. This platform is validated by pilot testing in test and validation sites across Europe. The test and validation sites are in the UK, Italy, Hungary and Romania. These sites explore the applicability of MICS impact-assessment tools in regions with differing needs, contexts, and approaches to nature-based solutions, and with various levels of citizen-science application. For example, in Western Europe, river restoration is increasingly carried out within an ecosystem-based management framework at river or catchment scale; in Southern Europe, river restoration tends to be issue-specific with some ecosystem relevance; in Central and Eastern Europe, river restoration is about ecosystem protection and related to existing infrastructure.

1.2 Purpose

The MICS project is tasked with setting up and implementing an Impact Assessment framework, tools and metrics for citizen science projects that serves to capture impacts in five distinct domains: society, science, environment, economy and governance. This report is a deliverable of Work Package 4 (WP4) – 'Test-site development and tool validation' which will develop and organise the pilot testing of the MICS Impact Assessment framework and tools in the test and validation sites in the UK, Hungary, Romania and Italy. The purpose of Deliverable 4.1 is to provide a description of the UK case studies and citizen science activities in which the MICS impact assessment will be tested on and reported on in the comprehensive evaluation report (Deliverable 4.5) in 2021.

1.3 Structure of the report

This document firstly outlines the types of citizen science activities in the Western Europe Region (UK). Following this, a description of the UK case studies (Outfall Safari, Riverfly, Farming Wildlife Advisory Group), and the impact domains the case studies address is outlined. A description of the citizen science activities completed to date is included, and the report concludes by outlining the next steps for measuring impact of the citizen science activities.

2 Citizen Science in the Western Europe Region (UK)

Volunteer involvement in science has a long history in the UK, but is now widely included under the umbrella of citizen science (West et al., 2016). UK Government and EU legislation (e.g., 25 Year Environmental Plan (Defra, 2018); Environmental Land Management Scheme (Defra, 2020; EU Habitats Directive (92/43/EEC); EU Water Framework Directive (2000/60/EC)) requires us to monitor and improve our environment, but in a context of diminishing resources (Mackechnie et al., 2011). Citizen science is an accepted and established method of engagement, data collection and monitoring in the UK, and provides an important source of information for understanding and monitoring our environment (Tweddle et al., 2012).

In the UK, citizen science projects are often contributory or collaborative. Contributory projects are led by scientists where citizens primarily collect or analyse data. In contrast, collaborative projects are designed by scientists, but participants are involved in more than one stage of the scientific process (perhaps contributing or analysing data, helping to inform the way in which the questions are addressed or communicating findings), (Haklay, 2013). More recently, a co-design approach, where citizen scientists are empowered and involved in leading ideas and decisions in every part of the scientific process of a NBS project is being encouraged (Catchment Monitoring Cooperative, 2020). Citizen science has played a progressively greater role within Catchment Based Approach initiative (CaBA) in England, driven, in part, by the availability of a wealth of field-testing kits and hand-held apps and platforms with which to capture and display the data (Collins et al., 2020).

In the UK MICS case studies, we draw on three established citizen science initiatives (Outfall Safari, Riverfly Anglers Monitoring Initiative and the Farming Wildlife Advisory Group) to investigate citizen science outcomes and longer-term impacts. We focus on established contributory and collaborative (scientist-led) citizen science projects to enable us to explore the long-term impacts of the citizen science activities across the MICS domains. As a result, the UK case studies differ in this respect to the Romanian, Hungarian and Italian MICS case studies, which focus on the co-design set up of citizen science activities and short-term outcomes. The UK case studies therefore allows us to compare the different approach to citizen science activity set up (e.g. scientist-led) and how that influences the project impact to provide recommendations for citizen science.

3 Outfall Safari Citizen Science Initiative

3.1 Introduction to Outfall Safari

Outfall Safari is an innovative citizen science method for locating, assessing the impact of, and reporting polluted surface water outfalls (PSWOs) (Zoological Society of London, 2019). The initiative was developed in response to concerns regarding poor urban river water quality within Greater London, and the need to address polluting outfalls and so-called ‘misconnections’ in the sewage

system. The objective of Outfall Safari citizen science project is to detect sewer related pollution in rivers from misconnections, cross connections and blocked sewers. The identified polluting surface water outfalls are reported to the regulator (e.g. Environment Agency) and Water Company to resolve the issue as soon as possible.

Figure 1. Polluting surface outfalls (PSWO). Source: Zoological Society of London (2017).

The UK sewer system consists of foul and surface water drains (Dunk et al., 2007). Surface water drains convey rainwater runoff from roads, roofs and hard standing areas directly to rivers and streams via surface water outfalls (SWOs), while foul drains carry domestic wastewater to sewage treatment works for purification. Misconnections occur when domestic 'white goods', e.g. washing machines, dishwashers and toilets etc., are incorrectly plumbed into the surface water drainage system. As a result, raw foul sewage can flow directly into rivers untreated and the outfall becomes a PSWO (Figure 1). The improper use of surface water drains can also be a source of PSWO, e.g. the disposal of waste such as wet wipes, oils, fats and chemicals.

Outfall Safari was developed in partnership with the Zoological Society of London (ZSL), Environment Agency, Thames Water, Friends of River Crane Environment and Frog Environmental. The method was first tested and applied in Great London, in the River Crane Catchment in 2016 (Citizen Crane Valley Partnership, 2015 – www.cranevalley.org.uk/projects/citizen-crane.html).

In 2017, over 110 volunteers completed Outfall Safari surveys across Greater London, covering over 142 km of rivers, assessing more than 1177 outfalls (Zoological Society of London, 2017). After the 2019 surveys there were a total of 179 volunteers who had been involved, surveying a total length of 255 km of rivers. In 2019, ZSL and The Rivers Trust produced a free guide and resources package on the Catchment Based Approach Website (www.catchmentbasedapproach.org/learn/outfall-safari-guide/) to assist environmental NGOs and water companies in applying the Outfall Safari method in other areas of the UK, e.g. Alfreton Brook, Derbyshire (www.trentriverstrust.org/project/the-river-starts-here/), and River Thame, Hertfordshire (https://riverthame.org/get-involved/volunteering/aylesbury-outfall-safari/). In early 2020, 44 new volunteers were trained in the Outfall Safari method, but the surveys were unfortunately cancelled due to the COVID-19 pandemic.

3.2 Measuring the Impacts of Outfall Safari Citizen Science Activities

Outfall Safari was selected as a case study to apply the MICS metrics and tools because:

1. Outfall Safari provides an example of an established citizen science method that has been running for over five years. Outfall Safari therefore provides the opportunity to look at outputs, outcomes and, importantly for MICS, the longer-term impacts of the citizen science activities.
2. Outfall Safari aims to identify polluting surface water outfalls, which provides baseline environmental data to help tackle misconnections and/or support the need for NBS implementation to reduce pollution impacts.
3. The project includes a wide range of stakeholders. For example, a typical Outfall Safari involves a private water company, environmental regulators (e.g. the Environment Agency, Non-Governmental Organisations (e.g. Catchment Partnerships, rivers trusts, conservation organisations) and the volunteer citizen scientists. This allows us to investigate different perceptions of impact related to the project.
4. The method has been tested and applied on over 255 km of rivers across Greater London and the UK, as a result there is a large citizen scientist cohort (179 citizens involved) and opportunity for investigating the impacts of the initiative spatially.
5. Outfall Safari citizen science activities have multiple impacts across all five MICS impact domains: Environment, Science & Technology, Society, Governance and Economy (Table 1).

Table 1. The MICS impact domains and the desired long-term impacts of Outfall Safari associated with each domain.

Impact Domain	Description
Science & Technology	Develop a standard method for assessing polluting surface water outfalls. Produce a baseline of data on polluting surface waterfalls. No previous monitoring or data set of pollution from surface waterfall outfalls exists.
Society	Raise awareness and increase knowledge associated with the problems of incorrectly plumbed - or 'misconnected' - home appliances, and the improper disposal of waste. Teach society how to identify polluting outfalls and provide a process for reporting them to the local authorities.
Environment	To improve London's Rivers for wildlife.
Governance	To resolve existing misconnections in older properties and prevent new misconnections occurring from new and re-developments through national legislation (i.e. all properties to require a 'drainage checks' at the point of sale, as outlined in GLAs Environ. Strat., Aug. 2017) and regional/local action (i.e. checks of drainage design at various levels of planning).
Economy	To increase spending in detection and in resolving issues of polluting outfalls Reduced investment in resolving costs of cleaning / mitigating pollution. To improve green infrastructure (landscape, wildlife and access) opportunities and investment.

The MICS case study focuses on Outfall Safari citizen science activities in Greater London and will then investigate impacts of Outfall safari in other locations in the UK (e.g. Alfreton Brook, Derbyshire). The case studies provide the opportunity to investigate the impact of the same citizen science initiative in different locations, with different stakeholders and in different environmental settings.

3.3 The Problem

3.3.1 Pollution from Surface Water Outfalls

Polluted surface water outfalls (PSWOs) can reduce dissolved oxygen and increase ammonia and phosphate levels, which can damage the natural environment (Zoological Society London, 2019). The earlier those PSWOs are reported to a water company and regulator, the sooner they can be investigated, and the pollution stopped.

Privatisation of the water sector in England and Wales in 1989, to improve efficiencies, resulted in 10 water and sewerage companies taking ownership and maintenance of the UK sewerage system (WWF, 2017). In England and Wales, water pollution offences are contained in the Environmental Permitting (England and Wales) Regulations 2010: regulations 38(1) and 12(1). Pollution incidents that fail to comply with the law, or breach permit conditions are investigated, at which point formal enforcement and fines may be required (WWF, 2017). Most of the present-day sewerage infrastructure was installed over half a century ago and many surface water outfalls remain undocumented. In addition, no standard methodology existed to monitor surface water outfalls before the development of Outfall Safari. Therefore, detecting the location of polluting surface water outfalls is problematic. Sewage pollution is a hidden problem and very little information is in the public domain, so public awareness is low.

At the national scale, it is estimated that 3% of properties are misconnected, amounting to 300,000 misconnections (CIPEHE, 2017). Evidence regarding the impact of misconnections and PSWOs has been divergent and contentious, with the issue complicated by the absence of a standardised method for identifying and monitoring PSWOs (Ellis and Butler, 2015). The work of the Connect Right Campaign (www.connectright.org.uk/campaign) and the development of Outfall Safari citizen science initiative aims to raise awareness about drainage and water pollution among property owners, the public and professionals.

3.3.2 Polluted Surface Water Outfalls in Great London

In the UK, the scale of misconnections is believed to be worst in the South East of England, specifically London, with an estimated 10% of properties in the Thames region being wrongly connected (Dunk et al., 2007). Within the Greater London Authority boundary, only one waterbody is at 'good' ecological potential under the Water Framework Directive (Zoological Society of London, 2017). The Environment Agency identifies misconnected pipes / polluting outfalls as being one of the major contributors to poor urban water quality.

Thames Water are responsible for the management of the sewer network in Greater London. Greater London is serviced by two drainage systems (Figure 2). The combined sewerage system is where surface water and wastewater drains flow through the same system and are diverted directly to the sewage facilities for treatment before discharging into rivers. Then there is a separate sewage system, which consists of a surface water drainage network which collects rainwater that flows straight into

rivers, and a wastewater drainage network which diverts domestic and industrial wastewater to sewage facilities for treatment prior to being released into the river system (Figure 2).

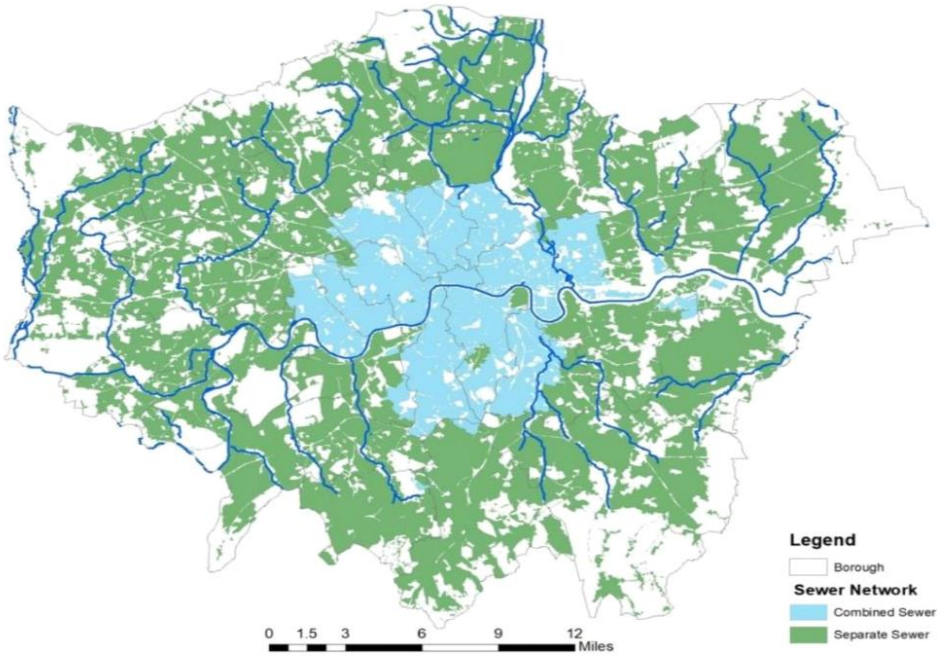


Figure 2. Rivers and sewage network of Great London. The River Thames and its tributaries are represented in dark blue. The dominant type of sewer – *combined* or *separate* – for each area is indicated. Source: South East Rivers, 2020.

Prior to 1997, Thames Water carried out only a limited amount of work to address PSWOs from the surface water drainage network. This in addition to the absence of a co-ordinated regional strategy and communication with the Environment Agency (EA) lead to concerns regarding the effectiveness of remedial works and responsibilities of enforcement (Dunk et al., 2007). To overcome these problems, it was agreed that Thames Water should work in partnership with the EA to address the complex problem of PSWO. Thames Water and the EA agreed the following strategy:

- Engage with local municipal authorities (there are 32 in Greater London)
- Incorporate PSWO within Thames Waters Asset Management Plan (AMP)
- Contract specialists for pollution tracing
- Develop an effective communication and education strategy for local stakeholders and communities
- Produce a protocol for the identification and remediation of misconnections
- Explore alternative methods of pollution tracing

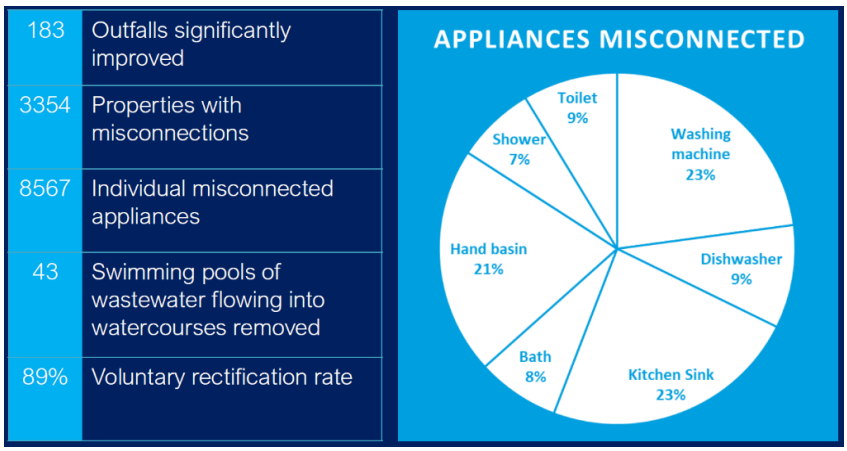


Figure 3. Details of sources of misconnections in the GLA identified and tackled under Thames Waters Surface Water Outfall Programme (SWOP) from 2015 – 2020. Outfall Safari citizen science activities alongside other actions by Thames Water have contributed to these statistics. Source: Thames Water (2019).

Thames Water have developed a Surface Water Outfall Program (SWOP), which aims to identify and fix polluting outfalls. The SWOP programme is part of the wider Thames Water Asset Management Plan cycle. Outfall Safari in Greater London is a key component to help achieve targets set in the SWOP programme. Figure 3 shows the achievements of the SWOP from 2015-2020. The activities of Outfall Safari and Thames Water contribute to these outcomes (Figures 3).

Thames Water have agreed to fund and support Outfall Safari citizen science activities with the Zoological Society of London to cover all rivers in the separate drainage system over the next five years (Figure 4).

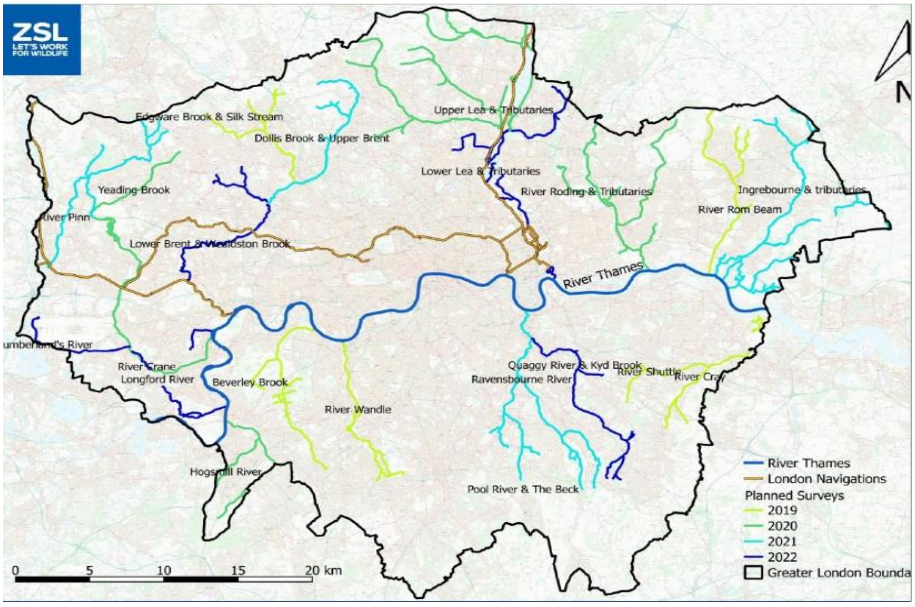


Figure 4. The main tributaries of the River Thames within Greater London that are planned Outfall Safari surveys over the next five years. From Shaw Stewart (2020).

3.4 Outfall Safari – The Method

Outfall Safari is a partnership project that involves the regulator, the water company, a host environmental NGO, the Catchment Partnership and volunteer citizen scientists (Zoological Society London, 2019). Volunteers are trained to identify pollution from surface water outfalls and how to use an app to record the data. Volunteers are assigned stretches of river to walk along the riverbanks and survey surface water outfalls. Volunteers geotag the outfalls location, take photographs and score the outfall on a scale of 0 – 20 on the visual impact and aesthetics (Annex 1). A score of 0 indicates the outfall is not polluting, while a score of 20 is given to outfalls that are visibly impacting >30 m of the river. Outfall Safaris are run over a one-month period and coordinated to optimise effort (each river section should be surveyed once) and to avoid rainfall events which can wash away evidence of pollution (surveys postponed for 48 hours following rainfall in the catchment). The polluting outfall scores are reported to local water companies who work to trace misconnected pipes to remedy pollution hotspots. Other forms of remediation involve setting back the outfalls and having a retention pond area, so pollution settles out before entering rivers. Safaris are conducted periodically to capture intermittently polluting outfalls.

The project helps raise awareness of the issue, collect valuable data and helps water companies target efforts to reduce pollution and improve our rivers. Citizen science activities through Outfall Safari therefore have both immediate outcomes and longer-term impacts for the environment and society.

3.5 Workshop 1: Understanding Citizen Science Perceptions of Impact

In January 2020, the MICS team hosted a workshop with the Outfall Safari citizen scientists and MICS partners to develop an understanding of citizen scientist's perception of how their involvement in Outfall Safari contributes to the impact domains: society, economy, governance, economy and science & technology. This section outlines the set-up, delivery and outcomes of the workshop.

3.5.1 Pre-Workshop Questionnaire

Prior to the workshop, the Outfall Safari citizen scientists completed a questionnaire, so the MICS team could understand the context of their involvement in Outfall Safari. The survey questionnaire and results are in Annex 2. In total, 12 citizen scientists responded to the questionnaire. The citizen scientists were involved in Outfall Safari citizen monitoring across Greater London including on the River Rom, River Shuttle, River Cray, River Dollis, River Mutton and Folly Brook, River Brent, Edgeware Brook, River Beam. Some of the volunteers, who had completed one Outfall Safari one year, completed an Outfall Safari on a different river the following year for example one respondent said: *"I was part of several of the surveys, walking the streams to identify polluting outfalls".* The volunteers highlighted different reasons for their involvement in Outfall Safari:

- Interested in citizen science and involved in other citizen science projects (e.g., Riverfly (macroinvertebrate), Morph (hydromorphology) monitoring) and wanted to try Outfall Safari.
- Interested in the environment / conservation / science.
- To increase knowledge in the local area.
- To give back to the local community and area - *'If I didn't do my bit, I cannot expect others to'.*

All of the survey respondents felt they had learnt something from taking part in the citizen science activities. The main learning outcomes identified were related to an increased understanding of the

difference between surface and fowl water drainage systems, about property misconnections and how to identify polluting surface water outfalls. The citizens also learnt about the importance of river condition for habitats and wildlife, river management, and new places to walk in their local area.

We then asked if the citizen's role and learning in Outfall Safari had been used / influenced their everyday life and if they had communicated the results/learning of the activities with people outside of the Outfall Safari group (questions and responses are in Annex 2). One respondent said they had not used anything they learnt from the project in their everyday life. However, the other 11 respondents said they had an increased awareness of rivers; they learnt about the importance of litter clearance from rivers; volunteers also felt they are more aware and confident of reporting river pollution. One volunteer mentioned they had checked their property for misconnections and another commented on the increased skills they had picked up associated with use of the mobile phone app, they now use these skills in their everyday life. Five of the volunteers stated they had shared their experience and knowledge gained from the Outfall Safari monitoring activities with friends and family. Others noted they only really talked about Outfall Safari with other citizen science monitoring volunteers (e.g., from the Riverfly Anglers Monitoring Initiative). Although this was a small survey (12 responses), it shows that Outfall Safari has spheres of influence on society beyond those people involved in the citizen science monitoring.

3.5.2 Workshop 1: Understanding Citizen Scientists Perceptions of Impact

The River Restoration Centre hosted the workshop at Cranfield University on the afternoon of 23/01/2020. The workshop was attended by: 15 MICS project partners, 1 project co-ordinator from the Greater London Outfall Safari and 6 citizen scientists who were involved with Outfall Safari citizen science activities on various rivers across Greater London.

The workshop began with an overview of the MICS project from the MICS team, followed by a presentation about Outfall Safari delivered by the Outfall Safari project coordinator. This was a good introduction to the workshop as it introduced the citizen scientists to the MICS project, and the MICS project partners to the Outfall Safari citizen science method. The citizens also found the Outfall Safari presentation useful as it provided an indication of how the data they collected is used. There was a very relaxed atmosphere and therefore the citizens felt comfortable asking questions after the presentations. This created informal interactions between the citizens and the MICS partners and the group were sharing ideas and discussions about their involvement in Outfall Safari, this lasted approximately 20 minutes.

We then split the attendees into smaller groups to discuss the five MICS impact domains that were written on large flip chart paper on 5 tables in the room (Figures 5 and 6). We asked each group to write notes on large sheets of paper in their groups. Prompt questions were available on each table to encourage thinking and discussion around each impact domain:

1. *What did you learn from the project in relation to the impact domain?*
2. *How does your role in the citizen science activity influence the impact domain?*
3. *How wide is the impact of your citizen science activity on the impact domain? – A particular location or wider?*
4. *What are the difficulties in evaluating the impact of the citizen science activity in relation to the impact domain?*

Figure 5. Photographs of the workshop and discussions about the impact of Outfall Safari on society, governance, economy, science and technology and the environment in January 2020.

3.5.3 Workshop Outputs and Feedback

The workshop was an informative event for the MICS team and increased our understanding of citizen science perceptions of impact. At the end of the workshop, we asked each group to summarise the comments written for that impact domain in one sentence:

- "Outfall Safari contributes to the ECONOMY by identifying problems early before the solution becomes more expensive, via cheap labour, although the reduction of economic costs is not a primary motive for the volunteers"

- "SOCIETY is divided; some [citizens] are interested and motivated to take action, some [citizens] are disconnected – the key is to connect the "bubbles" and network to generate real impact"

- "Citizen science provides an opportunity to fill the evidence gap which enables a positive action on policy, GOVERNANCE, and the redirection of resources to tackling the issue"

- "We learnt about pollution in our rivers and this is an environmental concern, however, the action of collecting data does not immediately impact the ENVIRONMENT, learning about how the data is used from our [citizen] involvement to improve the environment is important"

- "Citizen science provides the opportunity to collect scientific data over large spatial and temporal scales supporting SCIENTIFIC discovery and TECHNOLOGY development."

The event was also engaging and interesting for the citizen scientists involved. The citizen scientist's feedback forms indicated that all of the attendees enjoyed the event and learnt something new, one attendee said it "*expanded my horizons*". Several attendees had not considered their role in the citizen science project in this way before. In response to the question: Have you considered your role in the citizen science project in this way before one attendee responded *"not in a multi-faceted way"*, and another said "*not to this degree, I think I'd just thought of the science/environment impacts before".*

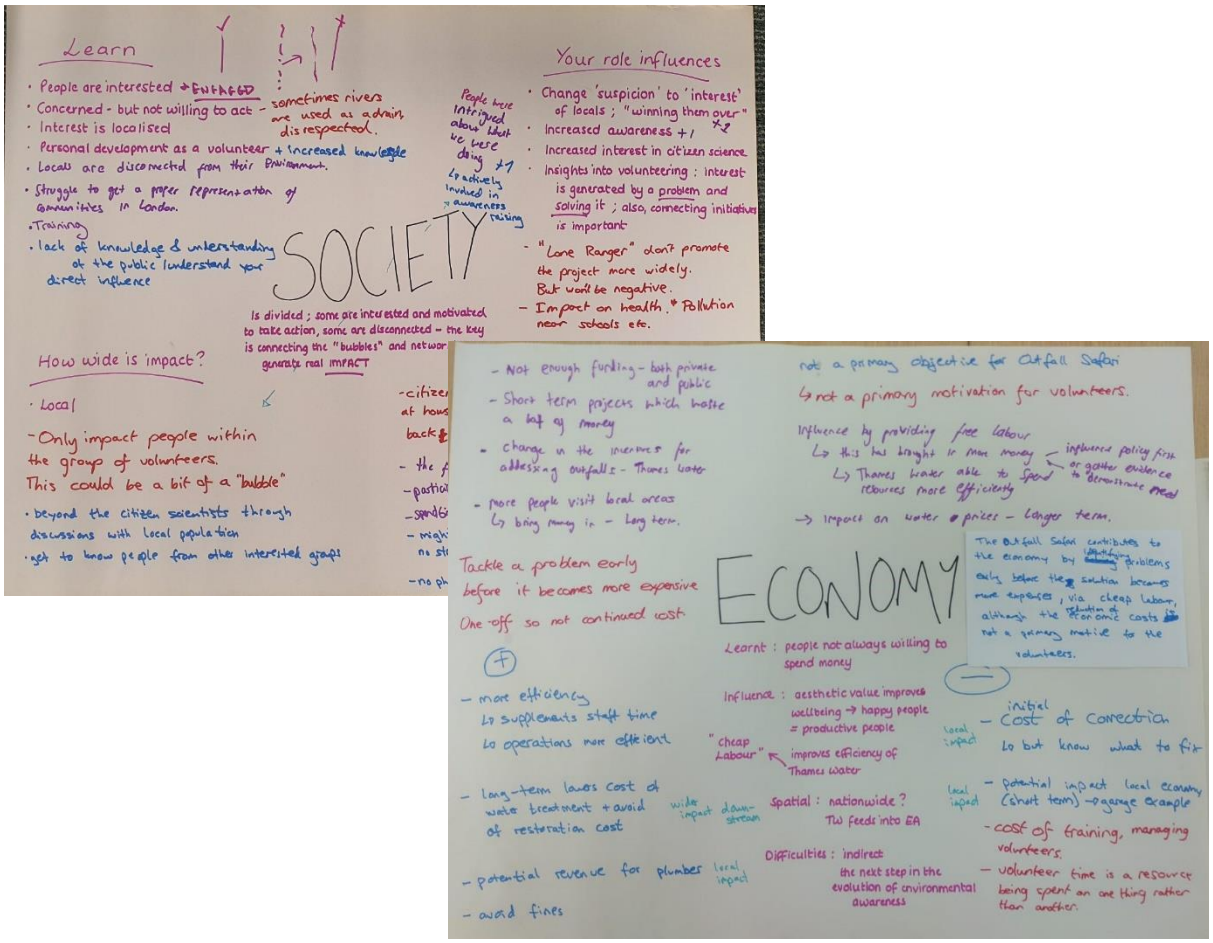


Figure 6. Examples of Outfall Safari impacts written during the MICS January workshop.

3.6 Next Steps for Measuring the Impact of Outfall Safari Citizen Science project

We are planning a series of workshops with the Outfall Safari stakeholders in Greater London to understand the impact journeys and indicators (developed in Work Package 2 and 3, in January 2021 D2.7) to measure the outcomes and impacts of the citizen science activities. The workshops are planned for early 2021 and their objectives are outlined in Table 2. Once we have built up a detailed understanding of the impact journeys and indicators needed to measure impact we will apply it to the case study. We will then roll out the impact assessment methodology to other Outfall Safari citizen science projects across the UK, such as Alfreton Brook, in Derbyshire.

We will also be comparing the process and set up of contributory citizen science projects (e.g. UK case studies) and the co-design citizen science activities (e.g. Hungarian, Italian, Romanian case studies)

and how the impacts vary between the different set up of projects to provide advice and recommendations.

Table 2. Planned Outfall Safari MICS Citizen Science Activities in early 2021 in the GLA.

Workshop #	Objective	Description	Delivery Month
2	Develop an impact journey for Outfall Safari: citizen perspectives	This workshop will build on the outputs of the January 2020 workshop 1 to develop an understanding of how impact is achieved through the Outfall Safari Citizen Science activities. The workshop will invite citizen scientists and be an online interactive event.	Feb 2021
3	Develop an impact journey for Outfall Safari: regulators / water companies / project manager's perspectives	This workshop will build on information from workshop 1 and 2 with the citizen scientists. This workshop will focus on understanding the impact pathways from stakeholders from water companies and regulators (e.g., environment agency) associated with Outfall Safari	Feb 2021
4	How do we measure the outcomes of Outfall Safari, and what are the priorities for monitoring?	This workshop will involve all stakeholders involved in Outfall Safari in the Greater London. It will firstly reflect on the impact journeys identified in workshops 2 and 3 and begin to prioritise outcomes and impacts and select indicators for monitoring and measuring the Impact of the citizen science activities	Feb 2021

4 The Riverfly Partnership

4.1 Introduction to Riverfly

The Riverfly Partnership (RP) was formed in 2004 in response to concerns relating to declining river water quality (The Riverfly Partnership, 2020). The scheme originated from collaboration between the Natural History Museum (NHM) and Natural England (NE) who formed the Partnership Project in 2002. In 2004 the NHM hosted the 1st Riverfly conference *Riverflies - A Beacon of Environmental Quality*, which demonstrated the support for a monitoring initiative. Shortly after the RP was formerly founded with the list of collaborators expanding to include the Freshwater Biological Association, the Salmon & Trout Conservation UK along with the NHM and NE. The RP is currently hosted by the Freshwater Biological Association. Table 3 details the impact domains of Riverfly.

Figure 2. Riverfly Partnership Logo. Source: www.riverflies.org,

The RP today has over 3,000 active volunteers and consists of a network of organisations (c. 180 in total) that includes angling clubs, conservation groups, water course managers, scientists, environmental charities and government agencies (Moolna et al., 2020). Monitoring activities are supported by 56 'catchment hubs' across the UK (The Riverfly Partnership, 2020). The primary objectives of Riverfly monitoring are to detect and report polluting events to the appropriate regulatory body (Environment Agency [EA] in England; Scottish Environment Protection Agency [SEPA]; Natural Resources Wales [NRW]; or Northern Ireland EA [NIEA]), gather long term data regarding the health of rivers and align the efforts of volunteers and regulatory bodies in improving rivers across the UK. This is achieved through monitoring key indicator (riverfly) species, e.g. Trichoptera, Ephemeroptera, and Plecoptera, and their habitats (Brooks et al., 2019). The RP is not a membership organisation but provides guidance to individuals and local interest groups regarding how to formulate water quality monitoring activities.

Several citizen science activities have been developed by the RP, from the Anglers' Riverfly Monitoring Initiative (ARMI) to the Extended and Urban Riverflies, the latter two of which fall under the Riverfly Plus project. The ARMI can be considered the RP's leading citizen science 'project'. Following successful trials in 2006 by the RP and EA, in association with Ryedale Anglers, Taunton Fly Fishers, Eden Rivers Trust, Rhymney and Sirhowy Monitoring Group and Frensham Fly Fishers, the project was launched nationally in at the 2nd National Riverfly Conference, *How good is your river?* held at the NHM in 2007.

Variants of ARMI fall under the project Riverfly Plus and include the Extended Riverfly and Urban Riverfly. The Extended Riverfly was initiated by the *Lincolnshire Chalk Stream Project* (LCSP) as a way of reinvigorating volunteer interest in Riverfly monitoring, by offering a more challenging alternative to ARMI (expanding the ARMI 8 groups monitored to 28) and a means of collecting extended information about river quality and stressors than the basic ARMI scheme by monitoring 33 invertebrate groups, and the that includes species prevalent in modified river systems.

Figure 8. Location of sites monitored by the ARMI volunteers in the UK. Grey lines represent river basins. From Brooks *et al*., (2019).

While the different coordinator groups of the Riverfly Partnership follow the same primary monitoring activities, differences arise in the length of time coordinators have been running activities, the way in which project coordinators engage with citizen scientists and the manner in which citizen scientist contribute feedback and influence activities and decision making.

4.2 Measuring the Impacts of Riverfly Citizen Science Activities

Riverfly was selected as a case study to apply the MICS metrics and tools because:

1. The RP is an example of a well-established citizen science project that has been running for over 16 years. Riverfly therefore provides the opportunity to look at the outputs, outcomes and longer-term impact of citizen science activities
2. The primary method used for Riverfly monitoring (ARMI) aims to assess river water quality, providing baseline data used to identify pollution events and changes in river conditions.
3. The project includes a wide range of stakeholders. The Partnership consists of c. 180 organisations and 3,000 active volunteers across the UK. Local monitoring is usually coordinated by an angling clubs or environmental NGO (e.g. Rivers Trust, Wildlife Trust, Catchment Partnerships etc.), with representative of statutory agency (EA, SEPA, NRW, NIEA) providing support along with volunteer citizen scientists.
4. The method has been applied nationally, but local/regional coordinators communicate with citizen scientists in different ways with varying levels of success. This provides an opportunity to compare different approaches.
5. While the majority of citizen science involvement is contributory, through monitoring, engagement varies between monitoring groups. For example, feedback from volunteers has resulted in modifications in the methods (i.e. Extended Riverfly), with citizen scientists working collaboratively with coordinators to modify the ARMI technique.
6. Riverfly citizen science activities have multiple impacts across all five MICS impact domains: Environment, Science & Technology, Society, Governance and Economy (Table 3).

Table 3. Table detailing the impact domains that Riverfly citizen science activities focus on and the rationale behind the projects focus on the impact domain.

Domain	Rationale
Science & Technology	To train volunteers in biology (macroinvertebrate identification) and ecology (how particular species correspond to habitat (type and quality).
Society	To engage with local groups To raise awareness and increase knowledge of river invertebrates and factors that may be harmful to them.
Environment	To improve the health of UK rivers.
Governance	To identify and remedy polluting events
Economy	To support a green and rural economy (e.g., fishing), treat pollution, reduce costs for remedying pollution

4.3 River Water Quality: The Problem, Policy and Practice

Macroinvertebrates are used worldwide for both routine and responsive monitoring of water quality, and invertebrates are used in one quarter of the assessment methods using aquatic organisms for assessing the quality of surface waterbodies under the Water Framework Directive (WFD) (Moolna et al., 2020). Sampling methods for monitoring macroinvertebrate communities were developed by statutory agencies in the UK during the 1970s, with the formulation of the National River Pollution Monitoring Survey (Hawkes, 1998) which was superseded by the Biological Monitoring Working Party (BMWP) system in 1976 (Armitage et al., 1983). The methods used by Riverfly Partners to monitor riverflies, e.g. ARMI, is a modified version of the BMWP, for further details regarding the method the reader is directed to section 3.3.

Anglers and local community groups were seen as natural guardians of the river environment, having a vested interest in their local rivers and ideally placed to monitor them. The ARMI method was developed by the RP to provide a simple, standardised monitoring technique, which groups can use to detect any severe perturbations in river water quality. Volunteers are required to carry out regular sampling at registered ARMI sites and liaise with local Riverfly Hub / Coordinator following the detection of acute pollution events. Pollution events are report to the relevant statutory agency (EA or regional equivalent) by the Hub Coordinator, who determine if remedial action is required to resolve the issue.

4.4 Riverfly: The Method

Several methods for monitoring macroinvertebrates have been developed by the RP, of which the ARMI is considered the RPs leading citizen science 'project'. There are several newer methodologies that fall within the project Riverfly Plus, which includes the Urban Riverfly and Extended Riverfly in addition to variations of the ARMI modified for application alongside other citizen science activities, e.g. the Westcountry Rivers Trust Citizen Science Investigation (CSI). These newer methodologies provide citizen scientists with a monitoring platform to capture more sensitive water quality stressors compared to the ARMI index.

The majority of the case study sites used in the MICS project employ the ARMI methodology. However, the Extended Riverfly has been used by citizen scientists coordinated by The Lincolnshire Chalk Stream Partnership (Section 3.5). Both the ARMI and Extended Riverfly methodologies are described below.

4.4.1 ARMI

The ARMI methodology requires volunteers to record the presence and abundance of macroinvertebrate groups sensitive to pollution. This is a simplified version of the BMWP system used by statutory agencies for monitoring freshwater macroinvertebrate species.

Species-level identification is not required for the ARMI methodology. Instead, Riverfly volunteers are trained to distinguish eight groups based on distinguishing features, e.g. the presence and number of tails and pairs of legs, appearance of gills and presence or absence of a case (specifically for identifying cased caddisfly larvae) (Moolna et al., 2020). This includes three insect orders (Ephemeroptera, Plecoptera, Trichoptera) plus the crustacean *Gammarus spp*. The abundance of each group is used to

calculate the ARMI index score, which is estimated on a logarithmic scale: zero individuals of a group scores 0; 1–9 scores 1; 10–99 scores 2; 100–999 scores 3; and 1000 or more scores 4.

To collect macroinvertebrates 'kick samples' are taken by volunteers. This involves entering the river and placing a net in the direction of flow with the open net mouth facing upstream while disturbing the river bed upstream of the net with the feet (in a kicking motion). Kick sampling is carried out for three minutes, during which time volunteers move around the site to ensure samples are collect from different habitats in the river, e.g. riffles, shallow water, slow water, reeds etc. Once samples have been collected live identification is conducted on the riverbank by carefully releasing the contents of the net out into a white tray filled with water from the river. Once identification is completed the contents of the tray are emptied back into the river.

4.4.2 Extended Riverfly

The Extended Riverfly has two principle aims:

1. To provide a more challenging task for citizen scientists
2. To extend the amount of information about the river.

The methodology of the Extended Riverfly is the same as that of the ARMI, but it extends the lists of taxa identified from 8 to 26. The 8 taxa identified in the ARMI primarily provide information regarding river water quality. The additional taxa identified in the Extended Riverfly provide information regarding additional stressors, specifically drought and abstraction pressures and sediment accumulation (Bartle & Boulton, 2017).

Unlike the ARMI methodology scoring for the Extended Riverfly requires splitting invertebrates into two groups: those that indicate fine sediment and low flow; and those that are sensitive to fine sediment and low flow. The final score is a balance between the abundance of taxa indicative and those sensitive to fine sediment and flow. The score increases with the identification of sensitive species, such as caddisfly larvae, and decreases in the presence of taxa indicative of fine sediment and low flow, e.g. leeches.

4.5 Location(s) of Case Study Site(s)

Several sites/organisations are selected that use the Riverfly monitoring techniques to apply the MICS impact assessment method to, these sites are described below.

4.5.1 Lincolnshire Chalk Streams Partnership (LCSP)

The LCSP was initiated in 2003 to monitor, improve and raise awareness of chalk streams in the Lincolnshire Wolds. The partnerships consist of the Environment Agency and Anglian Water (joint partner leads) Lincolnshire County Council (hosting partner), Natural England, Lincolnshire Wildlife Trust, Lincolnshire Wolds Countryside Service and the Wild Trout Trust.

The LCSP has been a Riverfly Hub Coordinator since 2013, involving organising activities and training 65 volunteers - 42 of which are currently active - and hold yearly training days. Activities are usually conducted in pairs and other than yearly face-to-face meetings there are no formal activities arranged for the wider group. Yearly meetings therefore serve to bring the wider group together and are an

opportunity to for coordinators to provide data feedback and volunteers to raise issues or concerns. The involvement of the Environment Agency is the LCSP projects means there is a professional level of interactions with volunteers.

Initially, volunteers followed the ARMI methodology involving the identification of 8 macroinvertebrate groups. However, volunteers involved in the Riverfly monitoring expressed an interest in developing a more challenging survey that would incorporate more taxa groups that would provide more details regarding the regarding river condition other than water quality (Bartle & Boulton, 2017). This, in addition to a desire to reinvigorate interest in Riverfly activities, led the LCSP to develop a new methodology – the Extended Riverfly. This new method was devised by members of the Environment Agency representing the EA in the LCSP. The Extended Riverfly method was piloted in 2015 on the River Hemingby and was piloted by the LCSP in 2015.

The Riverfly Hub at LCSP was chosen as a case study for MICS because it represents a *contributory* project that has developed over time into one that is *collaborative*, as citizen scientists have guided the development of new methodologies and expanded the scope of the monitoring objectives. This has been achieved through a healthy dialogue between citizen volunteers, the project coordinators and representatives of the statutory agency (EA).

Figure 9. Regular feedback is provided by LCSP to Riverfly volunteers at annual general meeting. Source: https://www.lincswolds.org.uk/library/RMI_small_classroom.jpg, accessed 25th November 2020.

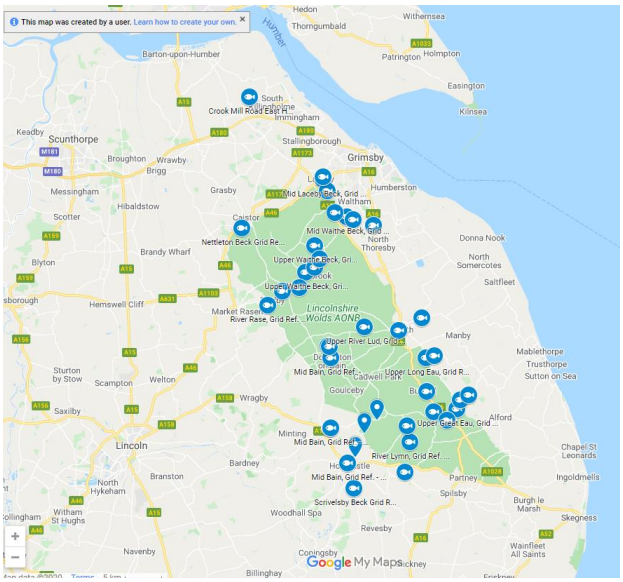


Figure 10. Map showing the survey sites for ARMI / Extended Riverfly monitoring organised by LCSP. Source: Lincolnshire Chalk Streams Project - Riverfly Survey Sites https://www.google.com/maps/d/u/0/viewer?mid=1aJG0gxOXhhfWCd8eg2lBN39GvO0&ll=53.409461869377787%2C-0.10164669999998321&z=10, accessed 25th November 2020.

4.5.2 Surrey Wildlife Trust

The SWT has coordinated Riverfly monitoring since 2014, managing activities on the Rivers Wey and Mole, both tributaries of the River Thames. Since training as a Riverfly hub the Trust has been

responsible for training c. 200 Riverfly volunteers and has collated over 500 surveys. In addition to Riverfly the Trust coordinates several other citizen science initiatives, including FreshWater Watch, Hedgerow Heroes and the Yellow Fish project among others. The Trust has two 'core' groups of volunteers – the Farnham Rivers Group and The Friends of the River Mole – involved in Riverfly monitoring and to lesser or greater extent other citizen science activities and restoration projects. At its peak these groups consisted of c. 100 individuals.

The Trusts approach to managing citizen science projects has changed in recent years. Originally the projects supervisor took a 'hands-on' approach, regularly engaging with volunteers both formally and informally. However, this management model was highly time consuming and unsustainable in the long term. Therefore, the decision was made to adopt a 'hands-off' approach, one aspect of which was the implementation of an online system and mobile apps for citizen scientists to record and upload their data. This approach had clear benefits, in particular reducing the workload of the project's supervisor. However, the Trust has been less successful in retaining long-term volunteers and forming coherent groups, which it believes, is the result of reduced face-to-face interactions. Despite this the Trusts have retained a core group of volunteers (members of the Farnham Rivers Group and The Friends of the River Mole) who continue to be involved in several projects, but have also taken on additional responsibilities. These additional responsibilities include: coordinating the monitoring and aims and objectives of existing projects as well as initiating new schemes, e.g. invasive species removal.

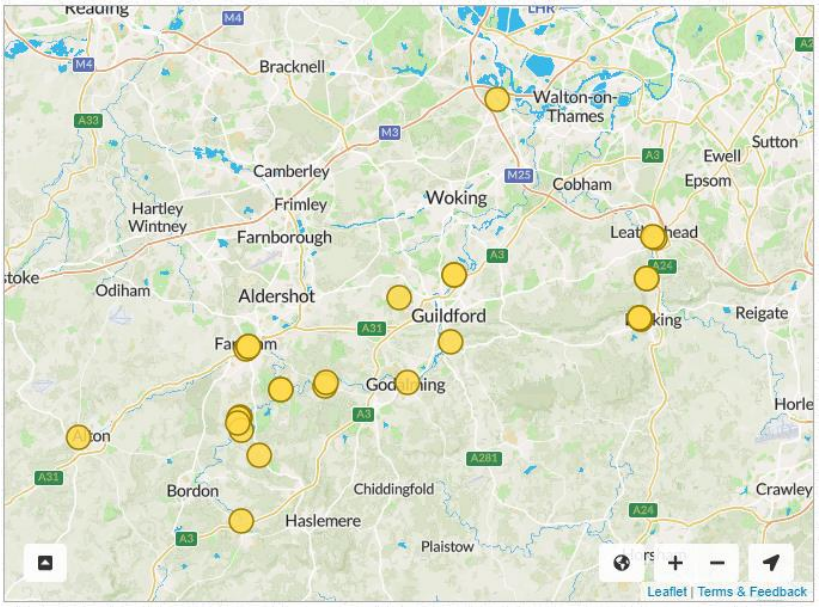


Figure 113. Map showing the survey sites for ARMI monitoring organised by SWT. Source: https://www.surreywildlifetrust.org/what-we-do/citizen-science/riversearch, accessed 25th November 2020.

The Trust is interested in measuring the effects of the citizen science activities and has had student led projects (PhD & MSc) investigating impact. For example, in 2014 a student investigated the societal impacts of citizen science activities, the primary aim of which was to "…understand volunteer decision-making, motivations and satisfaction in order to improve programme outreach, volunteer retention, and productivity" (Agnello, 2014).

The Riverfly Hub at SWT was selected as a case study to apply the MICS metrics because it represents a project in which citizen scientists were initially involved in a *contributory* capacity, but who have taken on additional roles, establishing their own objectives for monitoring (co-design).

4.5.3 Westcountry Rivers Trust (WRT)

The WRT incorporates ARMI within its Westcountry Citizen Science Investigation (CSI) project. Initiated in 2016 with support from Heritage Lottery funding (WRT, 2016), CSI volunteers are asked to take responsibility of specific sections of rivers and undertake monthly surveys in order to monitor water quality and identify potential pollution problems. Following an initial 6-month pilot period, surveys were adjusted to also include the option to record 'positive interactions'. The aim of this was avoid 'disenchanting' volunteers by asking them to only focus only on the negative aspects of rivers (e.g. pollution outfalls, invasive species, etc.) by giving them the option for e.g. wildlife spotting.

In total, the Trust has trained 317 individuals for CSI activities, from which a 'core group' of 70 – 80 people has developed who are engaged in several other citizen science initiatives as well as CSI (WRT, 2020b). Note this core group does not represent the total number of active volunteers. In total over 3,000 samples have been collected by volunteers across the South West. To maintain engagement regular feedback sessions are held to illustrate how CSI monitoring impacts the Trust decisions to tackle issues related to water quality and pollution.

The Trust currently receive feedback from CSI volunteers using Maptinonnaire (www.maptionnaire.com) but are keen to extend this to incorporate elements of co-design to enable citizens to engage with the development of future projects.

Figure 12. Screenshot of CSI data entry interface (Cartographer) showing sites across South West UK were CSI surveys have been collected (WRT, 2020).

The Riverfly Hub at WRT was selected as a case study on which to test the MICS impact metrics as it represents a well-established citizen science project. The WRT frames ARMI monitoring within its Westcountry CSI framework, which involves volunteers to collect other data alongside those required for ARMI. This includes recording 'positive interactions', which the Trust believes few other citizen science initiatives incorporate.

5 Water with Integrated Local Delivery (WILD)

5.1 Introduction to WILD

The Water with Integrated Local Delivery (WILD) project aims to improve water quality and biodiversity within the Cotswold Water Park located in the Upper Thames River Catchment (Figure 13). The project was initiated primarily to meet the requirements of the Water Framework Directive

(Good Ecological Status of water bodies) and in response to the 2007 winter floods. It is funded primarily by the Environment Agency, with additional grants secured through Thames Water.

WILD is led by the Farming & Wildlife Advisory Group (FWAG). FWAG was established in the 1960s by farmers who saw the environment as being integral to the future success of the UK farming industry.

In addition to FWAG, WILD project partners include the Gloucestershire Rural Community Council (GRCC), Cotswold Water Park Trust (CWPT) and the Countryside and Community Research Institute (CCRI) at the University of Gloucestershire. Local partners include town and parish/district councils (e.g. Cirencester Town Council and Cotswold District Council) and voluntary organisation. The Cotswold Water Park is the UK's largest marl lake system, containing 150 lakes that were created by the quarrying of glacial limestone gravel in the early 20th Century. The park contains working gravel quarries interspersed between agricultural land, nature reserves and leisure areas. While the area is a unique habitat containing several Sites of Special Scientific Interest (SSSI) only one third of surface rivers and water bodies within the catchment meet the required standards. A primary cause for water bodies failing to receive good ecological status is past and current agricultural practices, e.g. the inappropriate placement of dams, weirs and sluices and high levels of sediment and pollution entering rivers through runoff from agricultural land.

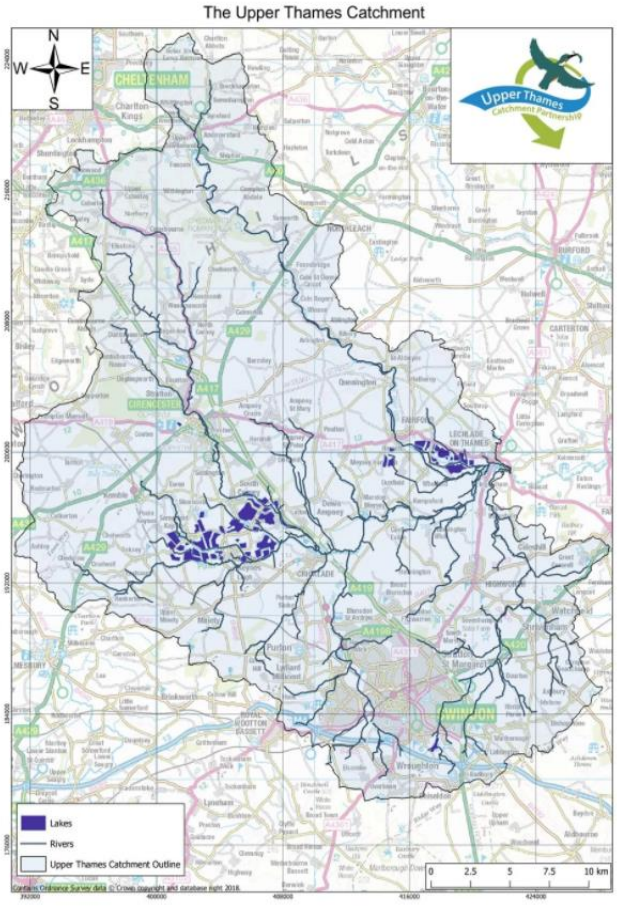


Figure 13. Upper Thames Catchment area covered in by the WILD project. Source: https://www.fwagsw.org.uk/upper-thames-catchment-description, accessed 16th December 2020.

The objectives of the WILD project are:

- To deliver Good Ecological Status by carrying out direct actions on 23 waterbodies in the Upper Thames Catchment;
- To identify other negative drivers impacting water quality and develop a framework to address these in the medium (2021) and long term (2027);
- To integrate and deliver the aims and objectives of partner's strategic programmes relevant to the project area using the Integrated local delivery approach developed by the Countryside and Community Research Institute;
- To assess the effectiveness of the project to inform future funding programmes.

To achieve these aims, the WILD project looks to:

- Improve riparian biodiversity and habitat management;
- Improve the management of SSSIs;
- Reduce diffuse pollution from agriculture;
- Reduce point source pollution;
- Provide assistance in the provision of clean drinking water, e.g. reducing pesticides such as metaldehyde;
- Increase sustainable productive land management;
- Increase cross compliance;
- Increase flood and drought mitigation.

Phase 1 of the project (2013 – 2016) involved identifying local stakeholders (landowners and farmers) and local communities with who to engage. This included site visits to 280 farms/estates with advice being provided for c. 22,500 ha of land. 24 farmers were also appointed to be 'Farmer Guardians' covering c. 12,600 ha of the Upper Thames Catchment. Local communities and interest groups in 20 parishes were also engaged, with volunteers helping to survey 300 km of ditches and conduct enhancement works along 5 km of river.

Phase 2 of the project (2016 to present) builds upon the success of Phase 1. WILD will continue to work with local communities and landowners to identify water-related issues, carry out habitat restoration and promote volunteering opportunities. In addition to these activities, wild volunteers will help to mitigate flood risk, installing measures to help control flow and increase water storage capacity along the River Churn upstream of and through Cirencester. Phase 2 will also embed water issues within local governance to ensure long term sustainability of the water environment.

Several other citizen science schemes FWAG coordinate, e.g. ARMI, fall within the scope and contribute to the WILD project.

5.2 Measuring the Impacts of WILD Citizen Science Activities

WILD was selected as a case study on which to apply the MICS metrics and tools because:

1. The project is an example of medium to long term citizen science engagement. FWAG have over 60 years of engagement with local farmers and citizens that the WILD project builds on. WILD therefore provides the opportunity to look at the outputs, outcomes and medium to long term impact of landowner engagement and citizen science activities.
2. The WILD project engages with volunteers from a wide range of backgrounds, from farmers and landowners to local communities, schools and other interest groups.
3. Citizen scientists are engaged in a diverse range of activities (e.g., monitoring, restoration work etc.), encouraging volunteers to take on new responsibilities and work collaboratively with project managers.
4. WILD citizen science activities have multiple impacts across all five MICS impact domains: Environment, Science & Technology, Society, Governance and Economy (Table 4).

Table 4. Table detailing the impact domains that WILD focuses on and the rationale behind the projects focus on the impact domain.

Domain	Rationale
Science & Technology	To provide advice to local farmers and landowners regarding alternative, environmentally friendly land management practices.
Society	To engage with local communities (e.g. schools and citizen volunteers), groups (e.g. conservation groups) and landowners (e.g. farmers). To raise awareness and increase knowledge of the surrounding environment.
Environment	To improve the health of river in the Upper Thames Catchment and enable them to reach Good Ecological Status.
Governance	To improve the Ecological Status of rivers and the management of waterbodies in the Upper Thames Catchment.
Economy	To work with land owners, farmers and local communities to improve agricultural practices, land management, urban pollution and flood damage.

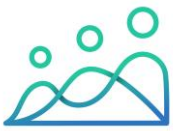
5.3 Achieving Good Ecological Status: The Problem, Policy and Practice

Pollution from agricultural and urban areas, poor land management practices and poor river connectivity have resulted in rivers in the Upper Thames Catchment failing to meet Good Ecological Status under the WFD. Addressing these issues requires engagement with local stakeholders (e.g. landowners and farmers), communities and statutory agencies to help address the key factors causing this failure.

The WFD came into effect in UK law in 2003, establishing a legal framework for the protection and enhancement of surface water bodies, i.e. rivers, lakes and wetlands, and groundwater (WFD, 2000). The overall objective of the WFD is that inland waters in the UK should reach Good Ecological Status by 2027. The WFD requires measures to reduce both point and diffuse pollution. In the UK farming is one of the main sources of diffuse pollution. The Reduction and Prevention of Agricultural Diffuse Pollution Regulations was introduced in 2018 as a means of regulating pollution from agricultural practices. This provides rules around the application of fertilisers and soil management to encourage good farming practice, so that farmers manage their land both to avoid water pollution and to benefit their business.

The WILD project focuses the efforts of statutory agencies (EA), utility companies (Thames Water) and local environmental NGOs in tackling the issues resulting in poor water quality, by engaging key local stakeholders. Stakeholders include the Gloucestershire County Council, Cotswold District Council; Thames Water Asset Management Team; Thames Water Pesticides team; Highways; Natural England; Rural Payments Agency, Cotswold Water Park Trust, Gloucestershire Rural Community Council, Countryside and Community Research Institute, the Environment Agency, the National Farmers' Union and Forestry Commission land owners and citizen scientists.

Phase 1 of the project was carried out between 2013 and 2016 with grant funding of £242,000. This funding was secured from the Thames Water Community Investment Scheme. Additional funds have



been secured through the Thames Water Community Investment Scheme for the completion of Phase 2 of the project (2016 to present).

5.4 WILD – The Method

WILD volunteers are involved in a variety of tasks based around conservation for wildlife and improving the quality of water, these include volunteer work parties, training events, guided walks, school visits, and community mapping.

Phase 1 (2013 – 2016): citizen volunteers were involved in site walkovers identifying sites for future enhancement and restoration works. This entailed conducting surveys of drainage ditches bordering agricultural land. This included:

- Shade reduction & tree pollarding works;
- Instalment of Large Woody Debris deflectors and faggots;
- Erecting new and improved fencing
- Removal of invasive species, e.g. Himalayan balsam.
- Collecting baseline data from various sites via monitoring activities, e.g. Riverfly ARMI.

FWAG, Gloucestershire, has had mixed success with regards to Riverfly monitoring. It initially began Riverfly monitoring in 2016, hosting a series of training events with interest stakeholders. However, following this initial interest monitoring activity gradually declined and the citizen science group gradually disbanded. At the time, this breakdown in the group was believed to be due to lack of communication and engagement with the FWAG members coordinating monitoring activities.

FWAG are now looking to re-initiate Riverfly monitoring building on the lessons learnt from their first attempt. During 2019 and 2020 FWAG initiated a communications campaign to build interest and attract potential citizen scientists. 30 individuals expressed interest in participating in training events scheduled for early Spring 2020. However, the COVID-19 pandemic resulted in these training events being postponed until November 2020.

WILD is selected as a MICS case study as it represents a collaborative and contributory citizen science engagement initiative that involves citizens not just for monitoring environmental condition, but helping to improve it by identifying and leading restoration and conservation activities. The WILD work builds on the long term engagement that FWAG has with farmers and landowners therefore the project provides an interesting perspective of impact from medium to longer-term citizen engagement.

6 Conclusion

In the UK, citizen science plays an important role in data collection and monitoring before, during and after NBS implementation. Citizen science activities are widespread across the UK and are an accepted method of engagement, stakeholder collaboration, data collection and monitoring. Many of the citizen science activities enable the assessment and monitoring of environmental problems.

We use five established and ongoing citizen science projects in the UK to understand impact journeys and measure the long-term impact using the MICS tools and metrics (Table 5). The UK case studies differ to those in Romania, Hungary and Italy as these case studies are following the co-design process set up of citizen science activities. The UK case studies are mainly contributory and collaborative projects, which allows us to investigate impact for different types and levels of citizen involvement. The UK case studies also allow the MICS tools and metrics to be applied to a large cohort of citizen scientists on established case studies and allow the MICS team to investigate the outcomes and longer-term impacts of citizen science impacts on society, the environment, science & technology, governance and the economy.

The next steps for all case studies will be to identify indicators to measure impact related to the case study's aims and objectives. This will be achieved through workshops with all stakeholders involved or through discussions with project managers. Once indicators have been selected, we will measure the impact. We will review the usability of the impact assessment and produce guidance and training so the MICS tools and metrics can be applied to any type of citizen science project. The results from these activities will be reported on in the comprehensive evaluation report (Deliverable 4.5) in 2021.

Table 5. Summary of UK case studies where the MICS impact assessment will be tested

Case Study	Project Information			Citizen Science Activities				Impact domains addressed				
	Project Start	Project End	Area covered	Type of citizen science involvement	Citizen Science Activities	# citizens involved	NBS	Environment	Society	Governance	Science & Technology	Economy
Outfall Safari (Zoological Society of London)	2015	Ongoing	Greater London	Contributory	Identification and monitoring of polluting surface water outfalls	179	Data contributes to identification / management of polluting surface water outfalls	✓	✓	✓	✓	✓
Lincolnshire Chalk Streams Partnership	2003	Ongoing	Lincolnshire	Collaborative & Contributory	Monitoring river water quality	40 - 70	Data contributes to baseline data for river water quality, identification of pollution events	✓	✓	✓	✓	✓
Surrey Wildlife Trust	2014	Ongoing	Surrey	Collaborative & Contributory	Monitoring river water quality	100, smaller core group currently active	Data contributes to baseline data for river water quality, identification of pollution events	✓	✓	✓	✓	✓
Westcountry Rivers Trust	2016	Ongoing	South-west England, (Cornwall, Devon, Dorset, and Somerset)	Contributory	Monitoring river water quality	70 - 80	Data contributes to baseline data for river water quality, identification of pollution events	✓	✓	✓	✓	✓
Water with Integrated Local Delivery (WILD)	2013	Ongoing	Upper Thames Catchment (Gloucestershire, Wiltshire, Berkshire and Oxfordshire)	Collaborative & Contributory	Various activities from site walkovers, surveying and enhancement work to monitoring water quality.	30	Monitoring contributes data to identification / management of surface water quality. Enhancement work undertaken to improve riparian and riverine habitat and flood risk mitigation.	✓	✓	✓	✓	✓

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Annex 1: Outfall Safari Survey Form

Outfall Safari basic survey form that can be adapted (e.g., including more room for photographs and comments section to comment on riverbank access) to suit different areas and groups. These forms are filled in by the citizen scientists. The scores from Section 8 Ranking of Visual Impact and Section 9 Ranking of the Aesthetics are combined to indicate the polluting potential of an outfall.

Question	Options	score
1. Volunteer name		
2. Date of survey		
3. GPS location		
4. Photo of the outfall		
5. Description of the nearest landmark		
6. Which bank is the outfall on (when looking downstream)		
7. Ranking of the discharge coming out of the outfall		
	a. No Flow	
	b. Trickle	
	c. Low Flow	
	d. Moderate Flow	
	e. High Flow	
8. Ranking of the visual impact of the outfall		
	a. No visible effect	0
	b. Within 2m of outfall	2
	c. Impact 2 to 10m	4
	d. Impact 10 to 30m	6
	e. Impact greater than 30m	10
9. Ranking of the aesthetics of the outfall		
	a. No odour or visible aesthetics	0
	b. Faint smell, slight discolouration	2
	c. Mild smell, mild discolouration, small coverage of sewage fungus	4
	d. Strong smell, strong discolouration, large coverage of sewage fungus and/ or litter	6
	e. Gross smell, gross sewage	10
10. Is there any sewage related debris visible?	Y/N	
11. Other signs of pollution	free text N/A	

Annex 2: Outfall Safari Volunteer Questionnaire

Questionnaire to Outfall Safari volunteers - January 2020
This questionnaire (below) was emailed to Outfall Safari citizen scientists in January 2020 to gather information associated with their involvement with the project's monitoring. This information was used to help design the citizen science activities during the MICS January Plenary at Cranfield University.

Number of respondents: 12

1. **What interested you to get involved in Outfall Safari?**

Answers:

- I was already volunteering on the Riverfly Monitoring project on the River Cray. I was born and bred in Orpington and have lived there ever since. I believe that conservation starts at home and I want to protect the habitat that Orpington still possesses. If I didn't do my bit, I cannot expect others to.
- I was running an art project that followed a part of the river Thames and wanted to learn about river Conservation.
- Combination of awareness & concern about the health of our rivers.
- I have done several ZSL citizen science projects (inc the Dollis Brook survey two years or so ago), I am very interested in conversation, science, volunteering (for retired) and social contacts.
- I wanted to volunteer in an environmental field. The Outfall Safari allowed me to do this and contribute to improving the local river area.
- An interest in the environment and a willingness to provide constructive assistance.
- I have long been interested and concerned about the state of London's rivers.
- concerns about water pollution and its impact on wildlife
- Interested in aquatic ecology and effects of pollution, with special interest in and past studies of local river to be surveyed (R. Cray, Kent). Also involved in RMI and MoRPh studies on this river and eel monitoring.
- Well, I was eel Monitoring on the River Cray, when I heard about the Outfall Safari, so thought I would put my name down to help out.
- Already a volunteer on a local river group. I believed it to be an interesting and valuable use of my time, and would be an ecological benefit.
- To assist in giving back some of my time to the local community.

2. **Which Outfall Safari project were you involved with?** (*numbers in brackets indicates number of people)*

- River Rom (3) Havering London
- Shuttle in South London
- River Cray (4)
- Dollis, Mutton and Folly Brook in 2017 and Deans Brook and Silk Stream in 2019
- River Brent (3)
- Edgeware brook
- River Beam

3. **What did you do on the project?**
    - Walked the river and tow path checking all the outfalls to the source as well as reporting any pollution on the dedicated app
    - Walked the banks of the river, and on some occasions in the river. The goal being to find outfalls and then examine any flow and report back on what could be seen.
    - We Checked Outfalls on the River, from Sidcup, down to Crayford. Fortunately, only finding 1 that was Mildly Polluting.
    - Surveyed stretches of the river catchment
    - Walked sections of water courses recording and scoring outfalls.
    - I was part of several of the surveys, walking the streams to identify polluting outfalls.
    - Assisted on two teams surveying different parts of the upper reaches of the River Brent for suspect outfalls.
    - measured the pollution from water run off overflows (30cm+) using gradings for flow, pollution distance from outflow, pollution colour/smell.
    - I coordinated one group and also helped with another. I loaded the results onto the database.
    - I helped 2 others (who had the primary responsibility) with all aspects - finding & reporting the outfalls along the lower brent
    - I surveyed assessed recorded photographed data and incidents that were a cause of pollution and blockages
    - Surveyed the river for outfall pipes and signs of pollution and logging them on the app.

4. **Did you learn anything from the project**
    - The importance of the condition of the river to sustain the habitat of wildlife, and the total disregard of using the river as a dumping ground
    - I walked places I had never previously been despite living local all my life. I learnt what is permissible and not permissible to discharge into the rivers. I became far more aware of what damage illegal discharges can do to the river environment
    - Yes, it was a very Interesting few days.
    - Learned how to locate and survey outfalls. Discovered more about the catchment and potential problems - mainly relating to poor habitat quality rather than pollution, as expected from the river's location in an outer suburban area.
    - About the difference between surface and fowl water drains and how they can become miss-connected How to identify signs of water pollution
    - The walking with the group provided a useful opportunity to study the current state of the catchment and its urgent needs.
    - Yes. 1) That waste water has two separate provisions, 2) There are limited records of what provisions are in place for water run—off provisions that are also misused.
    - some drainage from residential homes wrongly connected to run off sewers and not foul sewers, probably by poor DIY
        - Location of many outfalls. 2 Identified two bad outfalls. 3. Learned a lot about the course of the waterway inc accessibility. 4. Learned about outfall contamination from foul connections and also road runoff.
    - yes plenty
    - I learnt about river management

- I learned that there did not seem to be any signs of pollution entering the Cray from pitfalls.

5. **Please describe if you have used anything you learnt from the project in your everyday life**
   - General observation of the stream in our local park and helping and helping with rubbish removal from same.
   - I would be far more aware of, and far more likely to report river pollution that before I volunteered.
   - It was Interesting to find, when you pull the Plug in your Sink, or when your Washing Machine empty's. Where the Water can go, if incorrectly plumbed in
   - Reviving/enhancing past interest and experience in aquatic ecology, encouraging further volunteering (including on local ponds on Chislehurst Common)
   - I have checked my home for miss-connections. I have also reported polluted outfalls to Thames Water and or the environment agency if I see them where I am out and about
   - It has supported previous research along urban rivers.
   - A realisation that outside my own house there are the two separate provisions for water waste and an awareness of outfalls in rivers when I see them
   - I now regularly look for pollution in part of the River Ingrebourne while walking.
   - If I see a bad outfall in everyday life I know how to report it. 2. I windsurf on the Welsh Harp reservoir which is fed from the Edgeware and Dollis Brooks (amongst others) so I have a vested interest in the results and improvements. (I didn't know this when I started windsurfing).
   - put less solvent type chemistry into the environment
   - The mobile phone app was insightful and I now use a satellite mapper for photography and field trips
   - I haven't.

6. **Have you shared your experiences of the project with anyone else? and if so how?**
   - My colleague who volunteers with me to monitor the Cray for riverflies.
   - I was not sure about this so only on facebook
   - verbally but relatively incidentally
   - I have shared experiences with friends of a similar mind, both for interest and also to recruit for further studies.
   - there were 2 of us who checked a stretch of the River Ingrebourne/River Rom. The results were uploaded to the website given.
   - Not really other than within the teams on the survey.
   - I have discussed the work with local residents and other volunteers.
   - I have shared my knowledge with friends, neighbours and family
   - Sharing interests, results, ideas for further studies, etc with other volunteers (actual and potential) via personal contacts and discussions. Also at meetings, e.g. of DCCP and ZSL Forum
   - I have spoken to friends about it.
   - I certainly shared my experience within my own volunteer group, and friends in general.

- Shared the experience with family, especially with grand children who now help with any tidying up

7. **In your view, could the project be improved?**
   - Only by local advertising to bring awareness to the community and maybe having volunteers helping
   - I think a video that showed polluting out falls on the pre presentation would have helped. Some pollution is difficult to identify. Was frustrating to see lots of general waste in the rivers. A shame we couldn't combine its removal with the project.
   - The Cray survey was well planned and volunteers willing and active and there were no great problems regarding access, H&S, etc
   - Unfortunately unable to offer any constructive suggestions.
   - I think that the work needs to become a regular routine monitoring and reporting so that we can help the damaged river catchments improve.
   - We couldn't access all areas of the river where it ran behind houses. Therefore a full and complete survey wasn't possible.
   - I think the training went fine however the allocation of who does what and where is rather chaotic! There is a problem with many people volunteering but then not doing much.
   - GIS open access to all river info
   - Yes it needs expense budget for volunteers to claim food and travel it should also be I included as a post board along the river trails ie on an info board with contact details and website
   - I can't think of anything.

8. **Any other comments**
   - It would be good if the volunteer work could be videoed and put on facebook
   - A very worthwhile project. An one that I really enjoyed participating in.
   - Could we possibly do this annually?
   - Main comments: (a) need for more timely and clear feedback of results and outcomes to volunteers to show what they have achieved and to encourage further volunteering: (b) need to integrate CS programmes (e.g. OS, RMI, MoRPh, eel monitoring) and share results better (including with local Friends, etc groups, EA, TW, etc) in order to promote more cost- and resource-efficient and sustainable outcomes: (c) need to ensure CitSci programmes are run efficiently and fully completed despite continuous pressures to seek new ideas and funding to maintain the viability of the hosting organisation(s).
   - We need to help the population of London to realise that they can help the environment improve. As a start we need to help them to know where the rivers flow in their area.
   - Involvement in the project has brought to my attention the micro plastics being put in the environment from tyres and brakes. Disturbing.
   - The study was several months ago now so my thoughts are a bit rusty. Overall I am pleased that the study was made and that I contributed to it. I think the citizen science initiative with ZSL and partners is a winning idea on several levels.
   - I wanted to do more but was in between jobs since. Then I got work with British museum