Citizen Crane Outfall Monitoring Feasibility Study Final Report

October 2015

Executive Summary

Citizen Crane (CC) is the synthesis of two citizen science projects; the Riverfly Partnership's Riverfly Monitoring Initiative (RMI), coordinated by Zoological Society of London (ZSL); and a Phosphorus Monitoring Project devised and led by Friends of the River Crane Environment (FORCE) and frog environmental (frog). The project has a network of volunteers monitoring at 12 sites on the river. In April 2015 the programme launched a feasibility study into the value of monitoring surface water outfalls on the river, looking particularly at polluted surface water outfalls.

The volunteers at three of the 12 monitoring points collected data on a total of 22 outfalls over the period from May to August. Background information from Thames Water's Surface Water Outfall Programme (SWOP) were collected with these data and views gathered from other projects looking at this issue.

This report sets out the findings of this feasibility study and assesses the benefit of rolling out the pilot methodology across the catchment. The study finds that due to the high administrative costs associated with rolling out the pilot methodology coupled with the relatively low benefit, an alternative approach to engaging Citizen Scientists with the issue of polluting outfalls should be taken. Initial ideas are presented for this and these will be worked up with the overall project steering group with a view to delivering on them from April 2016

As has been shown in year 1 of the Citizen Crane project, Citizen Scientists have an important and valuable role to play in reporting pollution events and polluting outfalls. There is a good opportunity for Citizen Scientists to conduct dry weather flow (DWF) catchment surveys as part of the process for ensuring that all polluting outfalls in the catchment are recorded, assessed and prioritised for rectification. This type of survey is likely to be more valuable than regular monitoring of the same outfalls.

The project has also led to a better understanding of the Surface Water Outfall Programme (SWOP) operated by Thames Water. This has highlighted opportunities for closer working between stakeholders that will optimise the success of the SWOP programme in reducing the impact of polluting outfalls in the Crane Catchment.

Contents Page

List of tables

List of figures

Acknowledgements

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1. Aims

The aims of this report are as follows:

- To provide the background and context of the polluting outfall issue in the Crane Catchment
- To present the results of consultation with stakeholders and examples of other outfall monitoring schemes operating in London
- To review the outfall monitoring pilot study conducted in the Crane Catchment as an extension to the Citizen Crane project.
- To assess any benefits from applying the citizen science approach to monitoring outfalls and to make recommendations for future outfall monitoring projects.

These aims support the following River Crane Catchment Plan objectives:

- Clean clear water – to ensure that pollution is understood and controlled effectively
- Catchment wide approaches – local communities inspired to take action to solve domestic pollution, through greater public understanding of sources and impacts
- Partnership working between all stakeholders
- Promoting volunteer activities in the catchment and diverse opportunities to engage with the river.

2. Background

2.1 The Citizen Crane Project

Citizen Crane (CC) is the synthesis of two citizen science projects; the Riverfly Partnership's Riverfly Monitoring Initiative (RMI), coordinated by Zoological Society of London (ZSL); and a Phosphorus Monitoring Project devised and led by Friends of the River Crane Environment (FORCE) and frog environmental (frog). The CC project has a steering group that includes the Crane Valley Partnership (CVP), Environment Agency (EA) and Thames Water (TW). Now in its second year, the project is supported by the Thames Water Fund, provided to the Crane following the major pollution event of October 2011, and administered by the CVP. An outfall monitoring programme would seek to complement and extend upon existing work in the catchment under this programme. Further information on the Citizen Crane Project, including the project's interim report (following the first year's data collection), can be found at the following link:

www.cranevalley.org.uk/news/post/citizen-crane-year-1-interim-report-published.html

2.2 Surface Water Outfalls on the River Crane

The responses to a DEFRA consultation report on urban diffuse pollution (2012) approved the prioritisation of the identification and remediation of misconnections as being a fundamental basis whereby the chronic problems posed by Heavily Modified Water Bodies

(HMWB) might be appropriately addressed (Ellis & Butler, 2015). Whilst only parts of the River Crane are classified as HMWB, the catchment is urbanised with water quality and ecology shown to suffer significantly as a result of polluting outfalls. This is corroborated by Citizen Crane data, which regularly detects levels of Ammoniacal Nitrogen above 2mg/l in the upper catchment, and by the "Source Apportionment Geographical Information System" (SAGIS) modelling undertaken by the EA.

A number of studies have shown water quality in urban rivers does improve when misconnections have been remediated. Two prominent cases recorded in London are Milk Street, Bromley and Pyrles Lane, Loughton. Following investigation, misconnection rates were found to be 3% and 3.5% respectively, with toilets, baths, kitchen sinks & dishwashers discharging to surface water drains. In both cases significant improvement of water quality was recorded following the rectification of misconnections (Dunk et al, 2008).

The sewerage and drainage of much of the Crane catchment, as far downstream as where the lower Duke of Northumberland's River leaves the main channel at Kneller Gardens in Twickenham, is separated, with independent sewer pipes (to Mogden STW) and surface water drains into the river (refer to map fig 1). The lowest part of the catchment by contrast has a dual drainage system where both the surface drainage and sewage goes into the sewer network. Therefore, all of the catchment above Kneller Gardens is vulnerable to misconnected domestic appliances polluting the river through the surface water drainage system.

A 2012 survey of surface water outfalls by Thames Water and the EA identified over 150 outfalls into the river upstream of Kneller Gardens. The drainage catchment feeding each outfall typically receives run-off from all the local hard standing – from roads, pavements, roofing etc; as well as any land drains beneath open spaces; that are linked to the drainage system. A small number of these outfalls provide drainage for major roads or the rail network only.

The outflows into the river should, ideally, be of reasonable quality rainwater run-off, during wetter periods, supplemented by year round lateral soil drainage and/or water table inflow. However, they can also be subject to pollution from many sources, including:

- First flush run-off: Particularly following an extended period of dry weather, when accumulated material from the roads and hard standing is washed into the drainage system
- Gully pot flushing: when gully pots are flushed of accumulated solid materials
- Dual man-holes: some man holes in the network provide a connection between the foul and surface water system, which can lead to sewage flowing into the river when the foul system is surcharged
- The illegal disposal of polluted materials to the drainage system: This may include for example the pouring away of oil and paint, or unlicensed commercial washing activities on drained hard standing
- Misconnections: the incorrect plumbing of facilities, such as washing machines, shower units or lavatories, into the surface water drainage system rather than the foul water system

Identifying and quantifying sources of illicit discharges presents a challenging problem given the multiple source contributions that can occur (Ellis & Butler, 2015).

The Thames Water survey identified over 50 outfalls that exhibited evidence; from smell, rag, sewage fungus or plume; of being a pollution source for at least some of the time.

At the same time the EA has been using the SAGIS modelling system to assess the potential sources of phosphate into the Crane river system. Their work indicates that around a third of the river's phosphate load may be a result of misconnections, with another third coming from other surface water outfall pollution sources.

Thames Water has prioritised the Crane catchment in its asset management (AMP6) programme of misconnections work, with 46 surface water outfalls in the catchment being put onto the AMP 6 programme of 200 outfalls across the Thames region.

The misconnections programme works by means of physical investigations on the drainage catchment to narrow down the pollution sources, followed by house to house surveys to identify misconnections and finally working with the householder to remediate the faulty plumbing. The individual drainage areas may take anything from several weeks to several years to investigate and remediate, with any outstanding pollution sources being transferred to the local Environmental Health Office, who have powers of prosecution under The Buildings Act of 1984.

One of the emerging objectives of this study has been to engage with the wider programme of work by Thames Water and identify how citizen science may support this so as to optimise the benefits for the catchment.

2.3 Analysis of existing polluting outfall data

There are 2 main sources of data relating to polluting outfalls:

- A dry weather flow (DWF) survey undertaken in summer 2012 by the EA, Thames Water and other catchment stakeholders
- Reports from members of public to the EA and subsequent investigation by environment officer/ passed on to Thames Water for investigation

The data generated from the DWF survey were plotted onto a map of the Crane as part of Stage 1 of Citizen Crane (Nov 2013), and this is also included here in Appendix A.

In addition to these data, EA reports of polluted outfalls are passed to Thames Water who then follow up by sending a Network Engineer to investigate.

Thames Water has a SWOP to tackle polluting outfalls based on their investigations and assignment of priority. The SWOP is a part of the Asset Management Programme owned by each water company. Currently Thames Water update the CVP on their activity around the misconnection programme in the Crane Catchment every 6 months. Following discussions

between stakeholders it has been provisionally agreed that updates will be more regular, occurring at quarterly intervals, and feeding through the Citizen Crane steering group.

Using the data from Thames Water, CVP plot the location of known polluting outfalls, outfalls that are being investigated and worked on by specialist drainage engineering contractors of Thames Water, and outfalls that have been signed off as no longer polluting. This information is made available to members of public and can be found at the following link on the CVP website:

http://www.cranevalley.org.uk/images/maps/PSWODec2014.png

3. Stakeholder Engagement

Stakeholder engagement has been undertaken to help define potential benefits and constraints to Citizen Science led outfall monitoring programme. Table 1 lists the stakeholders and their role in relation to polluting outfalls.

Table 1: stakeholder analysis

Stakeholder	Role
Environment Agency	Environmental regulator – has a statutory duty to monitor and improve water quality in our rivers, logs pollution incidents including incidents of polluting outfalls. Supportive of partnership working and a member of CVP
Thames Water	Utility company - the owner of the sewerage system and often the owner of the surface water drainage system. Under regulation of the EA, TW are responsible for the Surface Water Outfall Programme and able to prioritise rectification of polluting outfalls with appropriate supporting data The Thames Water Fund is supporting this feasibility study. TW are supportive of partnership working and are also members of CVP
Local Authorities	Local Authorities have enforcement powers; they work with Thames Water and follow up with any property owners that do not repair misconnections through their Environmental Health Officers (EHO), with eventual prosecution powers. The 5 local authorities in the Crane catchment are members of CVP
Friends of the River Crane Environment (FORCE)	Local 'friends' group with 500+ strong membership focused on protecting and enhancing the River Crane. Lead partner in the outfall monitoring study.

frog environmental	Providing technical and administrative support for Citizen Crane project
Zoological Society of London (ZSL)	Leading the RMI element of Citizen Crane, part of the project team behind the development of the project and also part of the CPIL misconnection group (see below)
Citizen Scientists	Undertaking RMI and water sample collection at twelve sites throughout the Crane Catchment. Three site teams have taken part in data gathering on outfalls as part of this feasibility study.
Crane Valley Partnership	Administering funding for the scheme – catchment hosts for the Crane, coordinating work in the catchment.
Catchment partnerships in London (CPIL) (misconnections sub-group)	The CPIL has interest in taking a London-wide approach to the issue of misconnections and working in partnerships with other e-NGOs. The misconnection group is looking at a wide range of issues surrounding misconnections from enforcement and regulation to communication projects and surveying as well as lobbying.
River focused third sector organisations (Thames 21, South East Rivers Trust)	Other outfall monitoring schemes that engage Citizen Scientists are currently operating in the region and might inform development for the Citizen Crane project.
Academic community	Several London based Universities are engaged with Citizen Crane. There may be opportunities for active roles in project development and delivery if an outfall project is rolled out to catchment level. In 2014 Kingston University provided a student for six weeks to monitor and sample from the outfalls on the lower and middle Crane in a work programme running in liaison with this project
TFL, Network Rail & Highways Agency	Also responsible for outfalls that enter watercourses in the Crane Catchment. Run off from roads, rail and gullies can contribute a significant source of pollution in the River Crane. Recent project work by FORCE has shown that high levels of TPH in River Crane sediments (likely to have come from road run-off) can prohibit their re-use on site and render dredging projects not financially viable due to the disposal costs associated with waste classed as hazardous.

	There is a significant legacy issue for contaminated sediment that may also be a source of pollution back into the water column under unfavourable conditions.

Outcomes from stakeholder engagement include a more thorough understanding of existing data sources relating to outfalls and the communication protocols between key stakeholders relating to the assessment and prioritisation of outfalls for remediation.

Other Citizen Science projects relating to water quality and outfalls were assessed to analyse how they might inform the pilot project element of this feasibility study.

3.1. Identification of stakeholder needs

There were several areas highlighted by Thames Water and the EA where it is thought Citizen Science monitoring of outfalls could support organisational needs.

- Undertaking monitoring / water quality testing on outfalls where there is a suspected problem
- Taking part in an annual mapping exercise to record all outfalls in the catchment in dry weather flows
- Responsive monitoring where EA or Thames Water believe there is an issue but do not have available resource to investigate
- Monitoring outfalls that are undergoing works or have had work completed on them and have been signed off

3.2. Citizen Science outfall programmes in London

The **South East Rivers Trust (SERT)** outfall monitoring programme developed from the Pollution Assessment Volunteer programme funded by the EA. The outfall scheme has trained 70 volunteers and monitors 11 outfalls on the Wandle, 12 on the Hogsmill and 6 on the Beverley Brook. These are outfalls that the EA have received pollution reports on from members of the public.

At the time of writing data capture procedures for this project were being updated in order to help reduce unnecessary paperwork and decentralise some of the project administration. Going forward volunteers will fill in a spreadsheet designed by SERT directly with site data, as shown in Appendix B.

The main benefit of the project is that it allows project administrators to identify trends / changes in outfall behavior. All data are shared with a named contact at the EA. This is achieved through a shared spreadsheet kept in “the cloud”.

4. Pilot Outfall Monitoring Study

The pilot study ran from April to September 2015 with the following 3 established Citizen Crane sites partaking in outfall monitoring:

- Site 2, Spider Park
- Site 6,Yeading Brook Meadows
- Site 12, Mill Road

Mill Road (Site 12), is run by the core project team ZSL, frog environmental and FORCE along with St Mary's University, and this has allowed for closer assessment and consideration of different outfall monitoring methodologies.

The pilot study used an outfall assessment form designed by Thames Water to visually assess the potential damage a polluting outfall is causing. A copy of this form is included in Appendix C.

The principle of the scoring system is that a threshold is set that when breached would result in a report being made by the Citizen Scientist. The form records information on the following:

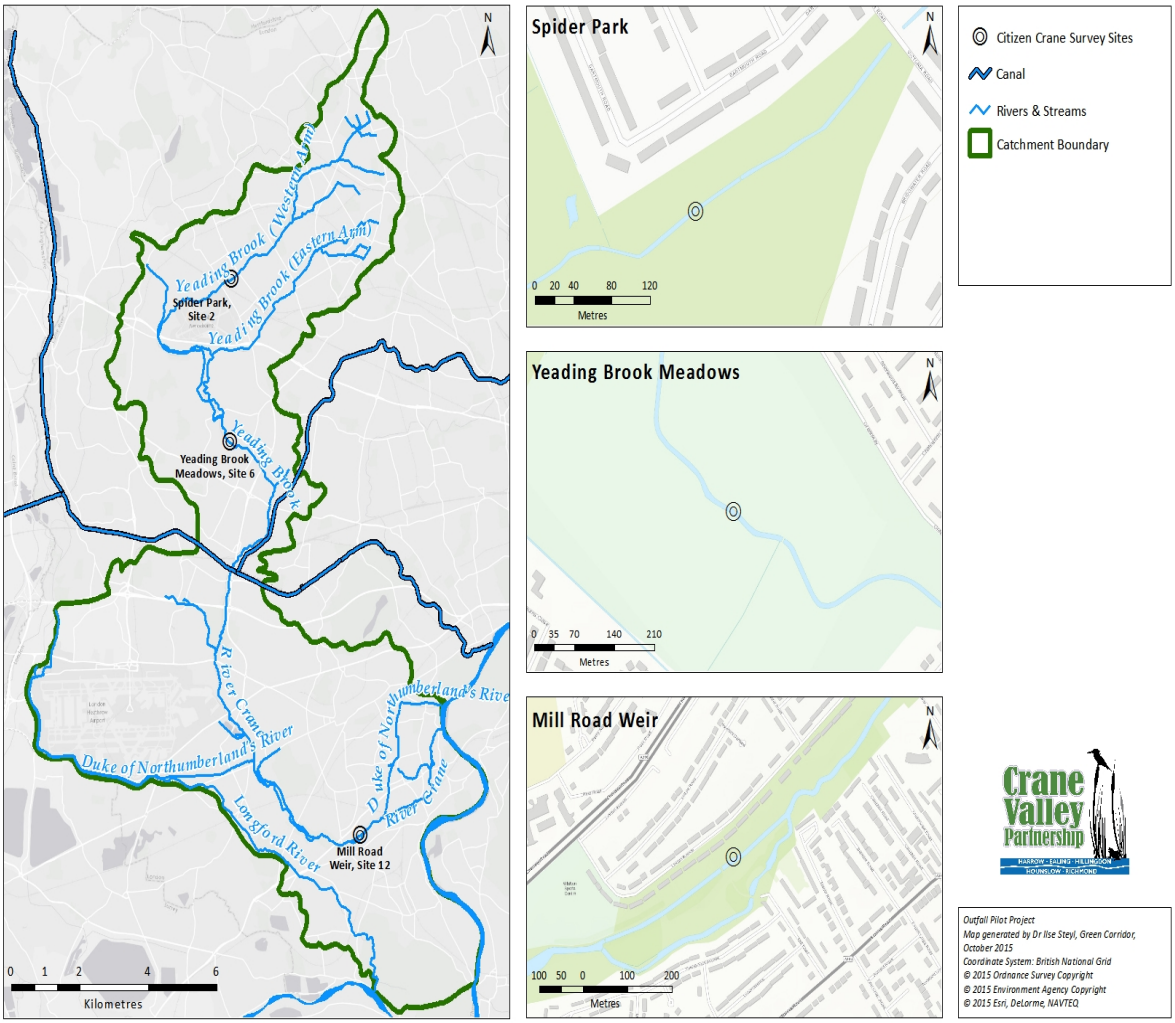
- A physical description of the outfall and its location
- A broad estimate of the flow rate
- The general aesthetic impact
- The general visual impact
- Smell
- The potential impact on communities downstream

All site teams were given instructions on how to use the Thames Water outfall assessment form. Information on outfalls was collected on a monthly basis on the third weekend of the month as per the Citizen Crane sampling. Some records, particularly where pollution problems were identified, were also collected during interim periods.

The number of outfalls to be recorded by each site was left at the discretion of the Citizen Science team.

As per the current project protocols, data were returned by email to the project administrator. The format of the data return was left at the discretion of the site team and would help inform the trial. Data were analysed by the core team and breaches of threshold identified and reported to Thames Water.

fig 1. Map of the Crane catchment outfall pilot monitoring sites



4.1 Pilot Study results

The results section includes a summary of results collected by Citizen Scientists, including the number of outfalls monitored per site, the number of threshold breaches per site and an analysis of the outfalls monitored by Citizen Scientists compared to known polluting outfalls.

A more extensive analysis of data from site 12 has been undertaken that sets out to match the outfall data collected to outfalls on the current SWOP and their status. This has been made available in Appendix D.

4.2 Data returned from monitoring sites

The trial period ran for four months from May to August 2015. Table 2 below shows the number of outfalls recorded per site.

Table 2: number of outfalls recorded by site

Site number/ name	No of outfalls recorded monthly
Site 2 – Spider Park	13
Site 6 – Yeading Brook Meadows	3
Site 12 – Mill Road	7

The number of threshold breaches at each site is noted in table 3 below.

Table 3: number of Threshold breaches recorded by site

Site name/ number	No of breaches recorded
Site 2 – Spider Park	4
Site 6 – Yeading Brook Meadows	0
Site 12 – Mill Road	1

4.3 Analysis of threshold breaches

Where Citizen Scientists recorded breaches of the scoring threshold, an analysis was undertaken to investigate whether the outfall was a known polluting outfall or not.

Table 4 below shows a summary of Spider Park (site 2). Four threshold breaches were recorded, two of these outfalls were successfully matched to known polluting outfalls, one outfall was not recorded as a polluting outfall according to existing survey data and one outfall was inconclusive, with more accurate site data required.

It should be noted that the EA Hotline was called by the site lead to report two of the breaches at site 2, as the pollution from the outfall was judged to be significant.

Table 4: site 2 analysis of threshold breaches to known polluting outfalls

Citizen Crane ref	Survey NGR ref - TW ref	Status
CC2-001	TQ1023485911 Ruislip Gardens	Matched / on SWOP waiting list
CC2-002	TQ1173286770 Field End Road	Matched / on SWOP waiting list
CC2-003	NA	Not previously recorded
CC2-011	NA	Inconclusive – further details required

Fig 2: site CC2 - 002 at Field End Road

At Yeading Brook Meadows no breaches were recorded at the time of monitoring. However, photographic evidence of the outfalls showed clear signs of pollution from two of the outfalls as well as end of pipe temporary mitigation measures to reduce impact. Both outfalls are known polluting outfalls from the survey, as can be seen from table 5 below.

Table 5: site 6 analysis of threshold breaches to known polluting outfalls

Citizen Crane ref	Survey NGR ref/ name	Status
CC6 – 01 RB	TQ1025882863 / Kingshill Ave	Matched / on SWOP waiting list
CC6 – 02 RB	TQ1025982858 / Kingshill Ave	Matched / on SWOP waiting list

Fig 3: evidence of significant pollution at an outfall monitored by the team at Yeading Brook meadows. The outfall did not breach the threshold according to the assessment.

The Mill Road site (site 12) monitors 7 outfalls monthly. These include six outfalls local to Site 12 and a further outfall local to Site 11, which was added due to public observations of polluted outflows reported to FORCE. Table 6 below provides a summary of the outfalls monitored matched to the known polluting outfalls on the Thames Water SWOP list. A more detailed breakdown of outfall data from site 12 along with first order calculations of polluting load has been provided in Appendix D.

Table 6: site 11 & 12 analysis of threshold breaches to known polluting outfalls

Citizen Crane ref	Survey NGR ref / TW ref	Status
CC-11-01	TQ1241773086/ Hanworth Road	Matched / Live project on SWOP
CC-12-01	TQ1281872738/ Lyndhurst Ave	Matched / Signed off as complete on SWOP
CC-12-02	TQ1362772651/ Beech Way	Matched / on SWOP waiting list
CC-12-03	No TW ref	Not matched / low impact according to this survey
CC-12-04	TQ1373772647/ Hospital Rd South	Matched / on SWOP waiting list
CC-12-05	TQ1373472665 / Hospital bridge North	Matched / signed off on SWOP (observed with some pollution returning following sign off – this resulted in further work being commissioned by

		TW for this site)
CC-12-06	No TW ref	Not matched /low impact according to this survey

5. Discussion

The pilot study shows that Citizen Science Volunteers can help regularly monitor outfalls and provide information that supports the objectives of the catchment plan. Their monitoring data shows a good correlation between recorded breaches and known polluting outfalls on the SWOP. The results of stakeholder engagement indicate that whilst stakeholders see benefits from Citizen Science outfall monitoring, there would be little benefit in regularly monitoring known polluting outfalls, as there is already a plan of action in place to investigate and improve these.

The threshold breaches that have not been matched to known polluting outfalls such as the example in site 2, Spider Park, are significant as they may point to the fact that not all polluting outfalls in the catchment have been recorded.

Where a known polluting outfall is not listed on the SWOP there may be a benefit in monitoring it. By doing so the project will provide evidence for prioritisation in a future AMP.

In one case (Hospital Bridge Rd at Site 12) Citizen Science monitoring has helped to identify returning pollution to an outfall that was due to be signed off – with the result that further TW investigations have been commissioned.

With regards to rolling out the methodology applied in the pilot across the catchment, there are constraints, mainly involving the administrative weight of such a scheme, and these are set out in table 7 below.

Table 7: summary of constraints analysis to roll out methodology at catchment scale

Constraint	Mitigation
High administrative load associated with operating the project (in the format tested) at a catchment level	Decentralising some of the administration to citizen scientists may help reduce admin time, however the estimate of 1 day per week required to operate the project is not commensurate with the benefits that it delivers in the format tested
No recognisable outfall coding system – no common language between stakeholders for identifying the same outfall.	A project specific numbering system was used in this pilot. This system does not lend itself to scalability or flexibility to add or remove outfalls, as each time this happens manual renumberin is required from project admin. A smart system based on NGR and photo would supercede the need for a numbering system.
H&S Whilst the project has strict safety protocols, safe	All of the Citizen Crane sites have been assessed from an H&S perspective. The resource required to assess

access to each individual outfall is something that cannot be assessed readily. This is a constraint to collecting samples or carrying out on site 'indicative tests' e.g. use of ammonia strips	safe access to every outfall that requires access from the river channel is likely to be cost prohibitive. Sampling from bankside is far less problematic but will not always be possible.
Motivation of Citizen Scientists if the same outfall is being monitored for potentially years, with no perceivable change	Ensure correct expectations are set with regards to how the data is being used and the purpose of monitoring
Low benefit – whilst there is a benefit in understanding where all polluting outfalls are in the catchment, once their location is known and it has been confirmed that work is planned to take place, there is a limited benefit in continually monitoring the same outfalls	It is proposed that the Citizen Science resource can be directed towards an annual dry weather flow survey of the entire catchment rather than a monthly assessment of the same assets.
Question as to if there are enough volunteers to cover a DWF assessment of outfalls in the whole catchment	Recruit volunteers for a limited period via environment job etc. ZSL has experience of this working successfully on other projects. Seek the help of students to augment the pool of available Citizen Scientists during the DWF survey.
Low sampling resolution (monthly)	A different method of recording and logging data (e.g. smartphone app) may make ad hoc monitoring more feasible and could help to overcome low sampling resolution issues

The high administrative costs associated with rolling out the methodology and relatively low benefit suggest that an alternative approach to the pilot methodology tested should be taken to engage Citizen Scientist resource with the issue of polluting outfalls in the Crane Catchment.

A key role for the Citizen Crane network might be to help deliver catchment wide dry weather flow surveys. The benefit of this would be in ensuring the behaviours of all outfalls in the catchment are recorded and the polluting outfalls in the catchment better identified. There may also be scope, if the reliability of the data can be assured, to include field testing into the programme that may be of benefit in quantifying the contributions of individual outfalls.

The results and discussions have also helped to identify several other potential benefits to citizen scientists recording outfall data, as well as wider benefits of the Citizen Crane network being kept up to date regarding the Thames Water SWOP, as follows:

- Analysis of the pollutant loadings derived from known misconnections, by including samples from outfalls with other Citizen Crane water quality data, can help to quantify the potential benefit (e.g. by indicating the percentage reduction of P and other contaminants) of Thames Water's successful removal of contaminants from the outfall under the SWOP
- The Citizen Crane network can help disseminate information about the SWOP programme to the local community and facilitate positive communication between those involved in the programme and members of the community. This has proven its use at site 12 where the Thames Water SWOP has benefitted from press releases from FORCE and LB Richmond, as well as discussion on Facebook pages, through this project. This is of importance, given the necessity of positive public engagement to the success of the SWOP programme.
- With regular update of information from Thames Water on the SWOP, Citizen Scientists could be mobilized to check on polluting outfalls that have been fixed by Thames Water. As noted above, ongoing monitoring of the outfalls at Site 12 has allowed the identification and reporting to Thames Water of continued problems at outfall 5 - Hospital Bridge Road North after this had been allocated for sign off from the SWOP programme. The example also highlights how the behaviour of outfalls may change and points to the value of a catchment scale dry weather flow survey.

These proposals will be reviewed with the project steering group and developed for incorporation into a programme of work starting in April 2016.

6. Recommendations for the development of the Citizen Crane project

1. Target communication to Citizen Crane volunteers local to where Thames Water's contractors are tracing the sources of pollution as part of the SWOP. Volunteers and project partners (such as local friends groups), can raise the local public profile of why contractors are in the area and what the environmental benefits are. This can significantly aid the effectiveness of the TW work.

2. Encourage Citizen Crane volunteers to adopt outfalls in 'their patch' and encourage a more on going ad hoc monitoring approach for these. Offer training, in partnership with the EA, in how to assess outfalls, things to look out for that might indicate the behavior of an outfall is changing and what to do in the event of a pollution incident.

3. Develop a methodology for a short term, citizen science, dry weather flow (DWF) survey of all outfalls in the catchment for summer 2016. Once the methodology is developed it can be used as a catchment management tool on an annual basis for instance. In order to reduce administration the DWF survey would most probably use a mobile app for data collection. Data to collect will include the outfall location, its behaviour and a photograph. More consultation will be undertaken by the Citizen Crane team in the coming months to assess the most cost effective way of achieving this. The mobile app will be piloted and assessed by Thames Water and the EA to ensure it integrates with their systems and is of maximum use to them.

4. Outfall specific water quality monitoring in order to help quantify the benefits of SWOP. The current water analysis programme has a 'spare' site (site 5), which has been used to gain a monthly analysis of water quality from individual outfalls local to site 12 as part of the pilot project, further details of which are provided in Appendix D. The approach has the potential to assess and quantify the benefits of Thames Water SWOP programme.

References

Ellis & Butler, 2015, Surface water misconnections in England & Wales: Pollution Sources and Impacts, Science of the Total Environment (526- 2015), (P102, P107).

Dunk et al, 2008, A new management approach for the remediation of polluted surface water outfalls to improve river water quality, Water & Environment Journal (22-2008), (P.33)