Citizen Crane Year 3

Progress Report

October 2017

CITIZEN CRANE PROJECT

YEAR THREE PROGRESS REPORT

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Glossary of Terms:

NH_3-N: Ammoniacal Nitrogen *(used as a measure of organic pollution e.g. related to wastewater)*

P: Phosphate *(P is the chemical symbol for 'phosphorus'. For the purposes of this report we will be examining phosphate, the fraction of phosphorus that is inorganic, soluble and reactive and therefore bioavailable. P will be used to denote 'phosphate' in the text unless otherwise noted)*

SWOP: Surface Water Outfall Programme

PSWO: Polluted Surface Water Outfalls

RMI: Riverfly Monitoring Initiative

WFD: Water Framework Directive

Acknowledgements:

All of the Citizen Scientists who after three years of hard work refuse to give up the idea of an unpolluted River Crane.

The Environment Agency, with special thanks to Amanda Maclean, Rosalind Brown and Matt Reed.

The students from various universities for their dedicated studies focusing on the Crane catchment.

Dr Iain Cross (St Mary's University) for taking Citizen Crane to a wider audience via his talk at the Royal Geographical Society.

Alan the mayfly, who regularly props up the RMI score at monitoring site 12.

Summary of Findings

Citizen Crane is a citizen science project designed to investigate the key causes of water pollution in the River Crane in west London and to identify, support and optimise measures to improve the river condition. The objectives of Citizen Crane are broadly aligned with the objectives of the Crane Catchment Plan. This report presents a summary of the Citizen Crane project at the end of the third year of investigations. There has been no change in the project structure or set up since the issue of the Year 2 report in November 2016.

The purpose of this report is twofold: firstly, to provide a Summary of the third year of the Citizen Crane project, and secondly to bring together all work and activities relating to Citizen Crane for future reference.

The Summary of Findings will present highlights of work in all key areas including water quality, Riverfly Monitoring Initiative (RMI) and the survey of outfalls. The summary ends with a note on Citizen Crane strategy up to spring 2020.

The body of the report then follows, which will include analysis of data and discussion of results as well as a summary of key areas in which the Citizen Crane project has diversified and developed during its third year of operation.

Importantly, the report will focus specifically on new data and also show how the emphasis of the project is moving from recording data to engaging stakeholders and taking action to improve the condition of the River Crane.

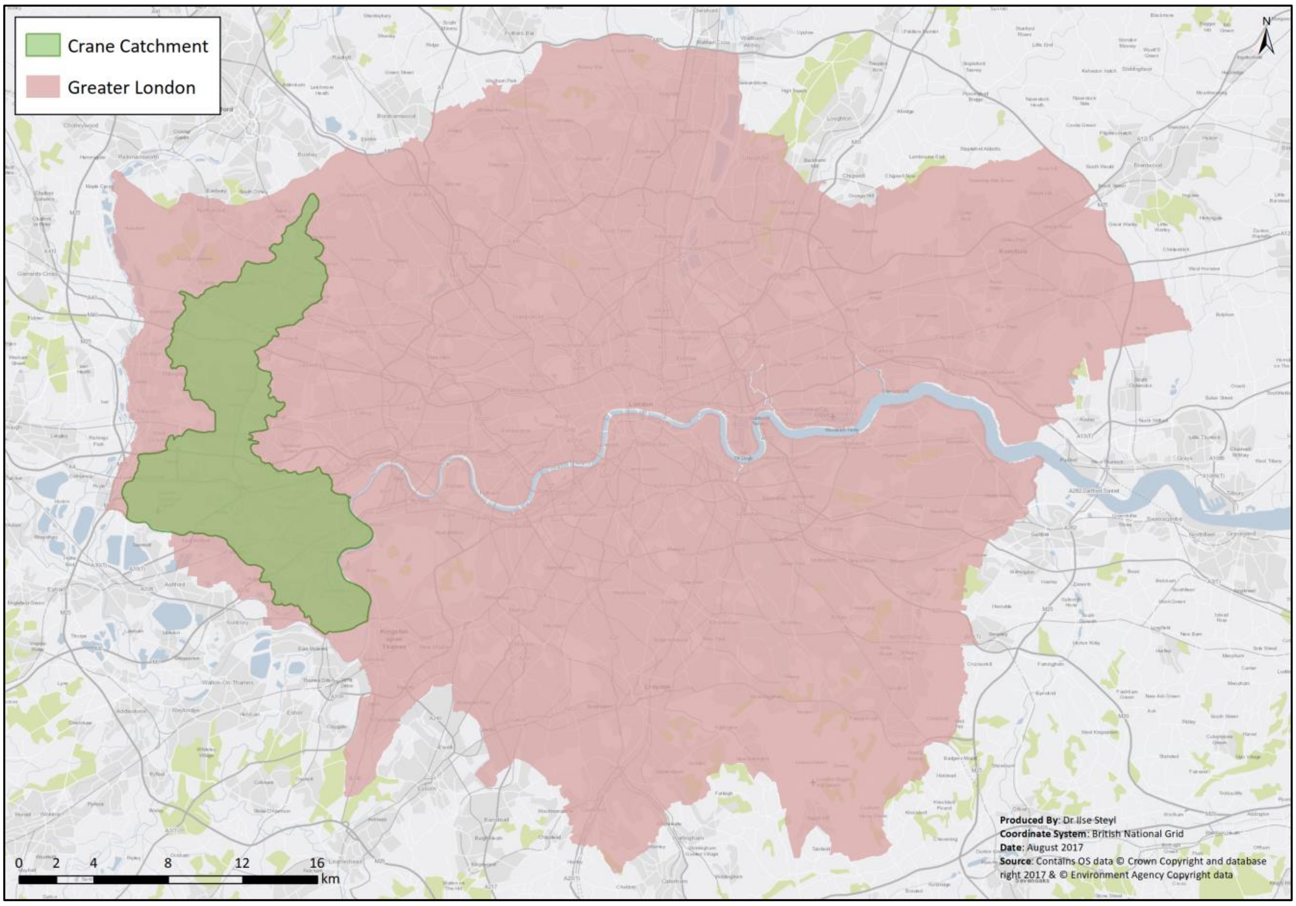

Figure 1: Location of the Crane Catchment within Greater London

Water Quality

Citizen Scientists have continued to diligently collect water samples at 11 sites along the Crane catchment every month during Year 3. These samples have been analysed by the Thames Water laboratory in Reading for phosphate (P) and ammoniacal nitrogen (NH_3-N) concentrations. Loading data have also been calculated, by combining the concentration data with the river flow rate, gauged at the same time as the sample was taken.

It should be noted that medians have been calculated and applied in Year 3 for all data sets, instead of means, due to the high degree of variability noted in the data. Medians have also been applied to the Year 1 and Year 2 data sets to ensure all data are comparable. The following maps give an overview of results to date. Further analyses and discussion of data can be found in the main body of the report.

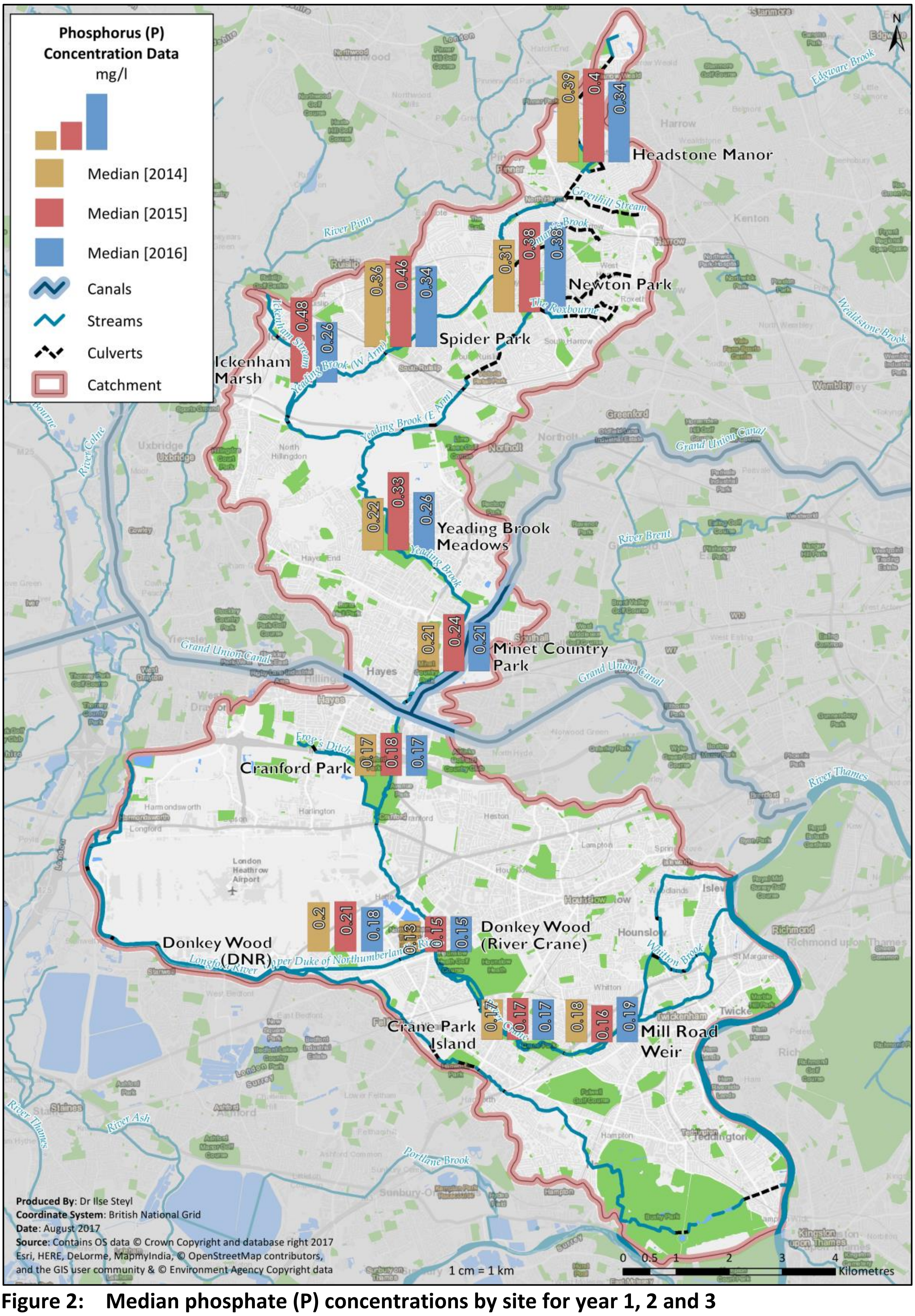

Figure 2: Median phosphate (P) concentrations by site for year 1, 2 and 3

Figure 2 shows median P concentration by year for each sampling site. Higher concentrations are consistently recorded in the upper catchment. Year 2 showed higher concentrations of P in the majority of sampling sites compared to year 3. Only one site (Site 12) showed a higher median concentration in year 3 than in year 2.

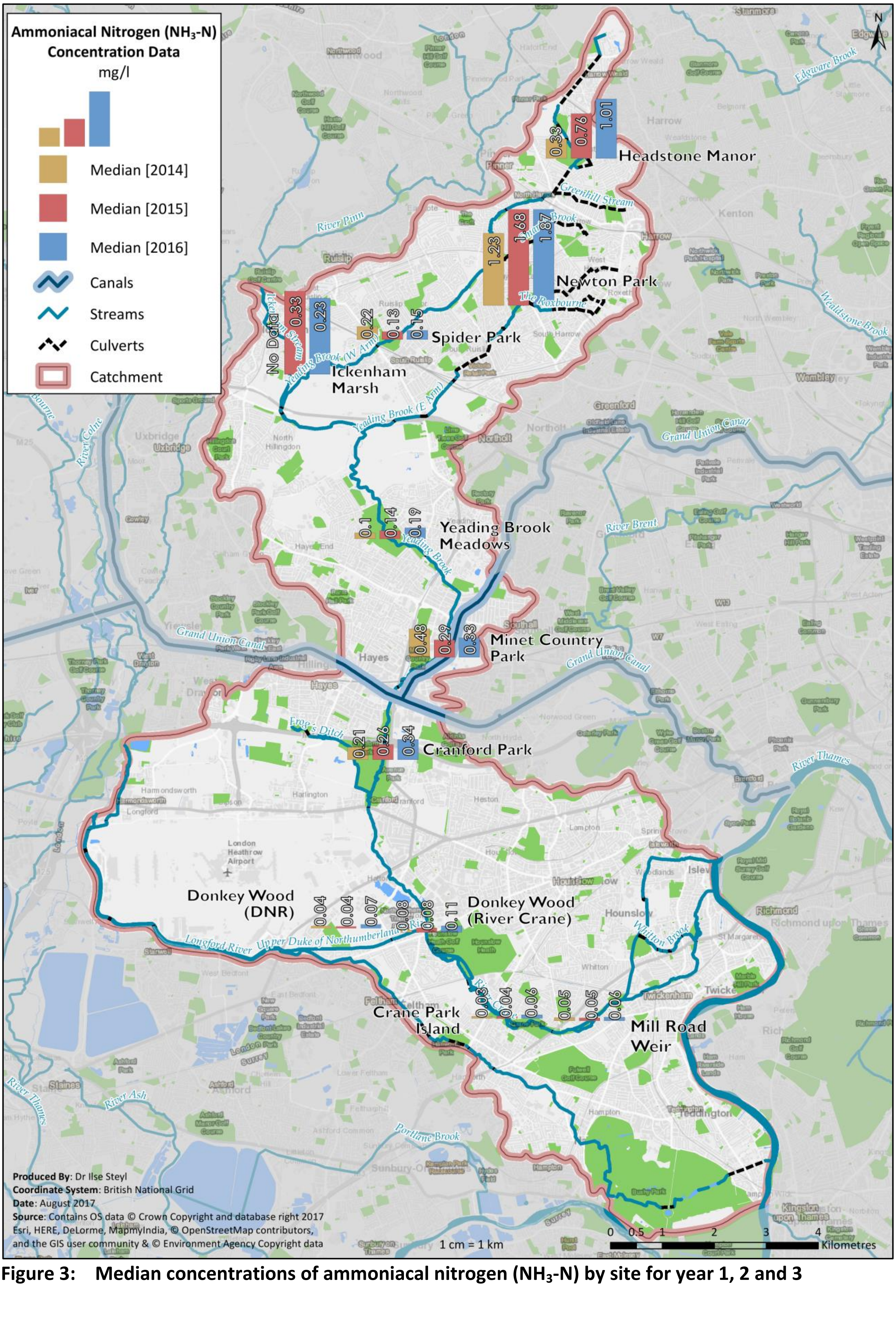

Figure 3: Median concentrations of ammoniacal nitrogen (NH_3-N) by site for year 1, 2 and 3

High concentrations are recorded in the upper catchment, where Individual peaks have been recorded at >4 mg/l. Spider Park and Yeading Brook Meadows are notable for their low concentrations in comparison to the sites above and below them.

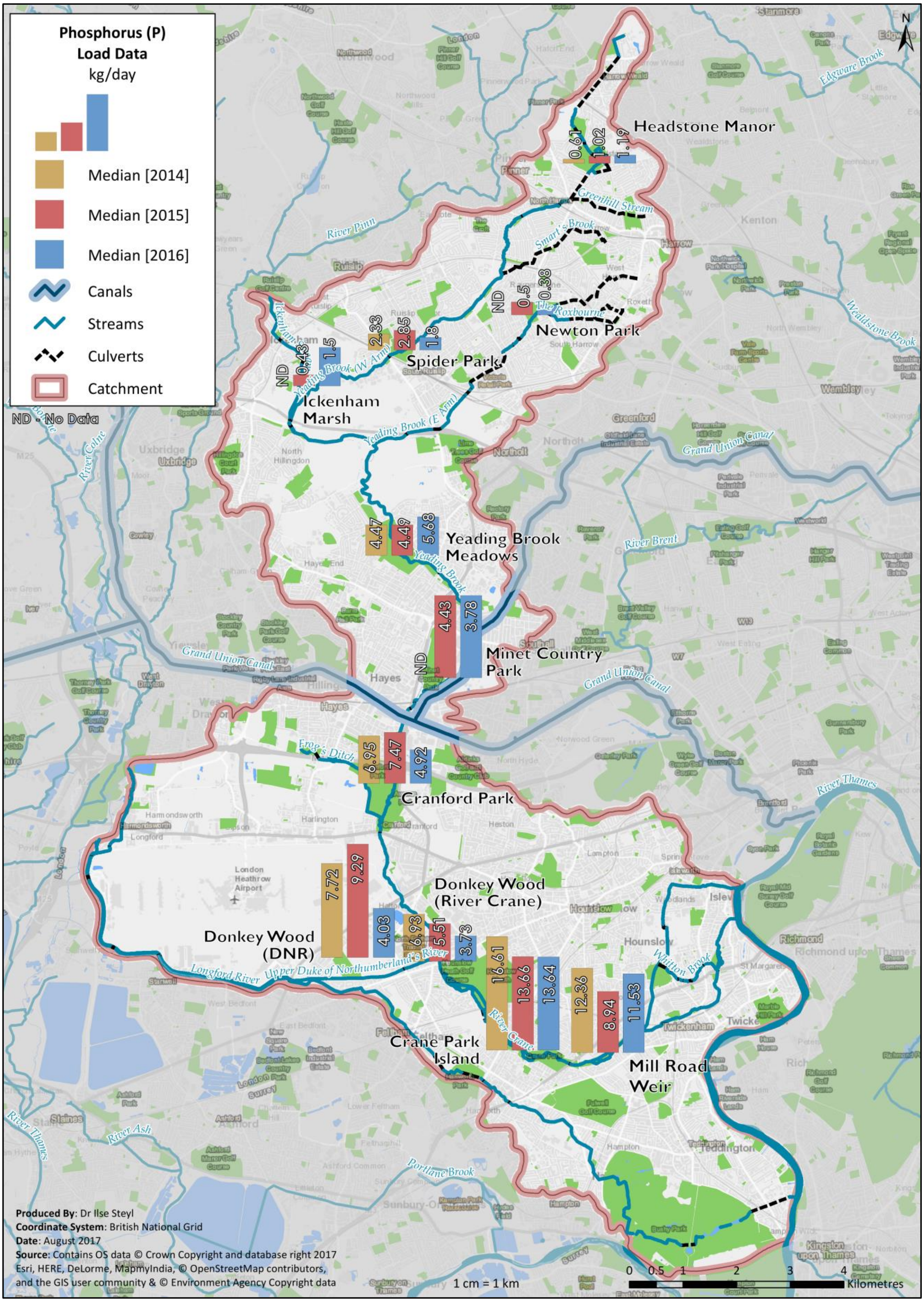

Figure 4: Median loadings for P by site for year 1, 2 and 3

P loadings are typically low in the upper catchment and higher in the middle and lower catchment. The feed from the Upper DNR shows a highly variable load of P delivered to the River Crane from the River Colne. Results show the loading between sites 11 and sites 12 reduces by between 2 and 6 kg/day in this short stretch. No consistent pattern of improvement or deterioration is recorded across the catchment.

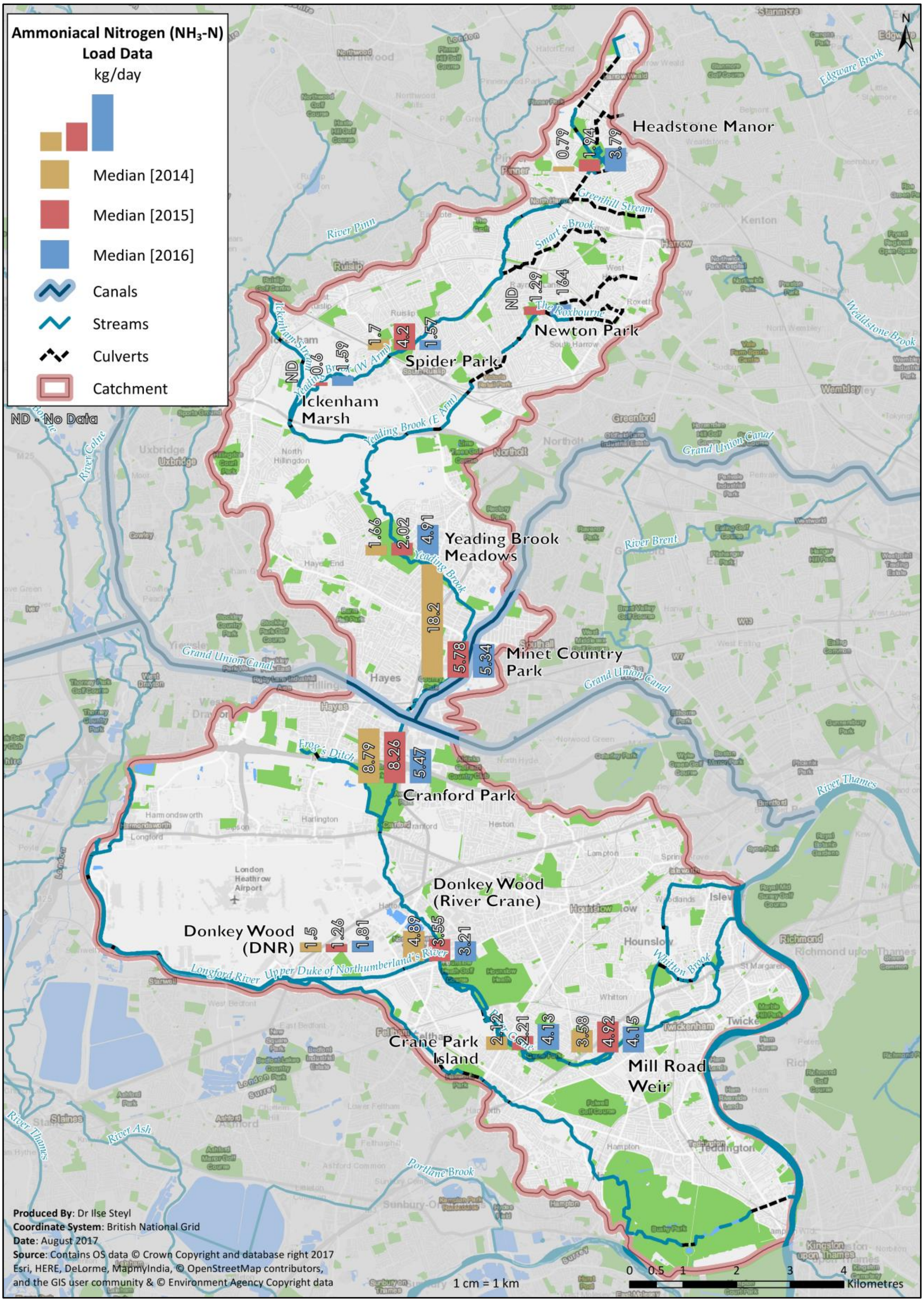

Figure 5: Median loadings of NH_3-N by site for years, 1, 2 and 3

The highest loads for NH_3-N recorded are towards the middle of the catchment. Headstone Manor (site 1) shows loadings have doubled year on year. Between the lowest 2 sites of the River Crane (site 11 and site 12) loadings doubled in year 1 and year 2 but remained consistent in year 3.

River Monitoring Initiative

A full description of the RMI methodology is available in the Citizen Crane year 2 report. The primary purpose of the RMI is to allow for the detection of pollution issues and gathering of evidence by trained volunteers to supply to the Environment Agency if further investigation is required. The most recent example was reported in January, February and March 2017 when trigger level breaches and significant signs of pollution were reported to the Environment Agency from Donkey Wood (Crane), Crane Park Island and Mill Road Weir (see Appendix A for a more detailed report of this incident).

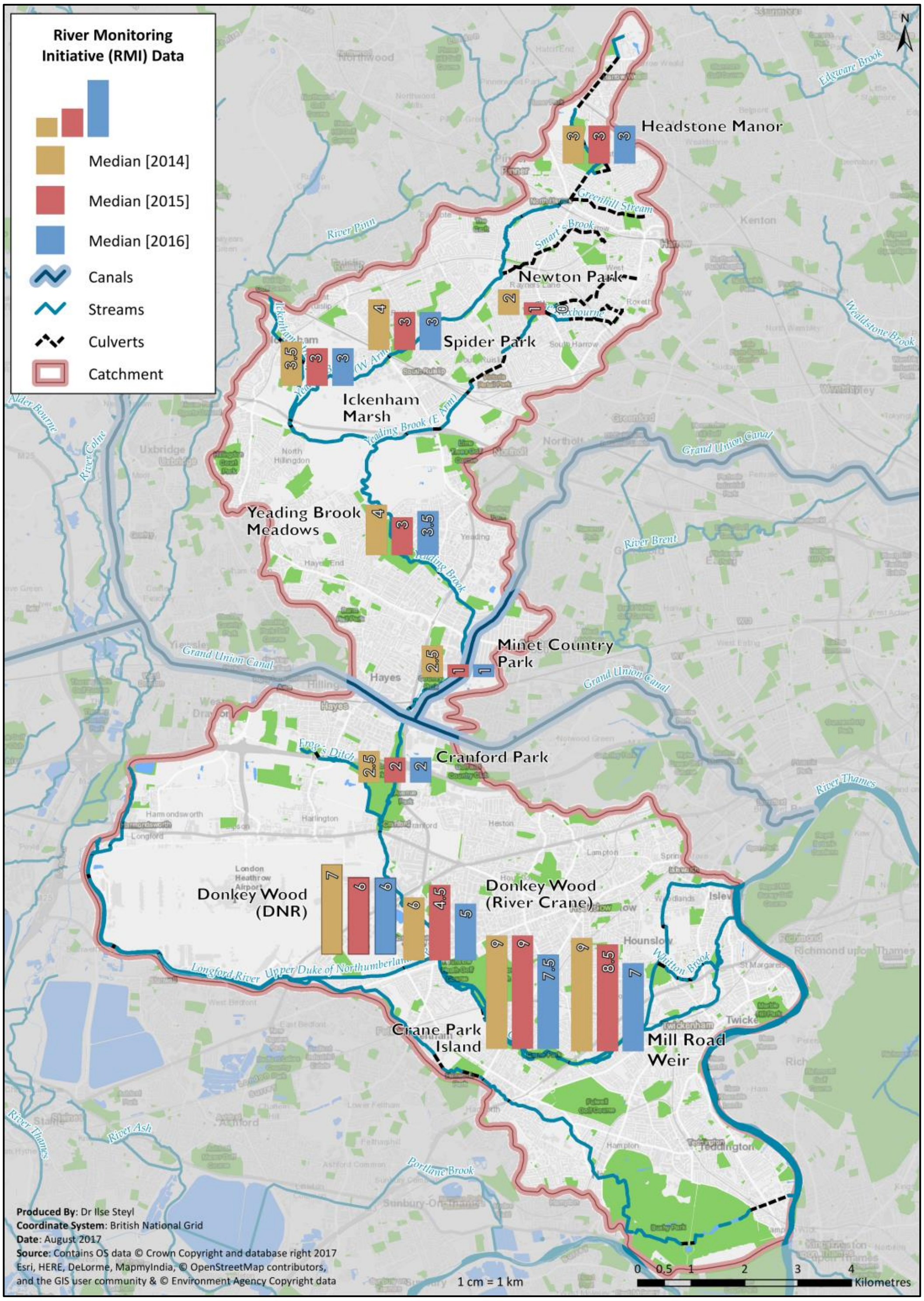

Figure 6: Comparison of RMI scores by site for year 1, 2 and 3

Figure 6 shows the median RMI scores for each site during each of the first three years of the project. RMI scores continue to be low throughout the upper catchment. The two sites downstream of the confluence with the Duke of Northumberland's River, Crane Park Island and Mill Road Weir, show markedly improved median RMI scores when compared to other sampling points.

Outfall Safari

In summer 2016 Citizen Crane volunteers conducted a survey of all the outfalls along 34 km of the main river corridor in the catchment and this was reported in full in the year two report. They photographed, located and assessed a total of 227 outfalls (see full methodology in the year 2 report). Impact scores were derived from each outfall assessment, using a methodology previously developed by Thames Water, with a score of 20 being the most polluting and 2 the least. Out of the outfalls assessed 64 (28%) showed some signs of pollution with 47 scoring 4 and above. Details of all polluting outfalls were passed to Thames Water's Environmental Protection Team for follow up action.

Since the creation of the Outfall Safari methodology by the Citizen Crane project it has been applied to over 100 km of river corridors across Greater London. Over 800 outfalls have been assessed and their details passed on to the Environment Agency, Thames Water and the relevant catchment partnership. ZSL will be reporting separately on the findings of this wider work later in 2017.

Further outcomes from the Outfall Safari in year 3 are summarised below:

- Identification of key polluting outfalls;
- Further EA investigations on sources of pollution within the catchment;
- Progress on development of a plan to reduce the impact of M4 outfall (Cranford Park) – see also the University investigations reported below;
- Sharing data with TW to allow re-prioritisation to their SWOP;
- Adoption and development of the methodology elsewhere in London;
- Potential to repeat in the Crane in 2019 and re-assess polluting outfalls.

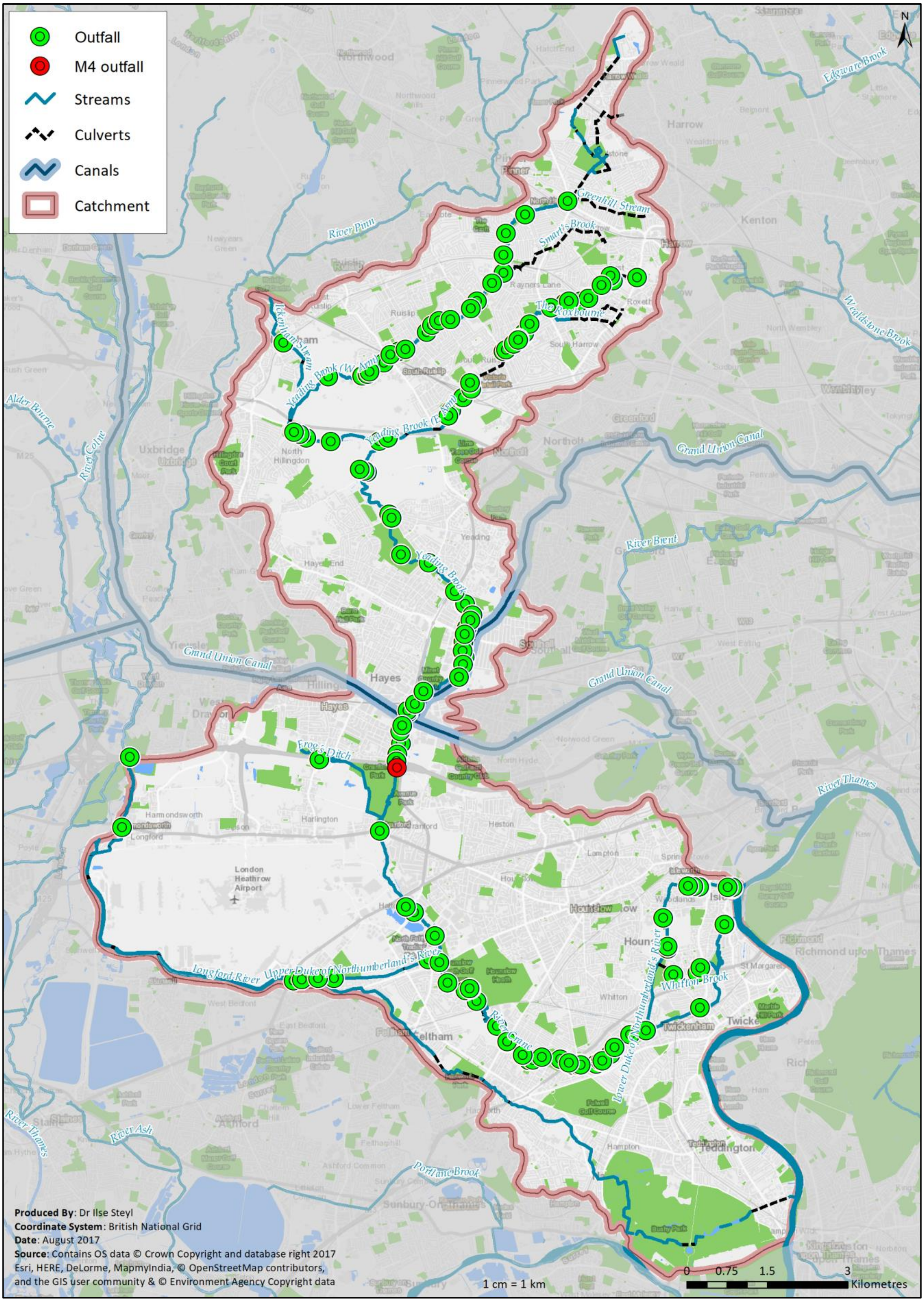

Figure 7: Outfalls identified by outfall safari with M4 outfall highlighted in red

Road Run-off Project

Contamination arising from road run off is likely to have an impact on the health of the River Crane, although how much of an impact is not currently well understood.

During year 3 of the project, two academic studies were undertaken investigating the impact of road run off in the Crane catchment.

Studies involving students from Royal Holloway University and Cranfield University collected field data from the Crane catchment in the form of water and sediment samples. All analysis was undertaken at UKAS accredited laboratories.

The Cranfield University study also sampled for total phosphorus (TP) to be analysed in each sediment sample. These data were applied to the long-term study of the catchment and the development of a mass balance model for nutrient and organic pollutants in the catchment (as reported below).

The Royal Holloway study focused on the M4 motorway outfall that is a known source of pollution, highlighted in red on Figure 7 (above).

At the time of writing, not all conclusions to the studies have been reported on. The outcomes will therefore be considered more thoroughly during Year 4 of the study.

Many contaminants that are a concern to the ecological health of the catchment arise from road run off. Their behaviour in the environment, impact on the food web and associated legacy issues are important to consider in the context of the wider efforts to restore the Crane. Both studies are expected to provide useful insight regarding the potential impact of road run-off in the Crane catchment.

Long Term Surveys and Surface Water Outfall Programme

Long-term surface water outfall surveys by Citizen Crane are providing a valuable insight into the impact of polluted surface water outfalls on the nutrient and organic pollutant loadings of the river system.

The lower reaches of the river, around Sites 11 and 12 within Crane Park, have been the focus of these long-term studies. These reaches have also had most focussed investigation and remediation by the Thames Water Environmental Protection teams. It has therefore been possible to develop an understanding of the potential benefits of the wider SWOP.

The monitored SWOP outfalls showed levels of P and NH_3-N in the order of 1 to 2 mg/l, with moderate to high levels of sewage fungus on the outfall apron. Several of the outfalls also displayed occasional “pollution flares” (lasting from a few hours to a day or two) with extended plumes of grey brown water indicative of raw sewage. Where pollution is extensive this can be indicative of a blockage and is always reported to Thames Water and the Environment Agency.

The typical polluted outfall has between 15 and 35 misconnections, including sewage sources as well as grey water, providing a chronic nutrient and organic pollutant load. The SWOP programme appears to have been largely successful in remediating the polluted outfalls, albeit that some outfalls require repeated investigation to fully resolve.

Preliminary assessments indicate that the SWOP is able to reduce the concentrations by a factor of five or so – at which point they remain around twice the concentration seen in the river at this location.

The monitoring of SWOP outfalls by the citizen science teams has had the following additional benefits:

- Field information has been provided to Thames Water on a monthly basis regarding the performance of the programme;
- Thames Water has used these data to refine its work and to revisit outfalls that were (or might otherwise have been) signed off as complete;

- There is much improved public awareness of the SWOP work and the issue of misconnections more generally. Around 3,000 information leaflets have been given out by Citizen Crane volunteers and there have been regular Facebook postings by volunteers and members of the public – including regular reports of pollution problems;
- Identification of several pollution incidents – including illegal disposal into road drains for example – at the SWOP outfalls;
- Linkages have been strengthened between the Thames Water and the councils' parks departments and environmental health officers.

These benefits have supported the effective engagement of the SWOP contractors. Improved public awareness is also expected to increase rectification rates of existing misconnections and reduce the appearance of new misconnections.

It is notable that those members of the public that use Crane Park regularly now appear more aware of the misconnection issue than when the project started. This is likely due to the regular presence of the monitoring team at Mill Road (site 12) who regularly engage with visitors to Crane Park. The park is well known and used by many local people and the ready association between a misconnected property and the park may have helped with the response rate to problems when found by the SWOP teams. Where the link between a misconnection and the local environment/river is not so clear, rectification rates may be lower. However, this is only a hypothesis at this stage as Thames Water report rectification rates for currently signed off projects in the Crane catchment are generally above 90% and no clear geographical variation has been identified.

The data collected have also been used to produce a preliminary mass balance for the catchment as a whole. These are presented in this report for comment, review and development as the project moves forwards. Key points at this stage include:

- The SWOP appears to have the potential to deliver a significant beneficial impact on the concentrations and loadings throughout the catchment. The Citizen Crane monitoring over the next three years can be used to see whether this potential is being realised;
- In-river processes, such as break down of NH3-N and the accretion of P, appear to have a major control on the concentrations and loadings throughout the catchment. Improved understanding of these processes and the controls upon them will be of great value going forwards;
- The rate at which new misconnections are added to the surface drainage system is likely to be critical to the investment needed to make the SWOP a success in terms of its impact upon river conditions. Further assessment of these rates will also be of value going forwards.

Additional data from a study by Cranfield University have provided a valuable insight into the total amount of P held in the river sediments. This total is equivalent to several years of input from misconnections and indicates the potential influence of sediment as a sink and source of P within the catchment.

The Environment Agency has created a Source Apportionment (SAGIS) model for the Crane catchment considering the potential sources of P across the catchment and these data are presented in Appendix B of this report. These data have not yet been assessed with reference to this water balance model and this task is a priority for year 4 of the project.

Summary of 2020 Strategy

During Year 3 of Citizen Crane the project team secured funding from Thames Water for three further years of investigations up to the end of Asset Management Programme (AMP) 6[1] in spring 2020. A ten point

[1] AMP 6. Asset Management Plan Six. The AMP is a five year investment programme agreed between the water companies and the regulators.

strategy for the next three years has been set out below for discussion and development with the wider Citizen Crane group.

1. Continue baseline monitoring of water chemistry and Riverfly Monitoring Initiative (RMI) sampling at 11 sites – along with continued regular engagement with Thames Water, Environment Agency and Crane Valley Partnership (CVP) as part of the steering group, until May 2020.
2. Continue to support Citizen Crane teams, seek to retain the existing volunteers and to engage new volunteers by:
   a) Providing feedback through regular contact and the annual forum;
   b) Offering training and development opportunities;
   c) Keeping volunteers up to date on the wider impact of the work they are contributing to;
   d) Supporting, where possible and through the catchment partnership, initiatives developed by the volunteer groups.
3. Recruit more Citizen Crane volunteers and develop the skills of the core group by adding two further citizen science activities up to 2020. Options currently include:
   a) Modular River Physical (MoRPh) survey – www.modularriversurvey.org;
   b) Testing geomorphological improvements at specific sites to assess the impact on RMI scores and their consequent value for wider implementation;
   c) A further outfall safari in 2019.
4. Identify the principal sources of NH_3-N and P in 2018, and give broad source apportionment figures in the river system, by refinement of the mass balances presented herein - including work with the EA SAGIS model, review of upper DNR flow data and wider discussion with key interested parties. Feed these data into Thames Water's PR19[2] process to help shape AMP 7[3] investment priorities in the catchment. Also feed into the Environment Agency and Catchment Partnership's developing programmes of work. Use Citizen Crane data to guide investment and management time.
5. Identify the causes of the 'pulses' of increased NH_3-N identified by the EA real time monitoring data (and reported in Year Two) and assess the potential impact of CSO's and other time limited inputs to the overall mass balance.
6. Track the changes in river condition caused by the continuing SWOP programme and other measures implemented by all parties e.g. TW system changes; river restoration projects; the provision of additional marginal vegetation etc. Use the Citizen Crane data to help optimise the implementation of these work programmes.
7. By 2019 to have mapped and ranked the principal road run-off impact zones and made mitigation recommendations. Note that this will require additional funding to the Thames Water funding. Work with partners to instigate remediation programmes at one priority road run off pollution site.
8. Continue to engage with other practitioners and academics in London and elsewhere to cross-fertilise ideas:
   a) Possible Doctoral Training Programme (DTP) training link with ZSL in 2018;
   b) London academics and practitioners forum;
   c) Other initiatives through the "Catchment Based Approach" and "Catchment Partnerships in London";
   d) National RMI initiatives;
   e) Other links to be identified.
9. Target of seeing, by May 2020, significant reductions in NH_3-N and P levels and increased overall RMI scores. Delivered through a combination of measures – and largely implemented by 3rd parties (SWOP; pollution prevention, system changes; marginal vegetation; SuDS, etc).
10. Citizen Crane will utilise social media to engage Citizen Scientists and the wider public and use these tools to raise the profile of the Crane catchment, SWOP programmes and other issues of importance to

[2] 2019 Price Review (PR). An Ofwat consultation that will set the price, investment and service package that customers will be receiving from 2020.

[3] AMP 7 is currently being developed (through PR19 *et al*) and will start in spring 2020.

delivering the targets set out above. The project team will deliver annual reports charting the progress of restoration efforts and manage an annual forum with an invited audience designed to support the delivery of these targets.

END OF SUMMARY

Project Findings and Outcomes

The Citizen Crane project is developing from recording and assessing the condition of the river ecosystem to actively engaging to deliver improvements. Sampling sites are shown on Figure 8 below.

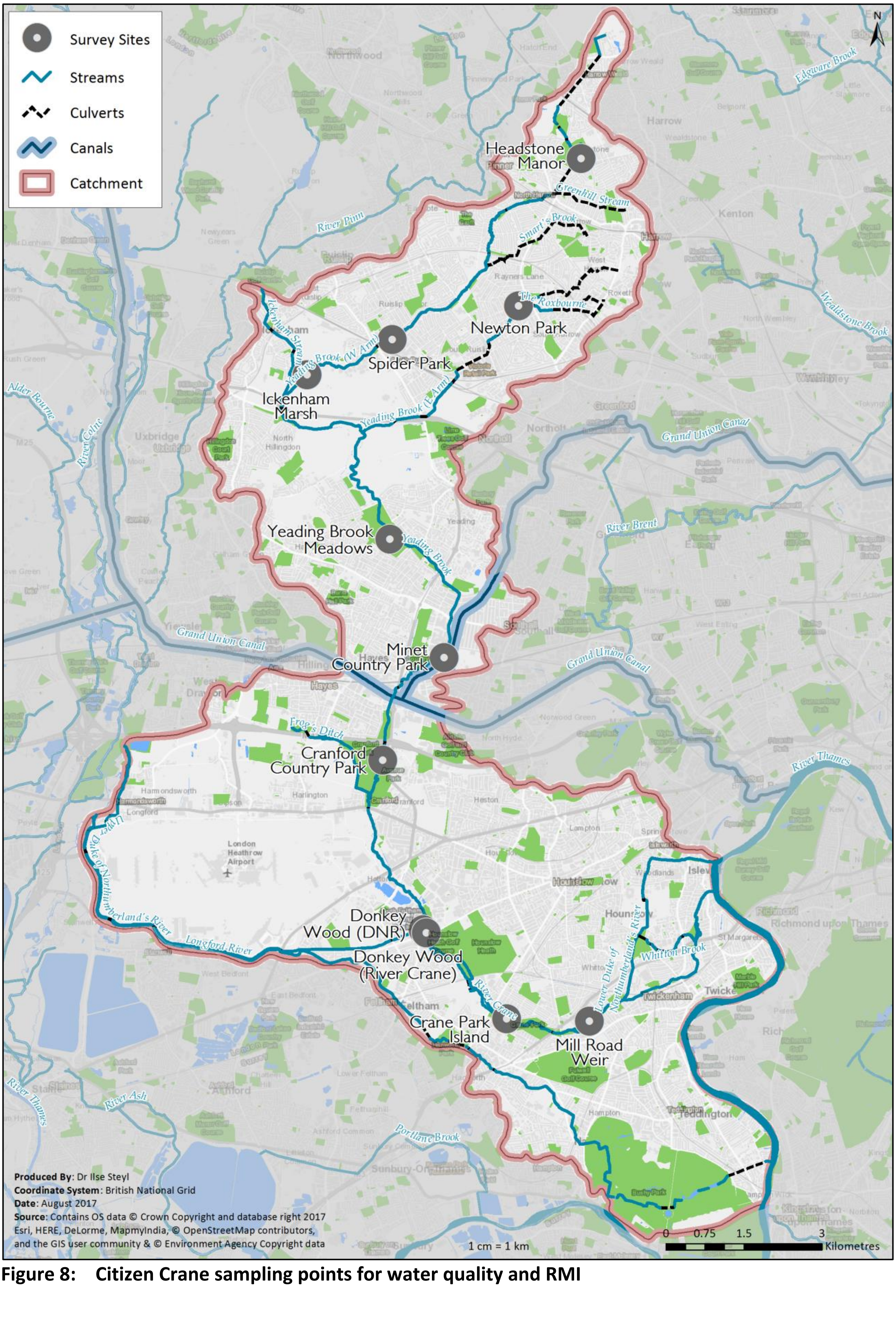

Figure 8: Citizen Crane sampling points for water quality and RMI

The following sections review water quality, River Monitoring Initiative (RMI) and outfall related studies. A catchment mass balance model is also put forward for discussion and development.

1. Results and Discussion

1.1 Water Quality results year on year

The following four plots (Figs 9 to 12) show the km length from the top to base of the catchment on the X-axis. The Y-axis shows the parameter measured (concentration or loading). The WFD standard for P concentration is also highlighted on the first plot.

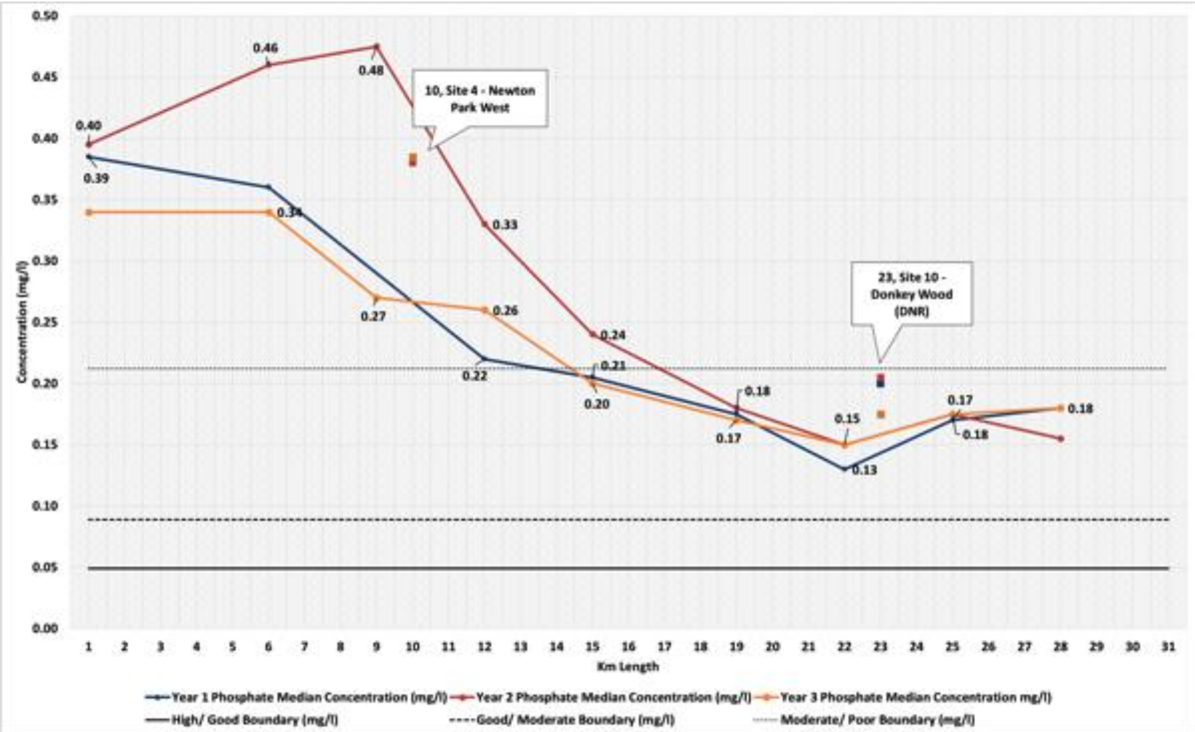

Figure 9: Comparison of median phosphate concentration by site for year 1, 2 and 3

(WFD standards do not relate to median data, therefore the threshold bars are shown for representative purposes, the threshold calculations can be found in Appendix C)

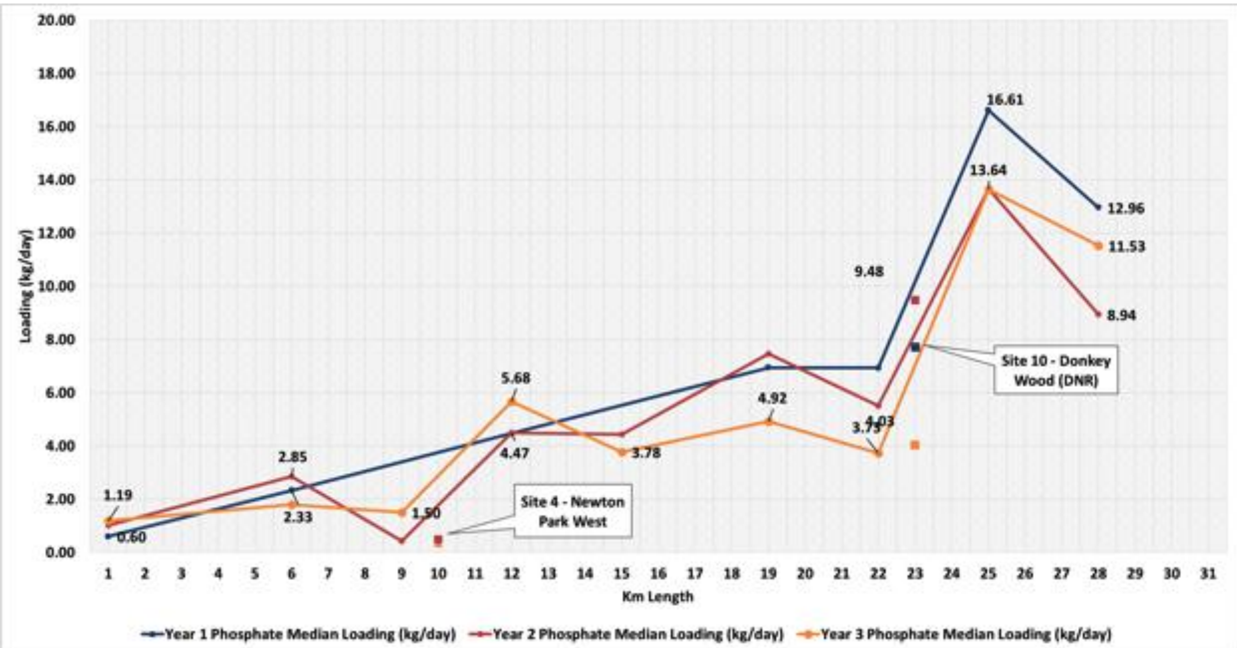

Figure 10: Comparison of median phosphate loading by site for year 1, 2 and 3

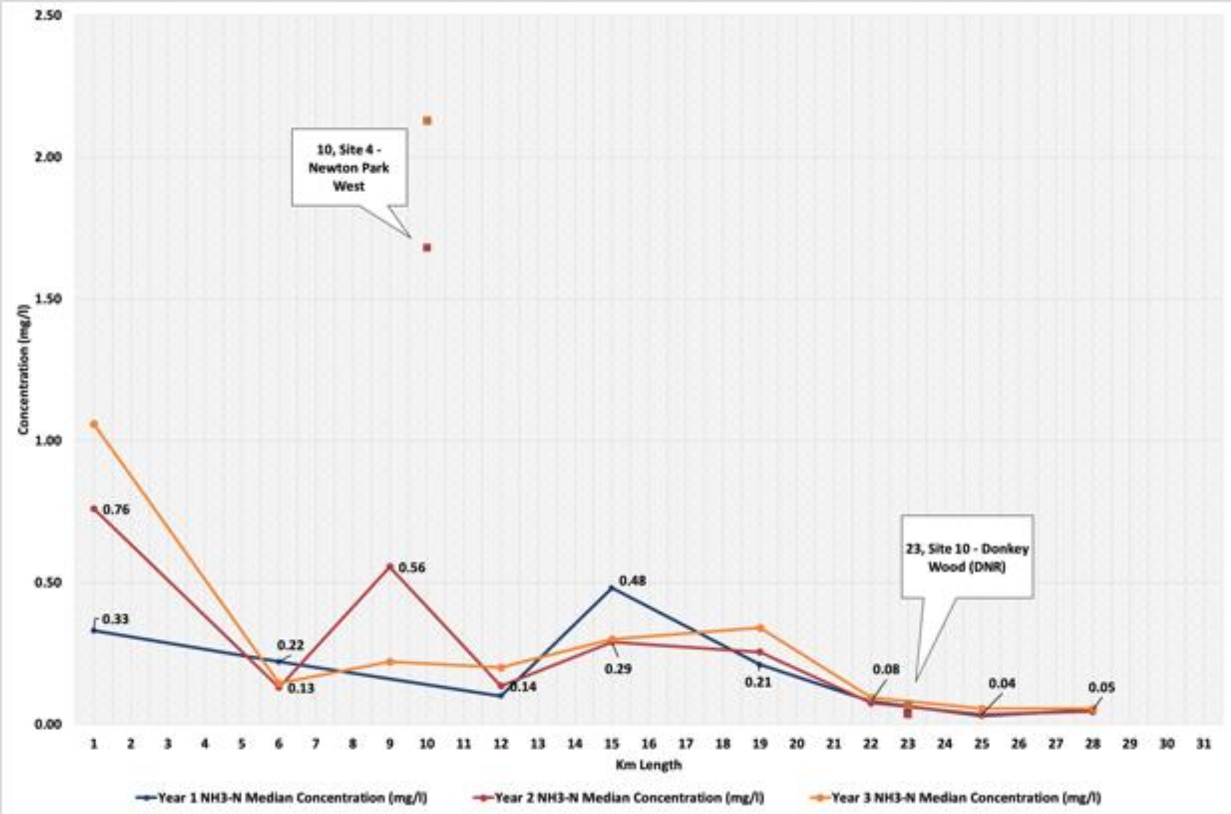

Figure 11: Comparison of median NH_3-N concentration by site for year 1, 2 and 3

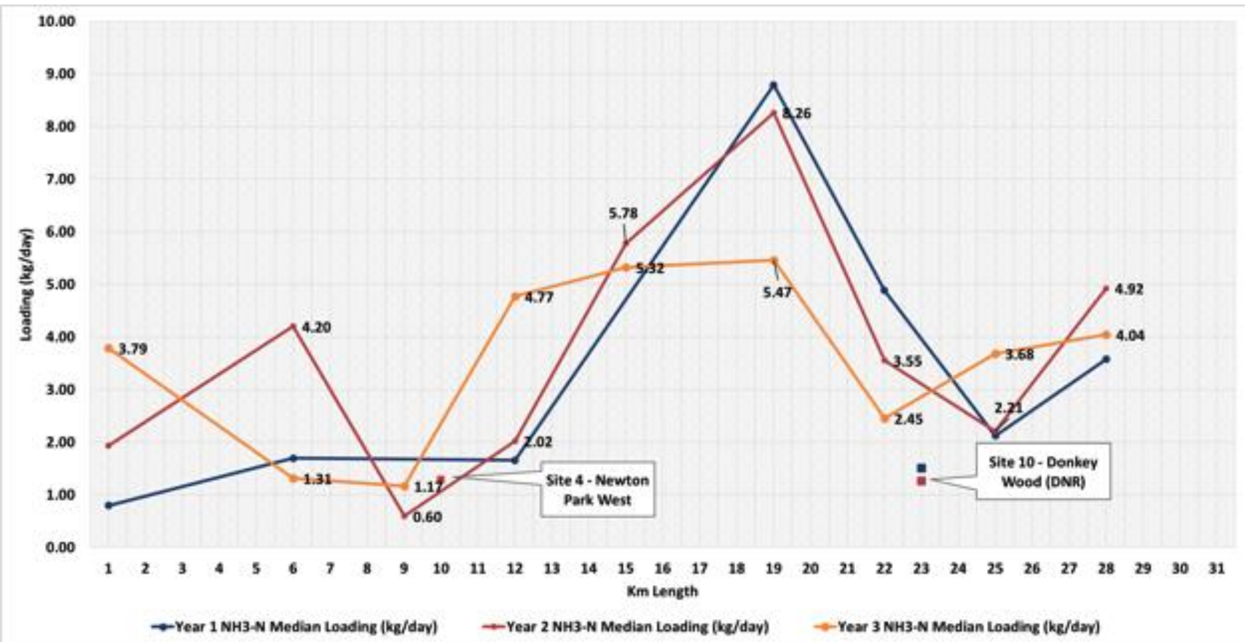

Figure 12: Comparison of median NH_3-N loading by site for year 1, 2 and 3

1.2 Discussion of water quality results

Overall the plots indicate a reasonably consistent picture of the distribution of P and NH_3-N across the catchment for each of the three years of monitoring.

The switch from mean data to median data has been done to take out the influence of isolated peak records. It is known from real time records (see Year two report, 2016) that there are occasional spikes in the levels of NH_3-N for example, lasting for a day or so and recording concentrations of five or more times the background chronic level. This change means the data better reflect the underlying trends in the data outside of these peak periods.

The highest concentrations of both P and NH_3-N continue to be recorded at Site 1 (Headstone Manor) and Site 4 (Newton Park) at the top of the two main tributaries of the river. Median levels of NH_3-N at these two locations were over 1 mg/l and 2 mg/l respectively at these two locations last year. It is noteworthy that these concentrations have increased significantly in comparison to 2014 and 2015.

Thames Water responded last year to the Citizen Crane findings regarding the high concentrations in the upper catchment by switching the focus of the SWOP to this part of the river system. Initial findings from Thames Water are that there are major misconnection issues in these areas, including entire schools and apartment blocks misconnected. In addition, LB Harrow has ambitious plans to incorporate settlement and infiltration systems into new ecologically sensitive designs for open spaces at both Headstone Manor and Newton Park – with some funding in place and initial works starting on site later this year. It is anticipated that the benefits of these works will start to feed into the results in the years to come.

The overall pattern of P concentrations and loadings has remained broadly consistent across the catchment over the last three years. It is interesting to note that the loading from the Upper Duke of Northumberland's River (upper DNR) – transferred from the Colne catchment – has recorded a reduction in concentration last year with a halving of the loading from 8 kg/day to 4 kg/day. This may suggest that the inputs to the River Colne, largely from Sewage Treatment Works reduced last year, whilst the overall inflow may also have been reduced. Comments from the EA regarding Blackbirds STW (situated on the Colne) being offline for improvements during part of last year's monitoring period support the hypothesis that inputs have reduced, albeit only temporarily.

The reduction in flows along the upper DNR may be the more important feature from the perspective of downstream water quality – as for the most part this inflow appears to benefit the overall water quality of the river downstream. This flow transfer is not regulated or controlled and is a function of inflow through a side channel subject to siltation. The issue is worthy of further investigation – and will be undertaken in year 4 using the flow data collected at Site 10 at the base of the upper DNR.

The middle and lower reaches of the river – particularly between sites 6 and 7 and between sites 11 and 12 – continue to show a capacity for removing P from the water column. Both of these site intervals recorded a net reduction of around 2 kg/day over the last year.

There are also two reaches – between sites 1 and 3 and between sites 8 and 9 – where reduction of NH_3-N is recorded. These site intervals record a typical reduction of around 2 kg/day and 4 kg/day over the three-year period.

These last two findings indicate that, even with continued inputs of both P and NH_3-N along the river system, there are in-river processes that are reducing (and on a consistent basis) the total loading. Further consideration of these processes are given in the mass balance below and it will be interesting to investigate these further, as well as how they can be encouraged and enhanced, over the next three years of the project.

Loading data is a key feature of the Citizen Crane project. These data are derived with the help of gauging stations at each monitoring site. As a quality assurance measure, all gauging stations are being renovated or reset in summer / autumn 2017 to maintain a high confidence in the raw data being recorded by Citizen Scientists.

Finally, it is important to note that the median results for the entire river system show it to be failing good ecological status with respect to P, with the upper half of the river system being classed as poor status.

1.3 RMI results year on year

Between May 2014 and May 2017 a total of 216 samples have been taken at the 11 sites. This is out of a possible total of 396 samples. Gaps in sampling have been caused by factors such as the addition of new sites following the commencement of the project, the unavailability of volunteers or heavy rain in the catchment causing unsafe river conditions.

Figure 6 above shows the median RMI scores for each site during the first three years of the project. RMI scores continue to be low throughout the upper catchment. The two sites downstream of the confluence with the Duke of Northumberland's River, Crane Park Island and Mill Road Weir, show significantly higher median RMI scores than those above.

Increased siltation at Newton Park over the lifetime of the project might be the underlying cause of the decline in RMI scores. In addition, during dry periods the site volunteers report the stream becoming very shallow with stagnant pooling and minimal flow. They also report regularly seeing and smelling oil.

Volunteers at Minet Country Park, which also shows declines in RMI scores, report that ' about 50% of the time there is an unhealthy smell from the river, and sometimes a sheen or it is slightly milky' The site is also becoming progressively more shaded which may have an impact on the invertebrate community.

The number of RMI invertebrate groups found in samples from each site, shown in Table 1, unsurprisingly follows a similar pattern to the mean scores by site. Greater invertebrate diversity, including the only records of true mayfly (Ephemeridae), has been recorded in samples downstream of the upper DNR, and the lowest invertebrate diversity has been recorded at Newton Park West and Minet Country Park in the upper reaches of the catchment. Gammaridae are the only group to be found at all sites and stonefly (Plecoptera) found at none. A total of three individual flat bodied mayfly specimens have been recorded from three separate sites, Yeading Brook Meadows, Crane Park Island and Mill Road Weir.

Table 1: RMI invertebrate groups recorded at each site during the period May 2014 to May 2017

Order / Family	Headstone Manor	Newton Park	Spider Park	Ickenham Marsh	Yeading Brook Meadows	Minet Country Park	Cranford Country Park	Donkey Wood – Crane	Crane Park Island	Mill Road Weir
Flat bodied mayfly (Heptageniidae)					✓				✓	✓
Mayfly (Ephemeridae)									✓	✓
Blue winged olive mayfly (Ephemerellidae)				✓	✓		✓	✓	✓	✓
Olives (Baetidae)	✓		✓	✓	✓	✓		✓	✓	✓
Stoneflies (Plecoptera)										
Caseless caddis (Trichoptera)							✓	✓	✓	✓
Cased caddis (Trichoptera)	✓		✓		✓		✓	✓	✓	✓
Freshwater shrimp (Gammaridae)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total nr of RMI groups found	**3**	**1**	**3**	**3**	**5**	**2**	**4**	**5**	**7**	**7**

1.4 Discussion of RMI results

Over 600 volunteer hours have been spent RMI sampling the river during the first three years of the Citizen Crane Project. An added value of community monitoring, although hard to quantify, is derived from the increase in community understanding of river ecology and the sense of ownership and stewardship that typically develops in well managed citizen science projects (TCV, 2014).

Considerable value has been derived from the significantly increased frequency of monitoring and the improved synergy with the Environment Agency (EA). The increased monitoring by the Citizen Crane network, for instance, has led to the early detection of specific pollution events that have in turn allowed the EA to respond quickly to problems. See for example Appendix A which shows the evidence gathered by volunteers at Donkey Wood, Crane Park Island and Mill Road in Winter 2016/17 in relation to a significant pollution event. These data are all being used by the EA to further investigate the causes of this incident.

In addition, the RMI data collected by volunteers provide a valuable baseline on which to build an increasingly detailed picture of the ecological quality of the river. The RMI methodology is a simplified, citizen science version, of the monitoring method used by the EA to check the ecological quality of rivers for Water Framework Directive classification. Invertebrate monitoring systems such as Whalley, Hawkes, Paisley, Trigg - WHPT use the differing tolerances of invertebrate families. Invertebrates with a lower score are more pollution-tolerant, and can also be tolerant of poorer habitat quality and siltation. Whereas, those with higher scores have a lower tolerance for these factors and are often absent in degraded or polluted habitats.

Table 2 shows the WHPT scores (UKTAG, 2014) for the taxa used in the RMI method. In the case of Stoneflies, Caseless and Cased caddis these are not taxonomic families, therefore no appropriate fit with WHPT scores exists. The scores are included here to illustrate the relative sensitivity of the RMI groups to pollution. With flat bodied mayfly and true mayfly being the most sensitive, and olives and Gammarus the least.

Table 2: WHPT Index values for the taxa used in the RMI method

Order / Family	WHPT score for abundance 1-9
Flat bodied mayfly (Heptageniidae)	8.5
Mayfly (Ephemeridae)	8.3
Blue winged olive mayfly (Ephemerellidae)	7.9
Olives (Baetidae)	3.6
Stoneflies (Plecoptera)	No score
Caseless caddis (Trichoptera)	No score
Cased caddis (Trichoptera)	No score
Freshwater shrimp (Gammaridae)	4.2

Analysis of Citizen Crane RMI data shows that invertebrate communities in the upper part of the catchment are compromised and that the environment of these reaches is degraded, and severely degraded in the case of Newton Park West and Minet Country Park. Only the more pollution tolerant RMI invertebrate groups, Gammarus and Olives, are present in any significant numbers throughout the river. Other groups that are sensitive to degraded river environments, such as Caddisfly and Blue winged Olives, are recorded at only a few sites above the upper DNR and these records are infrequent and in low numbers.

When reviewing RMI data however it is important to keep in mind that complex relationships exist in rivers. Invertebrate communities are not only impacted by water quality but also geomorphology, water quantity and flow, shading, sediment quantity and quality. The RMI scores should only be taken as an indicative guide to ecological quality at each sample site. To get a better understanding of the exact causes limiting invertebrate communities in the upper sites, more in depth chemical and abiotic analysis is needed. The RMI data do though highlight the need to prioritise remediation and environmental improvement works in the upper section of the catchment.

Note that data from Site 12 indicate that the RMI scores have reduced relative to Site 11 over the last two years whilst the water quality data have remained stable. Site 12 has been subject to increased shading over the last three years and has not recorded any cased caddis in the last 12 months for example whereas there are a significant number seen regularly at Site 11. There are plans to reduce the shading at this site and it will be interesting to observe how this might influence the RMI score in the future. This and other site-specific interventions over the next three years will help to build an enhanced picture of the relative sensitivity of various invertebrates (and the overall RMI score) to water quality and geomorphological controls.

2. Outcomes from the Outfall Safari

The Outfall Safari took place in Year 2 of Citizen Crane, and is reported fully in the Year Two report, whilst this section reports on the further outcomes of the Outfall Safari during year 3.

The Outfall Safari (OS) was devised by the Citizen Crane steering group following the Citizen Crane Outfall Monitoring Feasibility Study, conducted between May and August 2015 (report available from CVP). The aims of the OS were to:

- Record and map the dry weather condition behaviour of surface water outfalls across the Crane Catchment;
- Develop a low cost method that can be used periodically in the catchment to inform ongoing catchment management decisions. In particular to help identify (and potentially prioritise) outfalls for inclusion in the AMP 7 Thames Water Surface Water Outfall Programme (SWOP), due to start in 2020;
- Further engage the existing Citizen Crane network and recruit more volunteers in the delivery of the Catchment Management Plan.

Outcomes from the Outfall Safari in year 3 are summarised below:

- Identification of key polluting outfalls
- Further EA investigations on sources of pollution within the catchment
- Progress on development of a plan to reduce impact of M4 outfall in Cranford Park
- Sharing data with TW to allow re-prioritisation to their AMP 6 SWOP
- Adoption and development of the methodology elsewhere in London
- Potential to repeat the OS in 2019 and re-assess polluting outfalls.

3. Long term Survey data - Development of a Mass Balance for the Catchment

3.1 Introduction

This section of the report is designed to pull together the available information from the Citizen Crane project and start to develop a mass balance for phosphate (P) and ammoniacal nitrogen (NH_3-N) for the catchment. It is by no means a definitive assessment, and the project team would welcome comments and inputs by others in order to improve the understanding of this dynamic process.

In summer 2015 selected Citizen Crane teams started to monitor the status of the surface water outfalls local to their sites with the intention of testing the feasibility of a focused investigation into outfall conditions. Sites 2, 6 and 12 were included in this pilot study and the detailed findings of this work were reported in *Citizen Crane Outfall Monitoring Feasibility Study – October 2015*, available from the CVP web-site. One of the key outcomes of this work was the 2016 Outfall Safari project.

The long term outfall monitoring work has continued in the lower Crane (around Sites 11 and 12) until present, and has allowed longer term data to be collected about key surface water outfalls along a 3 km reach of the river within Crane Park in LB Richmond and LB Hounslow. Nine of these outfalls have been included in Thames Water's surface water outfall programme (or SWOP), designed to remove misconnected domestic appliances from the surface water drainage system.

Data were collected on a monthly basis, by visual assessment of the conditions at each outfall, including an estimate of the flow rate. For the first few months an assessment was carried out at every outfall in the area, although with time the focus was narrowed to five key outfalls known to be problematic and on the Thames Water SWOP. A total of twelve water quality samples have been taken from these outfalls over the last two years for TW laboratory analysis, so as to supplement these visual records with concentration and loading data for P and NH_3-N.

Further information has been collected over this period from other surveys of water quality and sediment, undertaken both by the project team and third parties including university students undertaking theses.

3.2 Data Outcomes and Evaluation

3.2.1 Data from Crane Park SWOP Outfalls

The long-term survey work has allowed the development of an improved understanding of the nature of the SWOP outfalls and their impact upon the river environment. The key findings are recorded below:

1. There are around 20 surface water outfalls in the 3 km within Crane Park around and upstream of monitoring sites 11 and 12. Nine of these have been included in the Thames Water surface water outfall programme (SWOP) and five in the Citizen Crane long term monthly monitoring programme.
2. The average monthly outflow from individual outfalls varies from around 0.3 l/s to 3l/s. The flows from each individual outfall are fairly consistent over time – for example, the five main SWOP outfalls typically vary from 1.5 to 3 l/s (average of 2 l/s – two outfalls), 2.5 to 4 l/s (average 3 l/s - one outfall) and 0.3 to 1 l/s (average 0.5 l/s – two outfalls) from monthly observations over the last two years. Outflows continue, though at a reduced rate, throughout dry weather periods, indicating that the drainage systems in this part of the river intercept the water table and are acting as groundwater drainage as well as urban rainfall drainage. The combined mean outflow from the nine SWOP outfalls has been estimated as 12 l/s.
3. The nine SWOP outfalls all had significant sewage fungus covering on their concrete apron prior to any SWOP works, indicative of high nutrient concentrations in the run-off. EA specialists have noted that this sewage fungus will only remain present for a matter of days in the absence of a nutrient load to sustain it. In addition, the outfalls were often noted as having sewage or detergent smells associated

with them. Occasional spot sampling from the outfalls indicated concentrations were typically between 1 and 2 mg/l for both P and NH_3-N.

4. Of most concern, several of the outfalls had occasional plumes of grey-brown, sometimes rag rich and foul smelling water, extending between 5 and 30 metres into the main river. These "flare ups" might last for a few hours, and on occasion up to one or more days, and were often reported to FORCE and others by local people, as well as being witnessed by the long term monitoring team. The flare-ups were sometimes, but not always, associated with rainfall events. The worst offending outfall (at Hospital Bridge Road) has displayed these flare ups every couple of months or so to the present day (July 2017), notwithstanding extensive SWOP investigations.
5. Given the total outflow from the SWOP outfalls in this area (estimated as 12 l/s – see above) then the loading from the nine SWOP outfalls prior to the SWOP was in the order of 1.5 kg/day of both P and NH_3-N.
6. The total amount of P and NH_3-N in the river in this location, based on annual average loadings recorded at Mill Road (Site 12), just below the SWOP outfall locations, is 12 kg/day (P) and 6 kg/day (NH_3-N). The contribution of these outfalls before the start of the programme was therefore around 12.5 per cent (P) and 25 per cent (NH_3-N) of the total loadings in the river at this location.
7. The SWOP has been active on many of these outfalls over the last two years. Typically the contractors found between 5 and 25 misconnected facilities on each outfall – including several toilets and large numbers of showers, hand basins, dish washers and washing machines.
8. Around 90 per cent of these misconnections were reported as being rectified by the home owner (or Housing Association), following an initial approach by Thames Water, with the remainder being referred to the council's Environmental Health Office for follow up.
9. Several of the worst performing outfalls have now been signed off by Thames Water, and subsequent field visits indicate there is little or no sewage fungus associated with them any longer. One outfall (Hospital Bridge Road) has proved more difficult to rectify, with continued problems of sewage fungus, high nutrient loads from spot samples and occasional pollution plumes being recorded. Further works by contractors found additional misconnections. Thames Water does not believe there are any cross connections into the sewer system linked to this outfall.
10. Samples were collected from several SWOP outfalls following sign off in 2016 and 2017, and the P and NH_3-N concentrations were each recorded at around 0.3 mg/l. This indicates a 5 fold reduction from the start of the programme – although these input levels remain at around x2 (P) and x4 (NH_3-N) the background concentration in the river at this location. Two recent samples, collected in June 2017, largely support this finding – Lyndhurst Avenue outfall showed levels equivalent to the river (P) and x2.5 (NH_3-N) whilst Hanworth Road outfall showed x4 and x6 respectively. Where the SWOP outfall has not been signed off, but extensive works have been done (such as at Hospital Bridge Road) the concentrations are typically double this level, at around 0.6 mg/l.
11. The impact at this location – assuming all outfalls are eventually signed off and achieve the reduction to 0.3 mg/l – would be to reduce the loadings of both P and NH_3-N from these SWOP outfalls by 1.2 kg/day to around 0.3 kg/day.
12. In general the SWOP process takes a few months to complete – although where there are recurrent problems, such as at Hospital Bridge Road, it may take one or more years.
13. One question is – where is the residual P and NH_3-N within the signed off SWOP outfall sourced from? There are various potential sources including: misconnections that have not been picked up; P and NH_3-N within the run-off – eg from dog faeces or other sources; and/or a continued input from sediment held within the drainage system. Ongoing monitoring of signed off outfalls will help to assess the relative importance of different sources based on whether there is a low level ongoing/increasing/decreasing load.

14. The loading data indicate these improvements in outfall performance are of sufficient magnitude to be detected by the river monitoring data (the chemistry if not the RMI). The loading of P in the river at Site 12 (Crane Park) would potentially reduce by around 10 per cent and the loading of NH_3-N by around 20 per cent as a result of these SWOP works when complete.
15. These records are taken from the base of the catchment where the flows are highest. The relative impact of a SWOP programme, with all other factors being equal, is therefore likely to increase at sites higher up the catchment. Given the knowledge of the major impact of polluted outfalls at the top of the system then it can be deduced that a successful SWOP would be of particular value there. This work towards the top of the catchment has started in 2017 and the impact may be seen in the data set for Year 4 and onwards.

3.2.2 Comparison with other field data

The table below (Table 3), from Ellis and Butler (2015), shows the dry weather pollutant concentrations associated with 43 polluting outfalls on the Rivers Roding, Ching and Rom. These data indicate higher concentrations of NH_3-N (3 to 4 mg/l compared to 1 to 2 mg/l) and lower values of P (0.5 mg/l compared to 1 to 2 mg/l) when compared to the lower Crane data. It may be that these data indicate a higher proportion of toilet based misconnections and correspondingly lower number of washing machines and other soap based misconnections than are being found in the lower Crane.

Table 3: Pollutant concentrations and range for PSWO discharging to urban stream in NE London
(Source: Ellis & Butler, 2015)

Pollutant	Concentration Range (Min–Mean–Max; mg/l	EQS
BOD_5	9.8–11.0–275.6 [9.9]	9.0*
Ammonia	0.04–3.5–6.55 [0.45]	2.5*
P_{Total}	0.35–0.47–1.4 [0.21]	0.5*
NH_4-N	0.2–4.6–10 [0.8]	3.1*
E.coli	4.8–44–242 x 10^4 (MPN/100 ml)	–

Values in square brackets e.g. [0.21] are average Event Mean Concentration (EMC) values for UK residential storm water runoff as given in Mitchell (2006).
* 90th percentile "poor" values as defined in Defra (2009).

Note that P has been progressively removed from washing powders and detergents in recent years – and from January 2017 has been banned from products in the EU. It would be helpful to understand more about current sources of P within surface water outfalls and the river system more generally so as to assess the potential implications of these legislative changes going forwards.

3.2.3 Real time monitoring data

Real time monitoring in the middle reaches of the catchment (see Year 2 Citizen Crane report, 2016) recorded short term peak concentration pulses in NH_3-N – whereby levels increased significantly (typically from around 1 to 2.5 mg/l) over several hours – and occurring every few weeks. These pulses, based on a mean river flow of 0.5 cumecs for the middle reaches, would be releasing approximately 5 to 10 kg of NH_3-N into the river. These releases are therefore around two orders of magnitude greater than the chronic releases from individual SWOP outfalls and indicate a different order of problem, albeit for short periods of time. These pulses, of 5 to 10 kg once or twice per month are equivalent to annual inflow of 120 kg (or 0.3 kg/day).

3.2.4 Wider catchment SWOP works

Data have recently been received from TW that set out the amount of SWOP works done in the Crane catchment as follows:

Table 4: Summary of Thames Water SWOP programme in the Crane Catchment (July 2017)

	Outfalls	Misconnections	Fixed
Active River Crane SWOP AMP 6	35	314	229
Crane Park	9	60	58
Waiting List AMP 6	20		
CP % active total	25	19	25
CP % AMP 6 total	16	12	
AMP 5	2		

The SWOP in Crane Park is therefore responsible for 25 per cent of both the total SWOP outfalls and the number of fixed misconnections to date. This percentage reduces to 12 per cent when considering the AMP 6 programme as a whole.

The Crane Park works to date are calculated (see 3.2.1 above) to have removed around 1.2 kg/day of NH_3-N and P from the system. On this basis the total amount of each removed to date by the AMP 6 SWOP would be 5 kg/day, whilst the total amount removed by the end of the AMP 6 SWOP (in 2020) would be around 10 kg/day.

These calculations suggest that the SWOP programme in AMP 6 could have a major beneficial impact on the organic loading into the river system.

In total there were 227 outfalls identified from the outfall safari over around 34 km of river (Citizen Crane Year 2 Report). The outfalls in Crane Park total around 20 and input to around 3 km of the river system. In both cases this represents around 8.5 per cent of the total.

On this basis (and following the major assumption that in total the SWOP outfalls are contributing a broadly equivalent load) the total input from chronic pollution by the SWOP outfalls would be around 1.5/0.085 = 18 kg/day of both NH_3-N and P.

The data from the treated SWOP outfalls indicate that there is an ongoing, though much reduced, load from them following the SWOP. This background loading may be a result of other run-off sources, residues within the system, as well as new misconnections. The loading post SWOP is typically reduced by a factor of 5. However, there are a total of 227 outfalls and only 55 in the SWOP. A first order assessment, assuming the remaining outfalls have the same load as post SWOP outfalls, indicates an additional contribution in the order of 18 x 175/55 x 5 kg/day = 11 kg/day, would be derived from these outfalls.

The inputs from the upper DNR (based on 3 years of mean annual data from Site 10) are in the order of 10 kg/day P and 1 kg/day NH_3-N.

The number of misconnections identified to date from 35 SWOP outfalls is 314. Assuming the final 20 outfalls have the same number of misconnections then the total in the SWOP will be in the order of 500. There are a further 180 outfalls in the catchment – though by and large these are likely to be less polluted than those in the SWOP. As a first order estimate there may be a further 500 misconnections in this further suite of outfalls giving a total of 1000.

A further consideration is the rate at which misconnections are being added into the system. It would be very helpful to understand better the likely age of the misconnections being located so as to better estimate this. However, if for the time being it is assumed these have all been added over the last 10 to 40 years then the rate of increase of misconnections would be in the order of 25 to 100 per annum. On this basis the SWOP would need to deal with this number merely to maintain the current chronic pollution condition.

3.2.5 Phosphorus in Sediment

Sediment samples were taken from a total of 22 locations in the middle and lower Crane catchment as part of a Cranfield University Masters study supported by this project. These were analysed for a wide variety of pollutants with a main focus on road run-off issues. However, total phosphorus was included in the suite to provide a first order assessment of the P load within the sediments of the catchment.

The data show fairly consistent levels of Phosphorus across the 22 samples, ranging from 1,200 to 4,600 ppm. If these sample results are representative for the entire catchment then this is a significant store of P within the sediment. A first order assessment of the amount of total P within the sediment has been produced using the following assumptions:

- River width – 5 m (varies between 1 m and 15 m across the river length;
- Mean sediment depth – 0.05 m (this is a major variable as it fluctuates considerably. Experience wading the river during the outfall safari in 2016 revealed large areas having little or no sediment and other smaller areas with up to half a metre);
- River length – 30,000 m[4];
- Mean concentration – 0.25 per cent P;
- Sediment density (wet) – 2.5 g/cm^3.

This would amount to around 50 tonnes of P held within the river sediment.

3.3 Mass Balance Considerations

A mass balance for the catchment needs to consider:

- Inputs from outfalls and other sources (e.g.: inflow from the upper Duke of Northumberland's River and CSO's);
- Sinks and releases within the system – through sediment accretion, chemical reaction or absorption processes, or take up in plants or algae for example;
- Outputs at the base of the catchment;
- Separate mass balances are needed for P and NH_3-N as these act in different ways in the river environment;
- NH3-N is reactive and tends to break down over time. The rate at which break down in the river environment occurs will be an important factor in this mass balance;
- P in dissolved form (Soluble Reactive Phosphate) tends to bind to sediment – either remaining in suspension or through sedimentation. It may then leave the catchment in suspension or bind into the sediment or onto the river bed, from where it may be subsequently released – particularly during flood periods. Note that the data above indicate a total in the order of 50 tonnes of solid P within the sediment of the river;
- Both P and NH_3-N can be taken up by plants and algae. Note that the rate of take up for phosphorus in agricultural plants is 10 to 25 kg/ha/yr. The total river bed area of the Crane is around 30 km x 5 m = 15 ha. Therefore, even if the whole of the river bed were vegetated then the take up would only be in the order of 0.7 kg/day. On this basis plant take up itself is likely to be an insignificant factor in the balance;

[4] This length only includes the main river length used for the purposes of the Citizen Crane project, not the total drainage length of the Crane catchment, which is 107 km.

- However, vegetative processes – plants and algae – may be crucial in (a) breaking down NH3-N as well as (b) acting to bind phosphate in its solid state into sediment.

The elements of the mass balances for P and NH_3-N we have estimates for are as follows:

Inputs

- The 55 surface water outfalls in the SWOP – 18 kg/day NH_3-N and 18 kg/day P. Note that there are major pollution issues in the upper catchment which may increase the loading from these areas - subject to further assessment;
- The remaining 175 surface water outfalls – 11 kg/day NH_3-N and 11 kg/day P;
- Upper DNR – 10 kg/day P and 1 kg/day NH_3-N;
- Pollution flare ups – around 0.3 kg/day NH_3-N;
- CSO's – the contribution of these is not known but they are recognised as being a further source of P in the EA SAGIS modelling, a summary of which can be seen in Appendix B. Note that the pollution flare ups referenced above may be caused by discharges from CSO's.

Outputs

- 4 kg/day NH_3-N and 11 kg/day P – based on the median outflow over three years as measured at Site 12 towards the base of the river system;
- There may be more released during floods – particularly phosphate bound to sediments – but this has not been recorded.

On this basis the system is absorbing or removing (or not recording):

P	–	18 + 10 + 11 – 11	=	28 kg/day;
NH_3-N	–	18 + 11 + 1 + 0.3 – 4	=	26.3 kg/day.

The SWOP programme under AMP 6 has had a significant impact on this mass balance by removing around 5kg/day of both P and NH_3-N, and may remove a further 5 kg/day by the end of AMP 6.

The system is not this simple of course – and other factors include:

- The rate of addition of misconnections to the system (such that the totals being looked at here are gross not nett). A first estimate indicates a rate of between 25 and 100 additions per year – i.e. a 2.5 to 10 per cent annual growth rate in the misconnections total. This is considerable and indicates the long term nature of the SWOP reduction challenge;
- Changes in the take up and release of P to an adsorbed form as the concentration in the water column changes. The enormous load of P within the sediment in the river, and its interactions with the water column and physio-chemical factors - e.g. dissolved oxygen levels and pH may be critical issues here;
- The effect of other factors such as algae etc.

Nevertheless there are a set of numbers here that can be developed and refined as further data and assessments are made available. These are set out below:

Table 5: First order assessment of nutrient and organic load inputs and outputs

	P provisional mass balance (Kg/day)	NH_3-N provisional mass balance (Kg/day)
Inputs		
SWOP outfalls	18	18
Other outfalls	11	11
Upper DNR	10	1.0
Peak flush	N/A	0.3
Total	**39**	**30.3**
Outputs		
Dissolved outflow	11	4
Absorbed/flushed as sediment	28	–
In-river chemical processes	–	26.3
Total	**39**	**30.3**

As noted above in Table 5, these mass balances are provisional and subject to change and development as more information becomes available. One observation at this stage is that catchment processes appear to be key to the river condition with respect to these parameters and it would be helpful to understand and assess these further over the next three year programme.

It will also be of interest and value to use this balance to develop an understanding of the works required (by SWOP and other means as appropriate) to meet the targets of moderate and good ecological status across the catchment.

It is interesting to compare the numbers in the mass balance with the first assessment of P loading within the sediment – of 50 tonnes. On the basis of the mass balance calculations above, this sediment load is equivalent to 4 years of gross input, a minimum of 5 years of sediment accumulation, and around 12 years of dissolved outputs.

These first order calculations show the potential importance of sediment as a sink and potential source of release into the system for the P model for the catchment. Given the enormous mass of P held within the sediment, the below variables may have a considerable influence on the P load within the water column:

- Frequency of high flow sediment scouring events;
- Catchment works, including works to vary the geomorphology of the river.

For example, works by the London Wildlife Trust (LWT) over the last 12 months have resulted in geomorphological improvements along 3,000 metres of river bed at four locations – or 10 per cent of the main channel total. These works have included the narrowing of the river and resulted in the large scale scouring of river gravels and the removal of sediment cover. On the basis of the numbers above, this could have released anything up to 5,000 kg of P into the river – roughly equivalent to the total dissolved outflow recorded at the base of the catchment over this 12 month period.

There is no doubt that these catchment works have been of considerable benefit to the river reaches in question and the catchment as a whole. However, there may also have been a significant short-term impact in P levels within the water column caused by the release of such a large amount of P rich sediment into the system.

3.4 Conclusion

The main conclusions drawn from this section of the study can be reviewed in the report summary (Page 12).

4. Review of the Conceptual Model of the River System

The year 2 report contained an overview of the project's understanding of the River Crane as a system. The overview split the river into upper, middle and lower reaches as well as commenting on tributaries and sources of pollution.

This section of the report concerns itself with how this understanding has evolved during the third year of the project:

Table 6: Summary of progress in knowledge and understanding of key processes and factors in the Crane catchment

Subject Area	Progress during Year 3
Misconnections and network issues	The relative importance of misconnections and network issues – particularly in the upper catchment – is actively being investigated. TW reports that network issues are considered to be less of a factor in the Crane than the Brent.
Spikes of ammonia	Whilst no further real time data have become available in Y3, the spikes in NH_3-N are assumed to remain present in the system. Further assessment may be possible over the next three years, including if and how these spikes link to the CSO's.
Impact of SWOP and marginal veg on loading	The long term data, as seen in section 3 (p.25), show the potential impact of the SWOP programme in managing the nutrient and organic waste loading in the Crane. The direct assimilation rates of marginal vegetation are deemed not to be a significant sink for nutrients. Any sequestration would also be temporary. However, marginal vegetation and/or algae may play a significant role in binding sediment and breaking down NH_3-N and this role has yet to be properly assessed.
Phosphorus loading	As can be seen in the section 3, long-term data, it is assumed that phosphorus is accreting in the sediment and that this is periodically flushed when the river is in spate. Whilst this might be proven by a targeted sampling strategy, the resolution of the current sampling schedule is not refined enough to prove or disprove this hypothesis. The physiochemical condition of the water column will also play a role in the sequestration of phosphate. In an anoxic event e.g. the release of high volumes of high BOD material into the river, such as from Glycol, P may be released into the water column from the sediment store. One further control might be in-river works. River restoration work in the upper catchment last year is thought to have resulted in the flushing of sediment from around 3000 metres of the river system. Whilst this will be to the long term benefit of the river it could also result in shorter term increase in the amount of phosphate in the water column.
Road run off	Two investigations have been carried out over the last year, led by universities. Conclusions will be drawn out during Y4. The studies are expected to further our understanding in this area.
Glycol and BOD	There was another significant Category 2 pollution incident in the early part of 2017. This affected several kilometres of the river and was picked up by the RMI data over several months afterwards (see report in Appendix A). The incident is currently subject to ongoing investigation and no further conclusions can be drawn here as yet.
Hypothesis on rate of new misconnections	At present the report has included a working assumption that equates to a rate of new misconnections between 25 and 100 per annum over the catchment. This would mean that an equivalent number would need to be resolved for the situation to remain unchanged. It is hoped that more information can be gleaned to refine these estimates during the next project

Subject Area	Progress during Year 3
	period.
The impact of other controls on the river condition	Other controls on the river ecosystem include river geomorphology and shading for example. There have been significant improvement works undertaken to the river ecosystem over the last few years and it would be very interesting to know if, and to what extent, these might have resulted in changes to the RMI scores at these sites. There is an opportunity to assess the potential impact of shading at Site 12 over the next year as a project is being designed that will include reducing the shading at this site. It may be possible to investigate other local controls on river condition at other selected monitoring sites during the next three years.

5. Stakeholder Engagement

5.1 Volunteers

Citizen Scientists continue to undertake vital data collection, without which Citizen Crane would not be able to operate. Volunteers are also playing an increasing role in the logistics of the project with water quality sample collection now mainly managed by volunteers.

Key points concerning volunteer engagement are as follows:

- High level of support for continued monitoring at the Year 2 Citizen Crane Forum;
- High level of engagement with outfall monitoring, both through the Outfall Safari and the longer term monitoring of selected SWOP outfalls;
- New volunteers continue to be trained in RMI and Outfall Safari – two training sessions last year;
- A good level of feedback from volunteers on a monthly basis;
- For data collection alone, more than 1200 hours of volunteer time has been logged by the end of year 3. This equates to over 160 working days. It should be noted that volunteering involvement with Citizen Crane stretches beyond data collection and the total figure for volunteer hours will be much higher.

5.2. Local Communities

The success of Citizen Crane hinges on positive engagement with the local community on issues surrounding the Crane.

During Year 3 of the project a short film was commissioned as a way of capturing both the community involvement within the catchment via Citizen Crane and to highlight the challenges the river faces.

The film and several shorter excerpts can be found at the following links or through the CVP website:

https://www.youtube.com/watch?v=ZC3uFlpVMmA

https://www.youtube.com/watch?v=aZebEOKxzzw

https://www.youtube.com/watch?v=odUmxh6yKiI

https://www.youtube.com/watch?v=7W7y_0o23HM

The Citizen Crane teams continue to engage with local people during their monthly monitoring sessions and to hand out leaflets explaining the project and the wider issues of misconnections and river pollution. FORCE volunteers and others also hand out these leaflets at community events and talks. Regular messages about the project and specific project findings are put out onto facebook and Twitter. In this way the general public, at least those using open spaces along the river, are reasonably well engaged with the project.

5.3 Thames Water

Thames Water has committed funds to support the Citizen Crane project from May 2017 up to April 2020. £30,000 has been received by the Citizen Crane project team to continue with project coordination and delivery monitoring and reporting activities in Year 4, 5 and 6. Thames Water has also committed to use of resources at their UKAS accredited lab for a corresponding period of time.

The use of Thames Water lab for water analysis is valued at over £2,000 per annum. Accredited lab results with appropriate collection and storage protocols give confidence to the data and support the use of Citizen Crane data in strategic decision-making.

In addition, Thames Water are key members of the steering group and have been very supportive of the project and acted positively with developments to the SWOP and other aspects of their programme in response to project findings. TW are currently assessing the potential for using the River Crane catchment as a pilot "smarter catchment" during AMP7, potentially the first urban catchment this approach has been applied to across the UK. This proposal is in part a response to the positive relationships developed over the Citizen Crane project.

5.4. Academia

The River Crane has been the focus of a great deal of work by lecturers and students from academic institutions both within and beyond the boundaries of the catchment. Table 7 below shows a summary of the studies that have been undertaken using the Crane as a focal point. Honourable mentioned should be made to Dr Iain Cross (St Mary's University), who presented a paper at the Royal Geographical Society on Citizen Science that drew heavily from his involvement in Citizen Crane from the start of the project.

Table 7: Summary of academic studies relating to the River Crane

Institute	Author	Area of study
St Marys University	Dr Iain Cross	**The potential of citizen science to inform expert understanding: a case study of an urban river**
St Marys University	Will Hawkins	**The Effects of Urban Influences, Including Heathrow Airport, on the Water Quality of the River Crane**
St Marys University	Gabby Judd	**Crane invertebrates in pools and riffles**
Kingston University	Andrew Carr	**An examination of spatial and temporal variance in Ammoniacal Nitrogen, Phosphorus, and Sulphate in the River Crane, alongside their impact on macro- invertebrate levels**
Royal Holloway	David Strachan	**Quantification of organic and inorganic pollutants arising from road run off in the River Crane catchment**
Cranfield	Anna Bukovski	**The identification of pollutant sources in the River Crane catchment**
Durham	Bertie Bricusse	**Water quality in an urban lowland river: The River Crane Catchment in West London**

5.5 Wider World

A presentation on Citizen Crane (Joe Pecorelli, ZSL) and a poster was produced for the 2016 **River Restoration Centre Conference** in Brighton**.**

Engagement with CaBA: The Catchment Based Approach (CaBA) embeds collaborative working at a river catchment scale to deliver cross cutting improvements to our water environments. Community partnerships, bringing local knowledge and expertise, are active in each of the 100+ Water Framework Directive catchments across England, including those cross border with Wales. More than 1500 organisations are engaged with CaBA nationwide including NGOs, Water Companies, Local Authorities, Government Agencies, Landowners, Angling Clubs, Farmer Representative Bodies, Academia and Local Businesses.

The Citizen Crane project has been presented at two CABA events in London.

Engagement with CPiL: Catchment Partnership in London (CPiL) brings Partnerships together to exchange experiences and share solutions. The Group is chaired by Thames21 and members consist of representatives of the Partnerships plus other organisations with whom there are shared interests and who contribute actively to this work.

The Citizen Crane project has been presented at one CPiL event and featured at the inaugural meeting of CPiL's academics and practitioners group.

The Citizen Crane project was presented to the National RMI conference in November 2016.

Prof Leonard from Brunel University presented Citizen Crane to the international Symposium for European Freshwater Sciences (SEFS) Conference in 2017.

References

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