Citizen Crane 2019/20
Year Six Report

Executive Summary

The Citizen Crane project started in 2014 and this is the sixth annual report. The work to date has shown that the data collected by teams of dedicated Citizen Scientists can support key investment decisions at a catchment scale.

Whilst this reflects very positively on the many volunteers who have contributed large amounts of time to regularly collect water and biodiversity data over a 6 year period, the data itself makes for less positive reading.

Despite significant investment from Thames Water in their Surface Water Outfalls Programme to remove misconnections, and the efforts of the Environment Agency and others in responding to pollution incidents, the data strongly suggests that little has changed in the Crane river system with regards to water quality and biodiversity. The project continues to show that the river ecosystem is constrained by poor water quality, flow diversity, siltation and contaminated road run off.

As the Citizen Crane project evolves, and the prospect of further investment from Thames Water via their Smarter Water Catchments program becomes a reality, there are many key questions that remain unanswered. Fundamentally, the project has shown that there are significant sources of Ammoniacal Nitrogen and Phosphate in the upper and middle catchment which have not been sufficiently identified or removed.

The reasons for the lack of improvement in water quality and ecological value may be:

- further misconnections not yet identified through the SWOP - or new ones being added at an unknown rate
- inertia within the river system response (caused by polluted sediment and/or other factors);
- the negative impact of meteorological factors such as low and/or more sporadic rainfall and changes in run-off and inflows;
- other pollutant sources - including from sewerage system inadequacies and/or blockages linking sewage sources to the surface water drainage system and/or glycol releases from Heathrow during cold weather;

and/or

- a range of other factors influencing the health and vitality of the invertebrate populations

This report identifies a total of eighteen variables that may be influencing the condition of the river ecosystem, and sets out our current understanding of the relative importance and impact of each of these variables. The report is not definitive about these impacts and their resolution, but provides a baseline understanding of the complexity of the ecosystem at the start of the Smarter Water Catchments programme.

The report outlines an approach for the next five to ten years of investigation and investment through the Smarter Water Catchments programme, included in Thames Water's Asset Management Plan from April 2020 onwards. This approach will be developed, with Thames Water and other interested parties, over the coming year.

CITIZEN CRANE PROJECT
YEAR SIX PROGRESS REPORT

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Abbreviations used:

AMP: Asset Management Plan
AN: Ammoniacal Nitrogen (NH_3-N) - *used as a measure of organic pollution e.g. related to wastewater*
CPiL: Catchment Partnership in London
CVP: Crane Valley Partnership
EA: Environment Agency
EHO: Environmental Health Office
FORCE: Friends of the River Crane Environment
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 bioavailable. P will be used to denote 'phosphate' in the text unless otherwise noted
RMI: Riverfly Monitoring Initiative
SWOP: Surface Water Outfall Programme
TW: Thames Water
URS: Urban River Survey
WFD: Water Framework Directive
WHPT: Whalley, Hawkes, Paisley, Trigg (invertebrate monitoring system)
ZSL: Zoological Society of London

Acknowledgements:

Thames Water, for providing the funding for the project.
All of the Citizen Scientists who, after six years of voluntary actions, continue to work towards a cleaner and better River Crane.
Steering Group members and their colleagues from Thames Water, The Environment Agency and Crane Valley Partnership.
Other partners and the wider public, for their engagement and interest in the project.

1. Introduction

This document sets out the findings and questions raised by six years of data collection by the Citizen Crane project up to the end of April 2020. The report provides an update on the findings of the Year Five report and needs to be read in conjunction with other reports for a full understanding of the project findings. All project reports can be viewed, along with the base data, at:
http://www.cranevalley.org.uk/projects/citizen-crane.html

The River Crane is a small urban tributary of the River Thames, with a total catchment area of 120 sq km, running for around 35km through five boroughs (Harrow, Ealing, Hillingdon, Hounslow and Richmond upon Thames) in west London. The Crane Valley Partnership (CVP) www.cranevalley.org.uk was formed in 2005, and now has 26 partners, with objectives to protect and enhance the value of the River Crane and its tributaries.

The location of the Crane catchment within the Greater London boundary is shown in Figure 1.

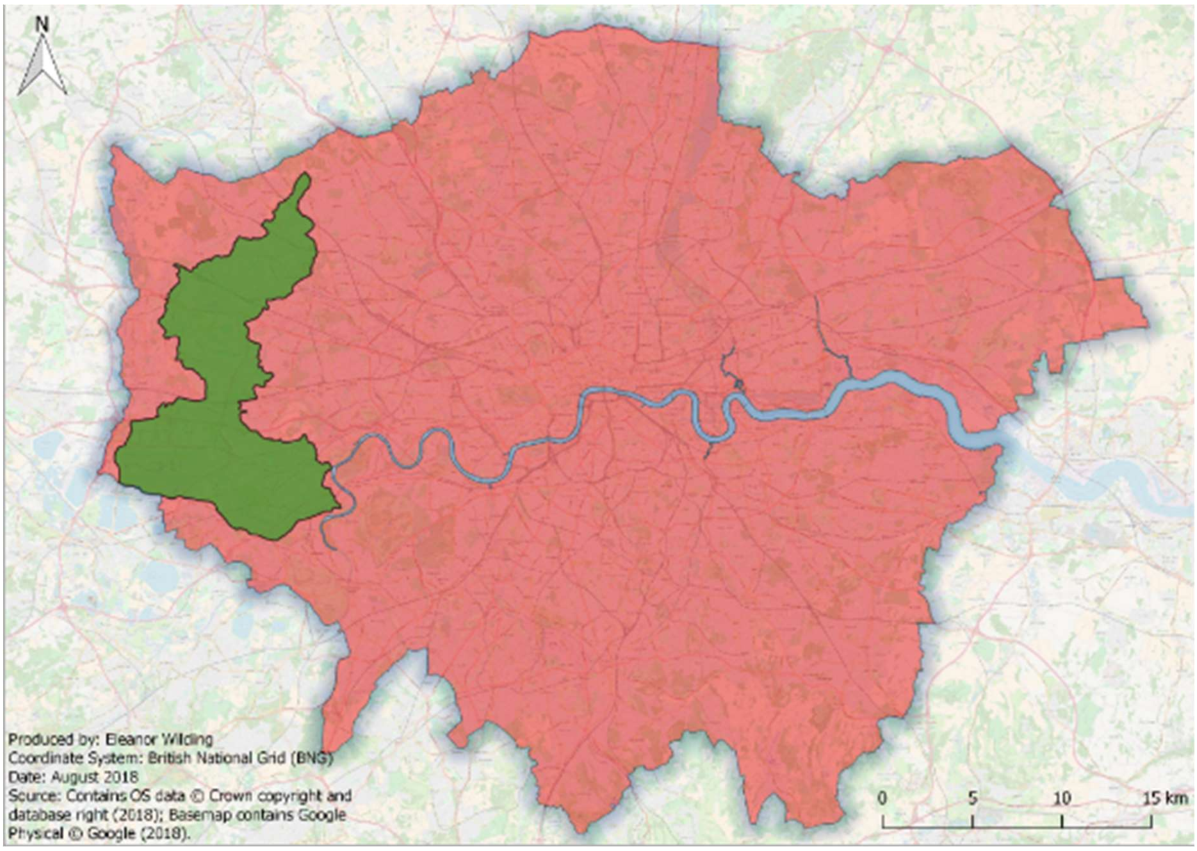


Fig 2. The Crane Catchment (in green) within Greater London (in red)

The river rises as two tributaries. The western arm is known as the Yeading Brook and its current source (where several small channels emerge out of culvert) is Headstone Manor in LB Harrow. The eastern arm is known both as the Roxbourne and the Yeading Brook East, and its current source is Newton Ecology Park (where two small culverted streams emerge), also in LB Harrow. The two arms flow south to meet on farmland to the east of Gutteridge Woods in LB Hillingdon, where the combined channel is still known as Yeading Brook. Several km further south the name changes to the River Crane.

In Donkey Woods the river is joined by an artificial channel, known as the Upper Duke's River, bringing an inflow of water from the River Colne to the west. The River Crane flows for a further 6km to Kneller Gardens, where it divides and another artificial channel, known as the Lower Duke's River, leaves the main river. Both channels flow eastwards to enter the River Thames in Isleworth.

The main features of the river, including the key Citizen Crane monitoring points, are shown in Figure 2 below.

Fig 2. The Crane Catchment, including principal RMI and water quality monitoring points

2. Project Overview

The project was precipitated by a major pollution incident in 2011, which had a devastating impact on the ecology of the middle and lower Crane - killing around 10,000 fish and leaving only a few aquatic snails surviving. The Citizen Crane project was devised by CVP members in response to this incident, with the intention of investigating the basic condition of the river, identifying and quantifying pollution risks and working with key partners - the Environment Agency and Thames Water - to reduce those risks.

The project management team comprises Frog Environmental (a small private consultancy), Zoological Society of London (ZSL – a major conservation charity) and Friends of the River Crane Environment (FORCE – a small local charity). This team is supported by a network of volunteer groups and individuals, with over 60 volunteers trained during the six years, and by now operating 16 monitoring sites. A project steering group of CVP, the Environment Agency (EA) and Thames Water (TW) meets with the project management team every quarter.

Eleven monitoring sites were initially set up at regular intervals (every 3 to 4 km) throughout the river system, each with a team of volunteers. The project operates by monitoring these sites at the same weekend every month for:

- invertebrates, using the River Monitoring Initiative (RMI) methodology
- water quality with the samples analysed in TW's UKAS accredited laboratory for ammoniacal nitrogen (AN) and phosphate (P) concentrations
- flow (by gauging the depth and velocity along a pre-measured river section), used to calculate loadings from the concentration data

A further five sites were added in the upper reaches of the catchment in early 2019 for water quality samples only (i.e. no RMI or flow measurement). These allow for a more detailed assessment of the sub-catchments and processes in the upper reaches, where the highest concentrations of organic pollution have been found.

These data provide the basic inputs for the Citizen Crane project, the scope of which also includes:

1. Engagement with TW and their Environmental Protection Team, investigating and resolving misconnections, under the Surface Water Outfall Programme (or SWOP)
2. Delivery of the UK's first Outfall Safari in 2016, using citizen scientists to visit and evaluate the condition of all 230 surface water outfalls across the catchment. A second outfall safari had been planned for spring 2020 but has now been delayed until 2021
3. Identification and monitoring of pollution incidents, in support of the EA and other stakeholders
4. Engagement with Universities and other researchers who wish to interrogate and add to the data
5. Development of a conceptual model of the chemical and ecological nature of the river system, including a mass balance of AN and P for the river
6. Engagement with projects investigating the impact of road run-off on the river system
7. Assessment of the impacts of river improvement measures
8. Engagement with local stakeholders, the general public and the wider world about the project and its findings. This includes supporting the extension of the project approach to other catchments in Greater London and elsewhere
9. Identification and initial assessment of eighteen parameters that have a potentially significant influence on the ecosystem
10. Supporting TW in the development of the UK's first urban "Smarter Water Catchment" initiative on the River Crane – which started in April 2020

This report provides an update on all these project elements. The report has been expanded to include a summary of all the key findings of the project and provide a baseline for the start of the Smarter Water Catchments project.

The data collection for Year Six has been impacted by significant external events:

- In January and February of 2020 there was a series of large storms. These storms resulted in very high flows in the river system, which meant that the RMI sampling and flow gauging could not be carried out safely. The data sets for this period are therefore incomplete
- In March 2020 the UK and the rest of the world were severely impacted by the Covid 19 pandemic. As a result, all volunteer activities were stopped from March onwards. At the time of writing (July 2020) the teams have just returned to full sampling

The data sets for Year Six are therefore for a shortened period (of 9 or 10 months dependent upon the parameter). Nevertheless, the analyses have been carried out using the same approach as for previous years.

3. Project support

The following project support elements have been delivered over the last year:

- Continued maintenance of all the site gauging stations
- Training new volunteers. ZSL provide training across London for recruits to the Crane and other rivers. Over 60 River Crane catchment volunteers have gone through this training programme to date
- Overhaul of the data management system. Data are now made available more regularly to volunteers and the intention is to provide regularly updated data sets for all interested parties on the Citizen Crane pages of the CVP website
- A fifth annual Citizen Crane forum was held in October 2019. The forum provided an opportunity to review progress to date and discuss future plans with all interested parties. A sixth forum had been planned for later in 2020. This has now been cancelled, and a launch event is proposed for spring 2021, linked to the Smarter Water Catchments programme
- Visits and other events for volunteers – including a social event in summer 2019 and a workshop to review Heathrow's RMI data sets in February 2020. Other events planned for 2020 were postponed

The Smarter Water Catchments (SWC) project started in April 2020, with an initial 12 months of project development, followed by four years of project delivery. Funding of £3.1m has been allocated to this programme over the five years to April 2025, with further funding envisaged over the next five year AMP period to 2030. Future funding of the Citizen Crane project, for the next five years to 2025, was also confirmed as part of this overall programme.

The SWC programme will include further engagement with volunteer groups and the wider public regarding the value of the Crane river system. The Citizen Crane project is seen as a key component in this process and the delivery mechanisms will be developed in the period to April 2021.

The start of the SWC programme has been delayed by the Coronavirus pandemic. At the time of writing (July 2020) the SWC programme is proceeding and there has been some progress on the development of the project principles. A revised Catchment Plan is proposed, for completion in April 2021, which will set out the detailed strategy for project implementation over the following four years.

4. Water Quality

Background

The purpose of taking water samples is to:

- Create a detailed and reliable baseline of water quality across the catchment
- Track changes to water quality over time
- Track the impact of interventions and remedial works; e.g. SWOP and new SuDS schemes
- Identify pollution 'hotspots' and inform the prioritisation of resources for interventions across the catchment

The water quality data consist of monthly concentration and loadings data for ammoniacal nitrogen (NH3-N) and phosphate (PO_4^{3-}) for each monitoring site. These two parameters are measured as they are considered to provide a good indication of organic pollution and nutrient in the river.

Flow rates are recorded at each site using a standard gauging board and flow velocity measurement system along with a pre-measured cross section. This cross section is re-measured every two years and in response to concerns reported by the local team. Flow data are used to calculate pollution loadings from the concentration data.

Between May 2014 and March 2020, a total of 1025 samples have been collected by citizen scientists, and analysed in Thames Water's laboratories, as follows:

- Year 1: 108
- Year 2: 122
- Year 3: 124
- Year 4: 120
- Year 5: 149
- Year 6: 102

Sampling in Year 6 was impacted by flooding in January and February (for some sites at least) and then curtailed by the Covid 19 pandemic, with the last samples taken in February 2020. Annual data sets have therefore been compiled using up to eleven months of data, from April 2019 to February 2020. Note that high water levels during floods in January and February 2020 also meant that flow measurements (and RMI records – see Section 6 below) could not be obtained in these months. Annual loading data for Year 6 are therefore based on nine months data between April and December 2019.

Samples have been collected from eleven monitoring sites for six years. In early 2019 a further five sites were added, in order to enhance the information available from the upper reaches of the catchment, where the most pollution problems have been identified. These data have not been included in the plots in this part of the report but are evaluated within the section entitled 'further investigations in the upper catchment' (P17).

The data have been reviewed and quality checked. Any data of concern have been either removed or flagged as unreliable. Full data sets were not always available due to the following reasons:

- Volunteers unavailable
- Very occasional issues with sample bottles (not available or leaking en route)
- River too deep to undertake RMI or flow monitoring
- Concerns about data reliability following initial analysis
- Loss of water level gauging boards (such that loadings cannot be calculated)

However, given the project is entirely reliant on volunteers and the variabilities of field work conditions, the overall return of reliable data (at around 90 per cent of potential data points) is considered very satisfactory. It is also very encouraging to note that this return has remained constant over the six years of the project.

Tables showing median year on year records for water quality and flow are presented in Appendix A. All the base data can be found on the CVP website.

Water Quality Concentration Data

Data are presented as median concentration and loading values at each site for each of the six years, measured from April to March (e.g. median 2017 = Year 4 = April 2017 to March 2018). Median data are used as these reduce the impact of individual outlier data points.

Data are plotted on the graphs below in terms of the distance from Headstone Manor, the effective source of the Yeading Brook arm of the river, creating a line plot between all the points on the main channel. Data points for Newton Park (Site 4, near the source of the Roxbourne arm of the river) and the Upper Duke's River (Site 10, where the Duke's River enters the Crane at Donkey Wood) are shown individually as floating points.

The six year data set for phosphate concentration is shown in Figure 3 below:

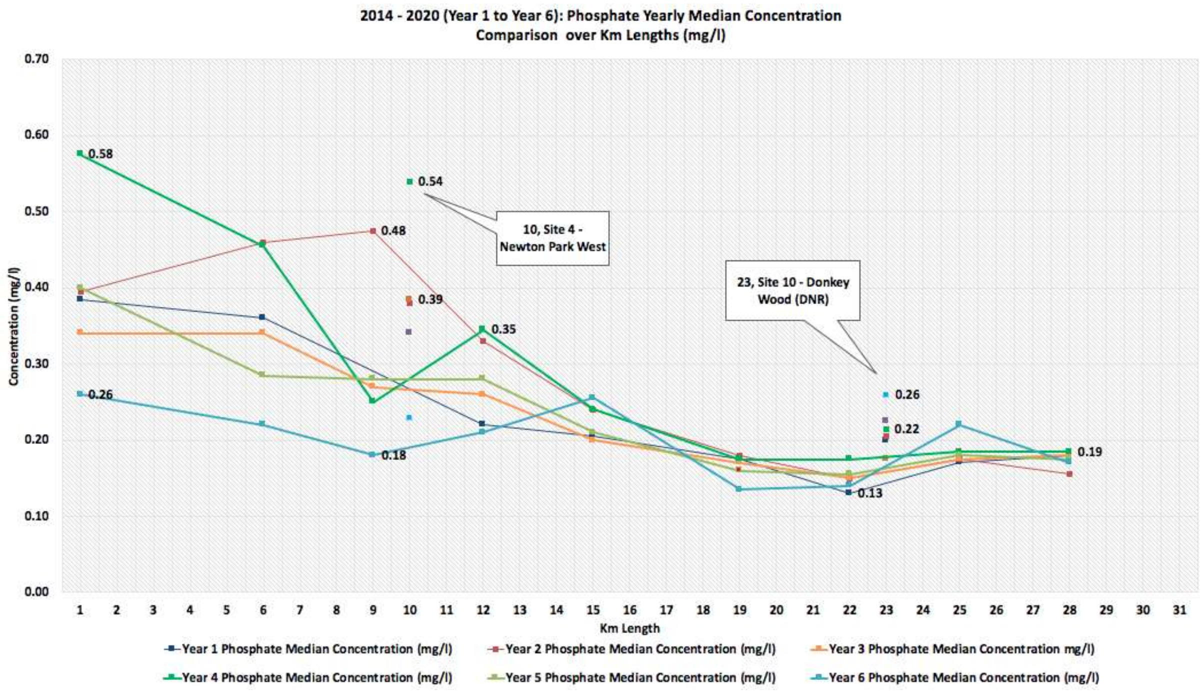


Fig 3. Median Phosphate Concentration along the River: Years 1 - 6

Note that the Water Framework Directive (WFD) standards for Phosphate (PO_4^{3-}) are calculated through a complex metric. However, in broad terms the boundary between poor and moderate status is around 0.2 mg/l whilst the boundary between moderate and good is around 0.1 mg/l.

The conclusions drawn from these data are as follows:

- Over years 1 to 5 a reasonably consistent pattern had emerged of higher P concentrations in the upper catchment (at both Headstone Manor – Site 1 and Newton Park – site 4) and concentration reducing with distance downstream. One result of these findings was that the emphasis of the TW SWOP was shifted to the upper catchment – from early in Year 4

- In Year 6 the pattern is less pronounced, with significantly lower P values in both Headstone Manor and Newton Park than previously. Median concentrations there, which had been around 0.5 mg/l previously, have reduced to close to 0.2 mg/l (moderate level)
- P concentrations in the incoming flow from the Upper Duke's River have been higher than the Crane receiving waters in every year of the record. In Year 6 the contrast was even higher, with the highest median concentration yet from the Upper Duke's (0.26mg/l) and the receiving water at or below their lowest concentrations yet (only a little above 0.1 mg/l – good status)
- Overall P concentrations appear to have reduced considerably in the River Crane system in Year 6 – indicating a significant shift for the first time in these data – though the higher concentrations in the inflow from the Upper Duke's River partially counteract this
- In Year 6, for the first time, there is no significant trend with distance downstream in these data and each median data point is between 0.1 and 0.3 mg/l
- Water quality in Year 6 approaches as close to Good Status with respect to P, in the middle and lower reaches, as it has done to date. However, in no year to date has a median concentration reached Good Status at any of the sites monitored

The concentration data for ammoniacal Nitrogen (AN) are plotted, using the same approach, in Figure 4 below.

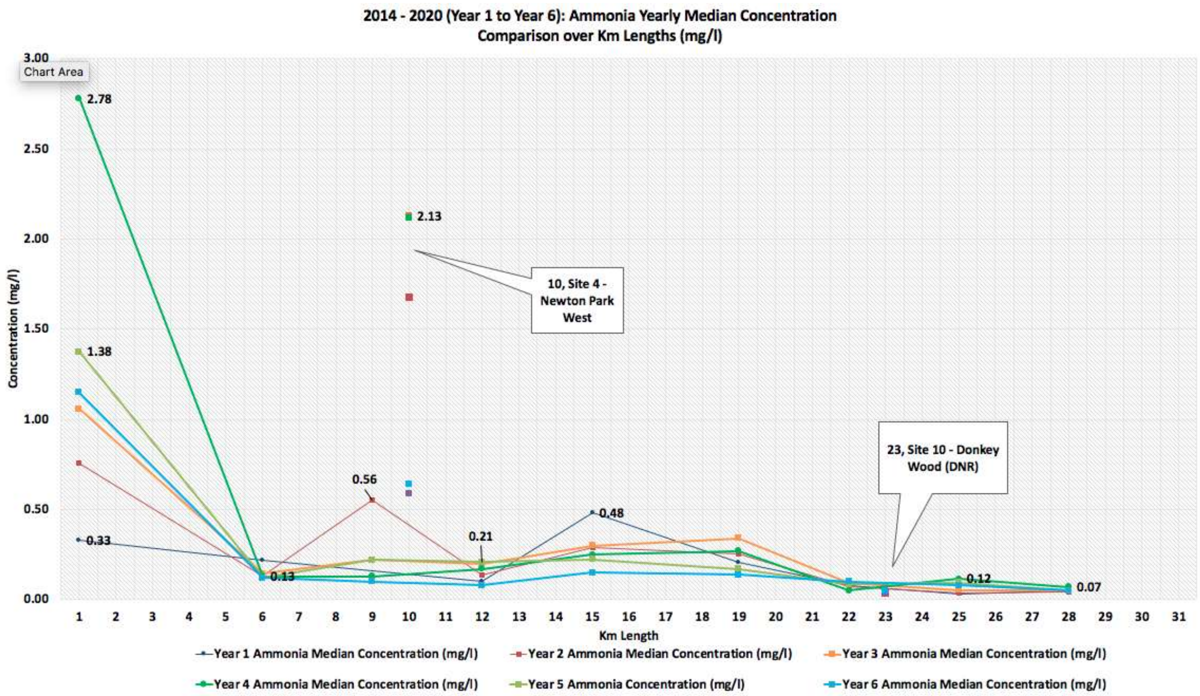


Fig 4. Median Ammoniacal Nitrogen Concentration along the River for Years 1 to 6

Initial conclusions drawn from these data are as follows:

- The median concentration of AN is significantly higher at the top of both arms of the catchment (Site 1 and Site 4) in Years 1 to 5, following a similar, though more exaggerated pattern, as shown by P. This pattern is repeated in Year 6, though concentrations are reduced compared to the highest years on record (including both the previous two years)
- AN concentrations in the middle catchment are significantly lower in Year 6 than in previous years. For the first time, concentrations between Site 2 and the base of the measured catchment at Site 12 are fairly consistent, at or around 0.1 mg/l

There is further consideration of these data – and in particular the water quality at the top of the catchment – in later sections of this report.

Flow Data

Flow estimates are made at each site every month using a flow gauging section and measurements of flow velocity and water depth. These data are used to calculate the loadings of phosphate and ammoniacal nitrogen at each site, and thereby gain an insight into how the loadings change along the river corridor.

The method used for gauging flow in the Citizen Crane project has been developed with the support of the Environment Agency, who also provided training for volunteers. It should be noted that the accuracy of results from flow gauging can be impeded by the following:

- Robustness of gauging boards at the flow monitoring station. Damage to gauging boards can arise from debris during flood flows, tampering by members of public, fly tipping and general wear. This can directly lead to missing or compromised flow data
- Seasonal issues such as aquatic weed growth. This can result in the river flow becoming funnelled into a tighter channel at the gauging station and the transect data becoming compromised. This may result in an artificially high flow rate being recorded by the volunteer
- Debris (natural or fly tipped) reducing the even distribution of flow through the gauging station and compromising the accuracy of the transect
- Shifting sediments/gravels following high flow conditions may lead to the gauging station transect being changed
- Access can be impeded to the gauging stations from terrestrial plant growth. Plant growth can also obscure and bury the gauging markers
- Occasionally flood flows can prohibit access or even submerge a gauging station. In these circumstances measurements cannot be recorded

Water quality returns for the Citizen Crane project run at a respectable 91% whilst flow data, which is used to calculate loading, runs at a more modest 77%. Some of the issues cited above come into play when considering the validity of flow data and the loading data it produces. Note that all the gauging stations were visited, new sections measured and gauging boards replaced where necessary, during late 2018.

Further maintenance work at several sites was carried out in 2019. At this time it was also decided to abandon the gauging station for Site 8 at Cranford Park. This station has proven difficult to maintain over many years and is only a few hundred metres downstream of the main EA gauging station for the river. The EA gauging station data have been used from Year 5 onwards for this site.

Table 1: An overview of different issues encountered at each gauging station over the last 6 years

Monitoring Site	Gauging Board Issues	Access issues	Aquatic weed growth	Storm damage	New material deposits/debris in channel
1				X	
2		X	X	X	
3	X		X	X	
4	X				X
6			X	X	X
7	X	X		X	X
8	X	X		X	
9	X			X	
10	X			X	
11					
12					X

Table 1 indicates the types of problems encountered at these gauging stations and illustrates the value of regular site visits to ensure records can remain reasonably reliable. It is worth noting that even Environment Agency flow monitoring stations frequently encounter problems such as debris and weed growth, which sometimes reduce confidence in the official flow record.

As part of the data review in 2018 two key changes were implemented:

- Where flow data have been compromised due to a combination of the aforementioned issues, the data have been excluded for the purpose of calculating loading
- Where there is a data return of less than 50%, or where there is a known issue impacting the confidence in flow data, these data have been excluded from calculations

The decision to exclude certain data sets is not a reflection on the dedication of the Citizen Scientists involved with the Citizen Crane project. The factors that affect the usability of data are beyond the control of volunteers.

Whilst flows in the upper and middle reaches are broadly comparable over the first five years of the project, the four sites that are used for monitoring flow in the lower reaches showed an overall steady reduction over the first 5 years of the project (see Table 2). The data in Year 6 show a recovery in median flow, closer to the flow recorded in Year 1.

Table 2: Annual median cumec record for lower catchment gauging stations

Site reference	Year 1 median cumec	Year 2 median cumec	Year 3 median cumec	Year 4 median cumec	Year 5 median cumec	Year 6 Median cumec
Site 9 Donkey Wood (Crane above DNR)	0.55	0.35	0.28	0.29	0.27	0.58
Site 10 Donkey Wood (upper DNR)	0.53	0.46	0.29	0.20	0.26	0.35
Site 11 Crane Park island (below confluence)	1.15	0.76	089	0.60	0.59	0.80
Site 12 Mill Road (furthest site downstream)	0.90	0.83	0.82	0.76	0.60	1.00

Annual rainfall data for the six years from the gauging station at Heathrow are as follows:

- Year 1: 663 mm
- Year 2: 652 mm
- Year 3: 476 mm
- Year 4: 674 mm
- Year 5: 409 mm
- Year 6: 721 mm

The annual rainfall in Year 6 is the highest in the six year period and this is reflected in the higher flows recorded at the monitoring points. It will also have had a significant influence on the changes in concentrations reported above. Note however that two of the highest rainfall months (January and February 2020) are not fully reflected in the flow data, as the river was too high for flows to be measured in many places. The impact of these factors illustrates the value of generating loading data, whereby the effect of flow variations is removed.

Variations in rainfall, and the relationship between rainfall, run-off and stream flow, are clearly of considerable importance to the nature of the river system and its water quality. Further analyses of these variations is outside of the remit of the Citizen Crane project, though it may be something to examine during the Smarter Water Catchment programme.

The Citizen Crane team has discussed the meteorological and hydrological characteristics of the river system with various professional and academic experts, with a view to exploring these data in more detail over the next year, either through Citizen Crane or the SWC. Initial work under the Camellia project is presented as Appendix B to this report. This indicates a significant change in the flow duration curve for river flows in the Crane pre and post 2015. This change would have important implications for the nature of the river system as a whole and requires further investigation.

The inflow along the Upper DNR is sourced from the River Colne to the west. The River Colne offtake is not actively controlled and the offtake is prone to siltation. FORCE has reported the problem of siltation at this offtake to the EA and other interested parties and it has been investigated as part of the Heathrow Third Runway project (currently on hold). It can be seen that flows along this channel have reduced in Years 3 to 5 compared to Years 1 and 2. Even in Year 6, with the highest rainfall of the six year period, flows did not recover to those from earlier years of the project. This is a particular concern as the inflow from the Upper DNR has a beneficial effect on the ecological value of the Crane downstream (see later sections of this report).

Loading Data

Loadings are calculated by combining the water quality concentration data with the flow data. Loading data provide an insight into the bulk amounts of phosphate (P) and ammoniacal nitrogen (AN) in the river system at a sampling point. These bulk amounts are a function of the inputs and the outputs from the system at any particular time. Figures 5 and 6 below set out the median annual loading data for P and AN over the six years of the project along with initial conclusions from an analysis of these data.

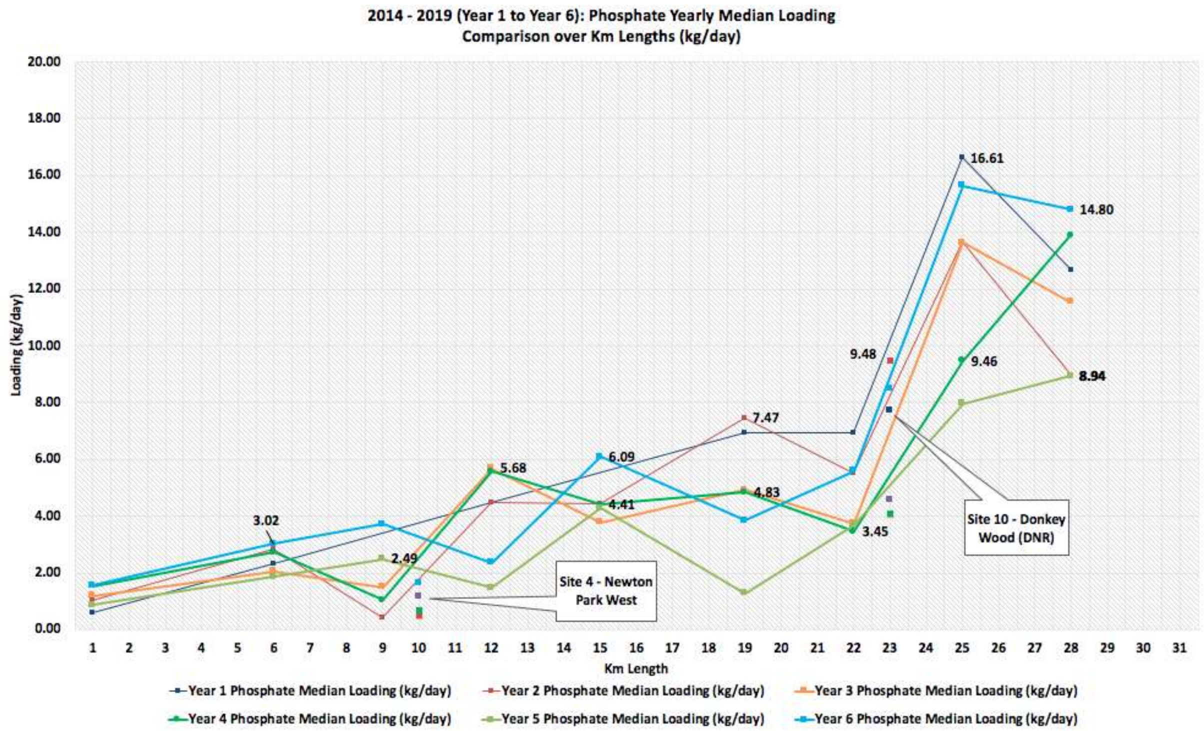


Fig 5. Median Phosphate Loadings along the River for Years 1 to 6

Initial conclusions drawn from these data are as follows:

- The overall pattern of loadings is reasonably consistent across the catchment and between the six years. There is a broad level cumulative increase in P load with distance downstream – starting at around 1kg/day and rising to around 4kg/day at site 9 (at 22 km)
- There is a significant increase in the P load from the Upper DNR in all years, adding a further 5 to 10 kg/day and more than doubling the overall P load in the river
- There is a varied pattern in the lower catchment, often showing an overall reduction in P load over the lower 5km being monitored, indicating the capacity of this part of the system to remove P
- This pattern is replicated in Year 6. The P load data reveal Year 6 to be a typical, if not higher than average, year – and this indicates that the reduced concentrations shown in Figure 3 may be more a function of higher flows and dilution than any significant change in pollutant inputs

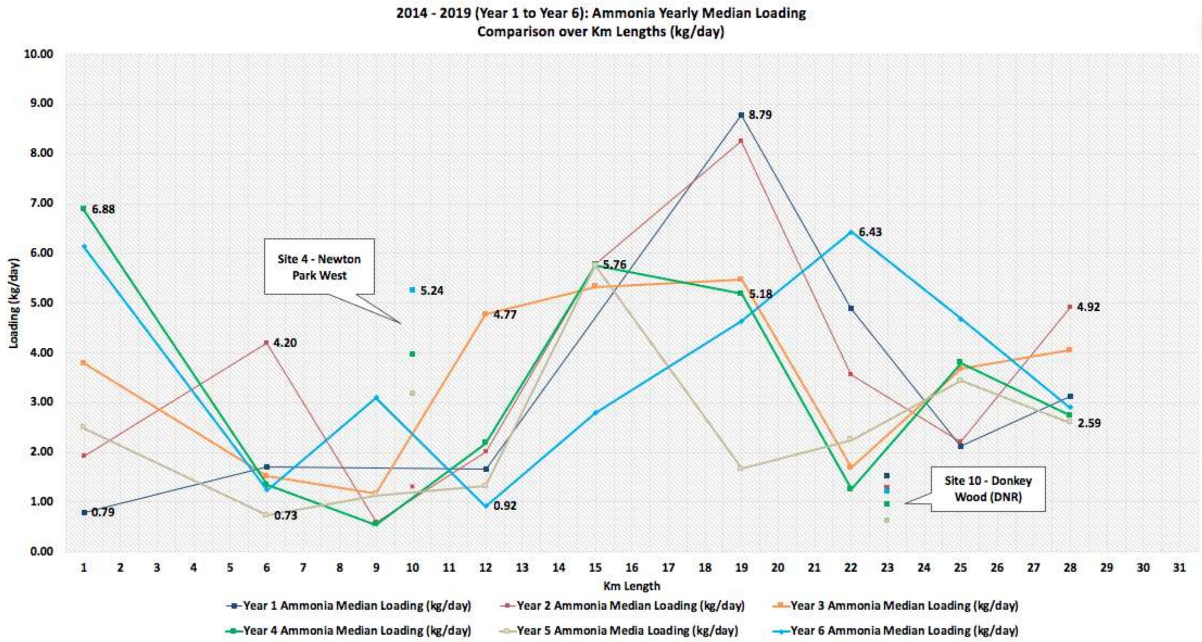


Fig 6. Median Ammoniacal Nitrogen Loadings along the River for Years 1 to 6

Initial conclusions drawn from these data are as follows:

- AN loadings are high at the top of the catchment, with several kg/day being input at the top of both the Yeading Brook (Site 1) and Roxbourne (Site 4) arms of the river
- The loadings vary with distance down the river, but often are at or below the loading at the top of the system. This indicates the capacity of parts of the river system to remove AN
- There appears to be a second large input of AN in the middle reaches of the river around Sites 7, 8 and 9. This source is more variable in size and location over the six years of monitoring
- The overall loadings at the base of the river (Site 12) are often at or below that the top of the system
- These features are all replicated in Year 6. The loadings at the top of the system in Year 6 are among the highest recorded in the six years of monitoring, with a combined input of over 10 kg/day to the two arms. However, the loading at the base of the river is among the lowest recorded over this period, at less than 3 kg/day
- Overall, the pattern in Year 6 is not dissimilar to previous years and, as with P, this indicates that the lower concentration data are more a function of dilution than a change in pollutant inputs

Further consideration of these data are provided in later sections of the report.

Further Investigations in the Upper Catchment

The upper reaches of the Crane catchment have become a focal point for the project due to the poor water quality and low ecological value (from the RMI data) recorded in the two tributary sources (Headstone Manor – Site 1 and Newton Park – Site 4) during the first years of the project. LB Harrow is investing a considerable amount in improving the environmental and aesthetic value of these sites, and this further increases the importance of resolving the pollution issues here. As a result Thames Water shifted (from 2017) the focus of their Surface Water Outfall Programme to these reaches.

At Headstone Manor:

- The source of the Yeading Brook is considered to be the moat around the manor house, fed by one stream at its north eastern corner. The build-up of polluted sediment in the moat has been a problem over many years. In early 2019 LB Harrow dredged the moat to remove much of this sediment. This dredging created some additional pollution load in the first months but is thought to have been beneficial from that point onwards
- A new monitoring site was added at the outfall from the moat (Site 13) in January 2019
- LB Harrow is creating a major new wetland system to intercept the culverted channel upstream of the moat. The channel between this new wetland and the moat will be taken out of culvert. Work has started on the ground (Summer 2020) and it is anticipated that this new wetland will be operational by 2021
- A second stream feeds into the main channel just downstream of the moat. LB Harrow is taking this stream out of culvert and creating a new sinuous open channel through the park. Work has started on the ground (summer 2020) and the new channel is anticipated to be fully operational in 2021. A new monitoring site was added where it meets the main channel (Site 14) in 2019
- A third stream feeds into the main channel where it turns through a right angle bend, just above Site 1. This stream drains the catchment where new housing development is taking place on the old Kodak industrial site. A new monitoring site was added where this stream meets the main channel (Site 15) in January 2019
- Thames Water, under the SWOP, has removed a large number of misconnected properties from the culverted drainage catchments upstream of this site over the last three years. However, there are still occasional pollution problems from these catchments, including a significant sewage input in winter 2019
- There is some evidence, from the data on the new monitoring sites, that water quality is slowly improving in these channels. It is too early to be definitive about this though and pollutant concentrations in each of the input sources monitored continue to often be classified as poor under WFD
- The water quality data for Site 1 (as presented and discussed above) indicate there has been a significant improvement in the median concentration of Phosphate and Ammoniacal N during Year 6. However, the loading data show no discernible improvement. Therefore it appears that the increase in flows and dilution experienced in Year 6 was the dominating factor

In summary, it would appear that any benefits from the large amounts of work being done in this system may be largely shrouded by the impact of short term events such as the sewage pollution incidents and dredging. It may therefore take more time for the positive benefits of these works to feed into the data sets and the conditions on the ground.

At Newton Park:

- A three-stage wetland system was installed by LB Harrow and opened in summer 2018. This takes the bulk of the stream flow and passes it through a network of open water, channels and marginal plants

- In August 2018 the Citizen Crane project started to sample the water quality both upstream (Site 4) and downstream (Site 5) of this new wetland feature. These data, for the period from August 2018 to January 2020, are shown in Table 3 below.

Table 3: Total P* and AN concentration data for upstream and downstream of the wetland system
*Note: total P is used here whereas dissolved P is used elsewhere in the data analyses

	Site 4 - Upstream of ponds																
mg/l	Aug18	Sep	Oct	Nov	Dec	Jan	Feb	Mar	May	July	Aug19	Sep	Oct	Nov	Dec	Jan	**Mean**
P Total	0.6	0.8	0.4	0.4	0.6	0.7	0.4	0.4	0.7	0.3	0.5	1.3	0.3	0.4	0.2	0.4	**0.5**
AN	1.2	0.3	0.4	0.6	1.5	2.8	1.2	0.5	1.9	0.4	0.4	3.8	0.6	0.9	0.1	0.6	**1.1**
	Site 5 - Downstream of ponds																
mg/l	Aug18	Sep	Oct	Nov	Dec	Jan	Feb	Mar	May	July	Aug19	Sep	Oct	Nov	Dec	Jan	**Mean**
P Total	0.4	0.6	0.3	0.4	0.4	0.5	0.3	0.3	0.4	0.4	0.4	0.7	0.2	0.3	0.2	0.3	**0.4**
AN	0.5	0.5	0.2	0.4	1.0	1.3	0.1	0.3	0.8	0.6	0.4	1.0	0.2	0.7	0.1	0.3	**0.5**

- There have been a large number of SWOP interventions in the upstream catchment and significant reductions in the pollutant load as a result. Misconnection sources have ranged from single properties to large accommodation blocks and schools.
- Nevertheless, the incoming water quality (Site 4) continued to be poor for much of this time period, with AN concentration varying from 0.1 to 3.8 mg/l.
- Specific pollution problems have also continued in the upstream catchment – including one sewage pollution incident in summer 2020 (ongoing as of July) that stopped the volunteers from sampling the site
- There also appears to be a chronic hydrocarbon pollution source in the upstream catchment. There is a serious build-up of hydrocarbon rich sediment in the upstream lagoon – with several centimetres of black oily sediment recorded during a field visit in winter 2019. This problem has been investigated but no source found to date. Plans are being implemented to intercept this pollution before it reaches the wetland
- Whilst data collected upstream and downstream of the Newton Park wetland at the same time are not directly comparable, there is strong evidence from the data set (Table 3) that water leaving the wetland and re-joining the channel has a lower nutrient and organic pollution concentration than water entering the wetland. The mean Total P level has reduced by around 20 per cent (0.5 to 0.4 mg/l) and AN by around 50 per cent (1.1 to 0.5 mg/l). [N.B. This wetland is showcased in a CVP video: https://www.youtube.com/watch?v=qLyA57Jzvf8&t=97s]
- These data are comparable to the data presented at a recent TW workshop for a wetland area at Pymms Park on the River Lea in LB Enfield (report by Natalie Gilbert of Thames 21, 2016). These were summarised as: P reducing from 1.6 to 1 mg/l and AN reducing from 1.4 to 0.4 mg/l
- Other data from the same Thames 21 project report showed BOD reducing from 7 to 5 mg/l; coliforms from 600 to 200 counts per ml; and nitrate from 5 to 3.5 mg/l
- The RMI data also indicate early signs of improvement in the downstream channel (see Section 5 below)

In summary: a very large amount of work has been done (by TW and LB Harrow) to reduce the pollutant loading and install beneficial wetland features. The early indicators are that these works are having some beneficial impacts. However, there remain some chronic pollution problems – both from organic pollutants and hydrocarbons – to resolve before the system can be relied upon to make a positive contribution in the mid to long term.

At Smart Brook:

- This culverted stream has been identified as being a significant potential pollution issue. A monthly sample has been taken here since February 2019 and is known as Site 16. These data are set out in Table 4 below:

Table 4: Water quality data from Smart Brook – Site 16
*As above – P Total used

	Site 16											
mg/l	Jan 19	Feb	Mar	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan 20
P Total*	0.5	0.4	0.7	0.9	0.4	0.5	0.3	0.7	0.3	0.4	0.3	0.4
AN	1.0	0.6	0.5	2.2	0.3	1.3	0.4	1.0	0.2	0.0	0.0	0.3

- These data indicate that, in early 2019, this small catchment was significantly polluted – comparable to the other culverted streams in the LB Harrow area – with AN levels in the order of 0.5 to 2 mg/l
- From autumn 2019 the water quality recorded appears to have improved significantly. P levels reduced and AN levels of 0 were recorded on two consecutive months. These data indicate a significant improvement in this small catchment over this period, which is very likely to be related to the TW SWOP work which has taken place here

In summary – this small catchment appears to have benefited from the SWOP. Monitoring will continue to see if this benefit can be sustained in the longer term.

There are ongoing discussions between the project team, Thames Water and LB Harrow about the potential causes of the pollution issues in the upper catchment. There is some encouragement from recent data that pollution levels may be falling, although conditions are generally still described as poor compared to WFD standards. The large amount of SWOP works may be revealing additional underlying problems, caused by the sewer network and other pollution sources.

Investigations by Thames Water in the adjacent Brent catchment have identified long term infrastructure issues in the LB Harrow area including:

- network cross connections – as part of the infrastructure
- network cross connections made many years ago to resolve local urban drainage flooding issues
- missing and broken caps in dual manholes that allow cross connections between the surface and sewerage networks
- blockages in the sewer network that lead to the activation of cross-connections or local sewer flooding into the drainage network by overland flow

Early assessments indicate that these issues are less prevalent in the Crane catchment. Nevertheless, the full extent of these issues and their implications for water quality in the upper Crane catchment are still to be fully understood. It is anticipated that this will be a significant research task for the Smarter Water Catchments project.

Key Findings

1. The water quality data continue to show a reasonably consistent pattern over the six years of data collection
2. The sources of the two upstream arms of the river appear to be improving (by some measures at least), and yet they remain the most polluted parts of the river system, with poor water quality overall
3. There appears to be a second area of higher pollutant input in the middle reaches of the river. The peak loading location appears to vary over the six year period of observation
4. Parts of the middle and lower reaches of the river indicate a capacity for self-cleansing, with little increase and some decreases, in pollutant loading with distance downstream
5. In the lower reaches the river is moderate WFD status in terms of water quality and indicates a potential to consistently achieve good status in the future

5. River Monitoring Initiative (RMI)

RMI Approach

A full description of the RMI methodology is available in the Citizen Crane Year Two report, available from www.cranevalley.org.uk/projects/citizen-crane.html 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 (EA) if further investigation is required. The basis of the RMI method is sampling macroinvertebrates, using a standardised method, and scoring the presence and abundance of indicator species groups. Trigger level sample scores were originally set in discussion with EA staff in Year One of the project and represent levels at which a pollution incident is considered to have occurred at each sampling site.

Between May 2014 and April 2020, RMI samples have been conducted on a monthly basis at the 11 monitoring sites along the river. There have been the occasional gaps in sampling at some sites, caused by factors such as the unavailability of volunteers, or unsafe river conditions due to heavy rain. At Newton Park, sampling was suspended for a period in 2018, due to the inaccessibility of the site during the construction of the new wetland area, and resumed in early 2019. Our RMI volunteer at Cranford Park left the project in winter 2018 and the project team have struggled to find a long term replacement since.

RMI Data Sets

Mean annual RMI scores at each site for each of the six years are set out in Figure 7 below. As with the water quality data, these run from April to March, such that Year 6 runs from April 2019 to March 2020. This chart also shows the trigger level set for each site.

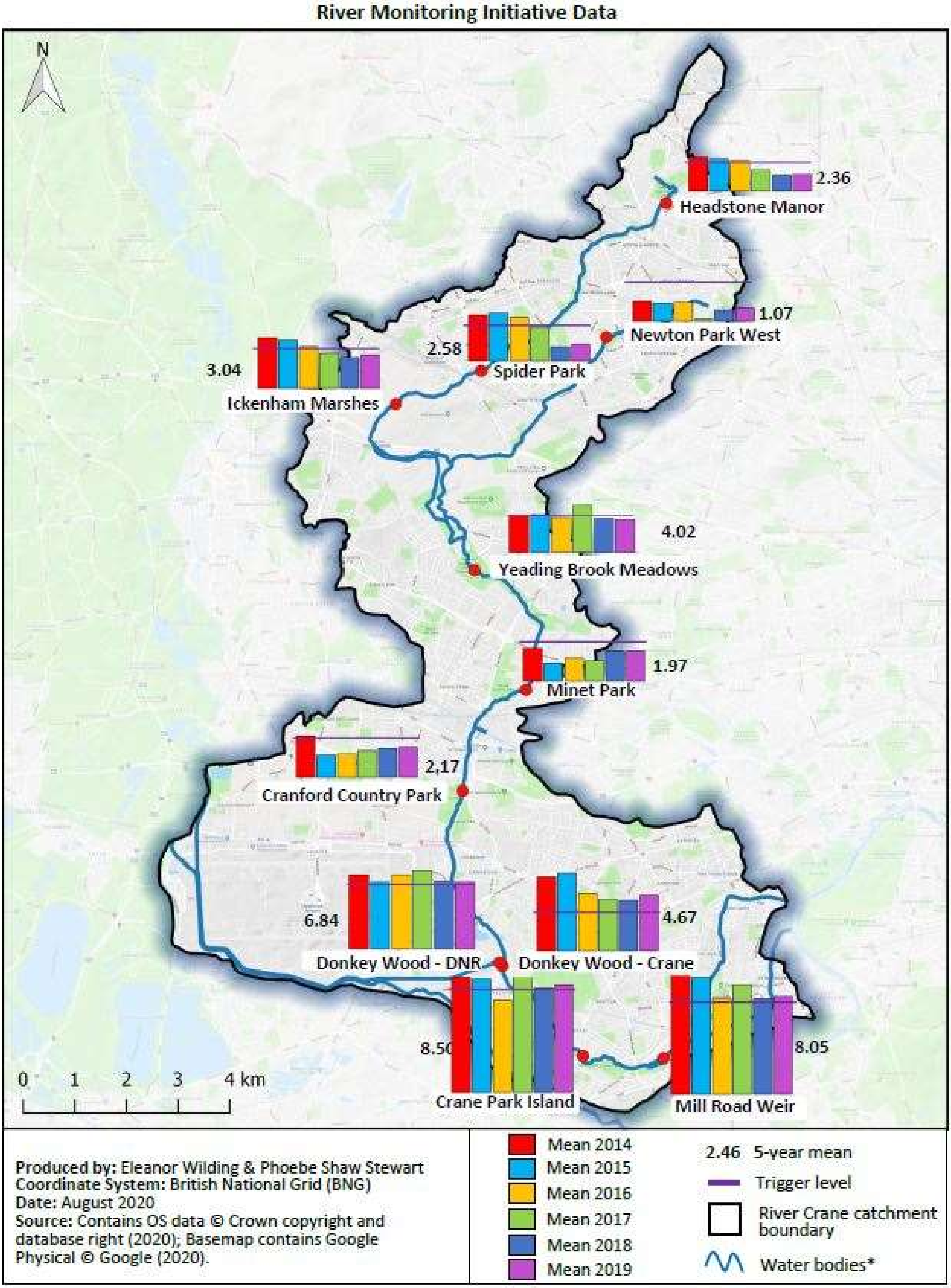


Fig 7. Mean annual RMI scores for each year of the 6 years of monitoring for all sites

Figure 8 shows five years of RMI scores over time for the three sites downstream of the Heathrow Eastern Balancing Reservoir outfall on the main river (Donkey Wood, Crane Park Island and Mill Road). The data show regular monthly variation and some trigger breaches outside of winter. These plots were produced in order to investigate further issues of sewage fungus and reduced RMI scores during and following cold winter events.

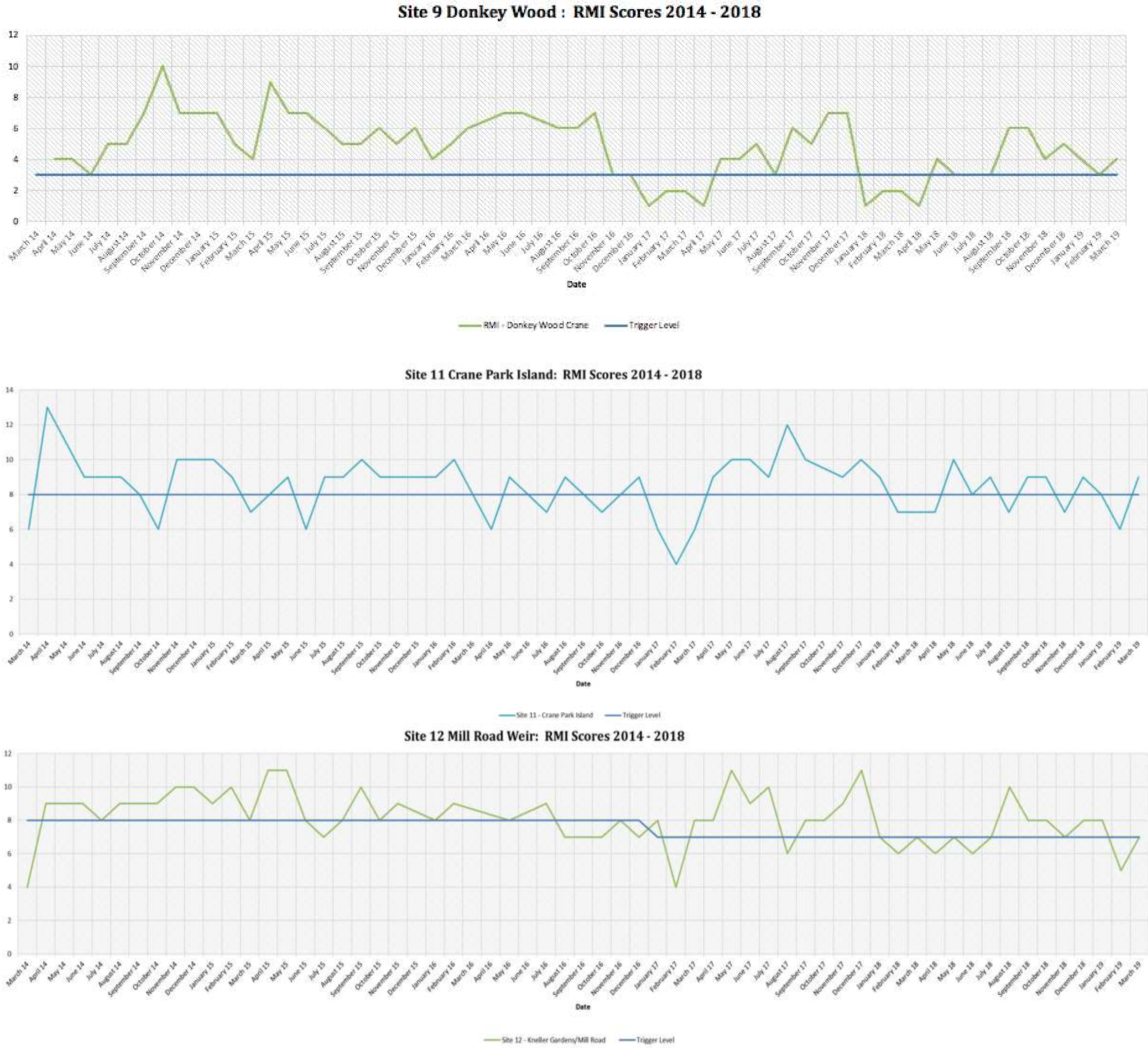


Fig 8. Five years of RMI scores over time for sites downstream of the Heathrow Eastern Balancing Reservoir outfall. Note: the straight blue line on the charts shows the site trigger level

The RMI targets eight species groups in four invertebrate orders; Amphipoda, Ephemeroptera, Plecoptera and Trichoptera. Figure 8 shows the mean counts of the RMI indicator groups found in samples at Crane Park Island, Mill Road, Yeading Brook Meadows and Minet Country Park.

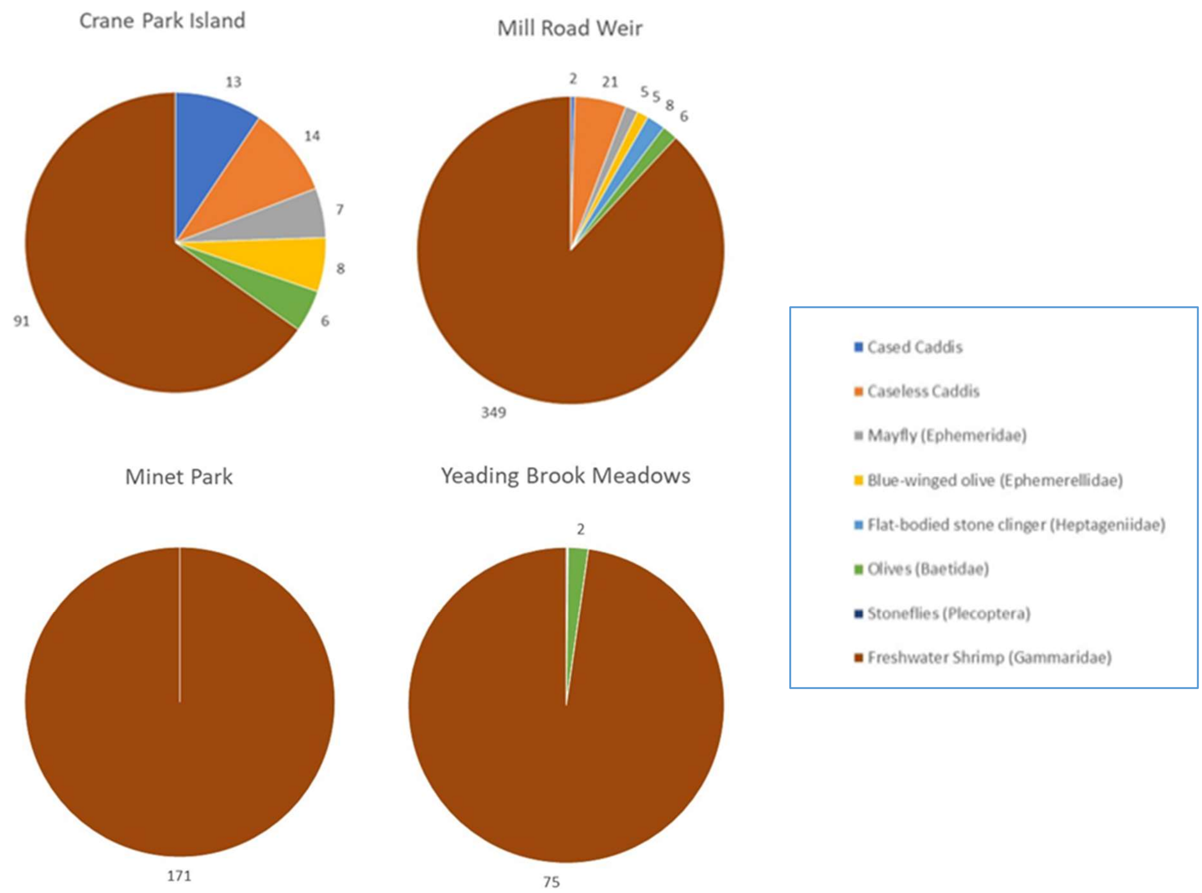


Fig 9. Average number of indicator species groups found at monthly samples in 2019/20 at Minet Park, Yeading Brook Meadows, Crane Park Island and Mill Road.

RMI Data Review

Over 1000 volunteer hours have been spent RMI sampling the river during the six years of the Citizen Crane Project. Considerable value has been derived from the high frequency of monitoring by trained volunteers who, after six years with the project, have honed their invertebrate identification skills and their ability to detect other signs of pollution in the river that might not trigger an RMI breach. The increased monitoring by the Citizen Crane network has, for instance, led to the early detection of many pollution events that have in turn allowed the EA and TW to respond quickly to problems. The volunteers involved in Citizen Crane provide a valuable service to both the Catchment Partnership and EA.

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 purposes.

When reviewing RMI data it is important to keep in mind that complex relationships exist in rivers. Invertebrate communities are not only impacted by water quality but also by geomorphology, water quantity and flow, shading, and sediment quantity and quality. The RMI scores are an indicative guide to the overall ecological condition at each sample site.

Of the RMI indicator groups, only the more pollution tolerant RMI invertebrate groups, Gammarus and Olives, are present in any significant numbers throughout the river. Gammaridae are the only group to be found at all sites and stonefly (Plecoptera) are found at none. In terms of presence and abundance of indicator groups the data show a reasonably consistent distribution pattern over the last six years, with lower scores in the upper catchment. Figure 9 illustrates this with the average composition of two sample sites upstream (Minet Park and Yeading Brook Meadows) compared to the downstream sites (Crane Park Island and Mill Road Weir).

At the low scoring sites in the upper catchment, the normal trigger level procedure built into the RMI system, of reporting breaches to the Environment Agencies National Incident Reporting system, is no longer being implemented. Volunteers have reluctantly accepted, for now, the chronic nature of the problems, and that water quality and geomorphological improvements are dependent on the ongoing long-term works programmes by TW and LB Harrow in particular.

Minet Country Park and Cranford Park, in the middle reaches, consistently score below trigger levels agreed with the EA. Volunteers at Minet Country Park report that about 50% of the time there is an unhealthy smell from the river, and sometimes a sheen or slightly milky look to the river. The site is also becoming progressively more shaded, which may also have an impact on the invertebrate community. The site at Cranford Park is both over-shaded and over-wide – resulting in a heavy sediment load and poor geomorphological character.

Greater invertebrate diversity and abundance, including the only records of true mayfly (Ephemeridae), have been recorded in samples downstream of the upper DNR. 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. 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, whereas they are seen consistently, often in significant numbers (teens of specimens) at the sites downstream of the upper DNR.

As the three sites from Donkey Wood downstream show higher RMI scores, the trigger level breach reporting protocol continues to be followed. Trigger level breaches were reported to the EA from all three of these sites in the winters of 2017, 18 and 19 (as shown in Figure 8). The trigger breaches have been accompanied by an extensive covering of "sewage fungus" on the river bed, which on each occasion was traced back to the Heathrow eastern balancing reservoir outfall in Donkey Wood.

Heathrow Airport Ltd (HAL) has recognised the issue with glycol supporting the proliferation of sewage fungus in the river and have invested £20m in a new glycol treatment system. In the winter of 2018 HAL operated this system for the first time. In February 2019 Citizen Crane volunteers again recorded sewage fungus and trigger breaches at Crane Park Island and Mill Road.

In spring 2019 the Citizen Crane team met with HAL representatives to look at the system and discuss this issue. HAL noted that the system was only 50 per cent operational in winter 2018/19 and the operational team are still learning how best to optimise its use. There is a more detailed review of this issue in Section 6 below.

The overall conclusion from the RMI data is that there is no evidence for improvement in the RMI scores over the six years of monitoring, and some evidence for a reduction in RMI scores, particularly in the upper reaches of the catchment.

Environment Agency commentary* on RMI data

*This section has been provided by the EA, following review of the draft report, and presents an analysis of long term EA data for the River Crane.

The graphs below show the percentage confidence of the five WFD invertebrate status classes calculated by RICT for all surveys that have been undertaken at each of three long-term EA monitoring sites on the River Crane - Crane Park, Hanworth; Crane Above Duke of Northumberland River (Upper); and Yeading Brook, at Watersplash Lane. The class confidences are presented as 100% stacked columns for each survey with a line tracking the total number of scoring taxa (NTAXA) overlaid. The largest coloured segment in a column indicates the probable status of invertebrates at that site during that survey. All statuses other than Good and High are considered as failing under WFD. In addition the overall annual (combined spring and autumn – as would be done for WFD reporting) classification for Crane Park, Hanworth is shown in Figure 10.

Looking at the graphs, it is clear that invertebrates have fared differently at the three sites over the past decades. At Crane Park, Hanworth (the most downstream site), there has been a steady improvement in invertebrate status from Poor in autumn 1991 to High in autumn 2019 with Good/High invertebrate status being achieved for most surveys since autumn 2013. At Crane Above Duke of Northumberland River (Upper) there was improvement from Bad to Poor/Moderate status in the late 1980s and early 1990s which then stayed fairly stable until the most recent autumn surveys in 2014 and 2017, which both achieved Good status, albeit the intervening spring 2017 survey was Moderate. At Yeading Brook, at Watersplash Lane (the most upstream site) there was modest improvement from Bad to Poor status in the early 1990s but it has fluctuated around the Bad/Poor status boundary ever since with no sign of recent improvement.

Overall these datasets indicate that invertebrate status is improving in the lower parts of the river Crane (e.g. Crane Park) whilst the upper reaches (e.g. Watersplash Lane) have shown no recent sign of improvement, likely indicating an ongoing problem with water quality in the upper reaches. The recent improvement above Duke of Northumberland River (upper) is promising, albeit since the spring 2020 surveys were cancelled due to Covid-19 lockdown we do not currently know if the improvement was temporary or if it has been sustained. The WFD status for the waterbody as a whole is driven by all three sites, as such the river Crane as a whole is still considered to be failing for invertebrates due primarily to the poor results at Watersplash Lane.

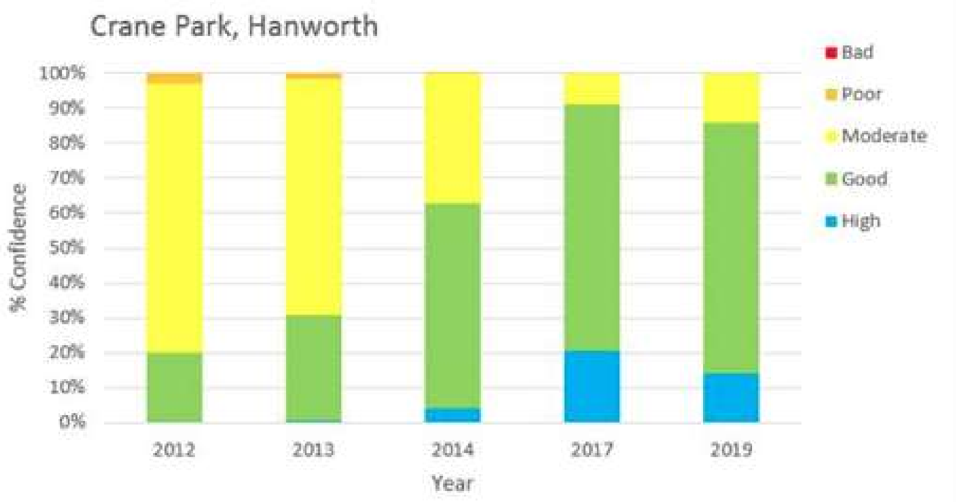


Fig 10. Percentage confidence for invertebrate status from 2012 to 2019*, Crane Park, Hanworth

*Project team note: the river was completely wiped out in 2011 and heavily polluted again in 2013. This change in condition marks a recovery from those two major pollution incidents.

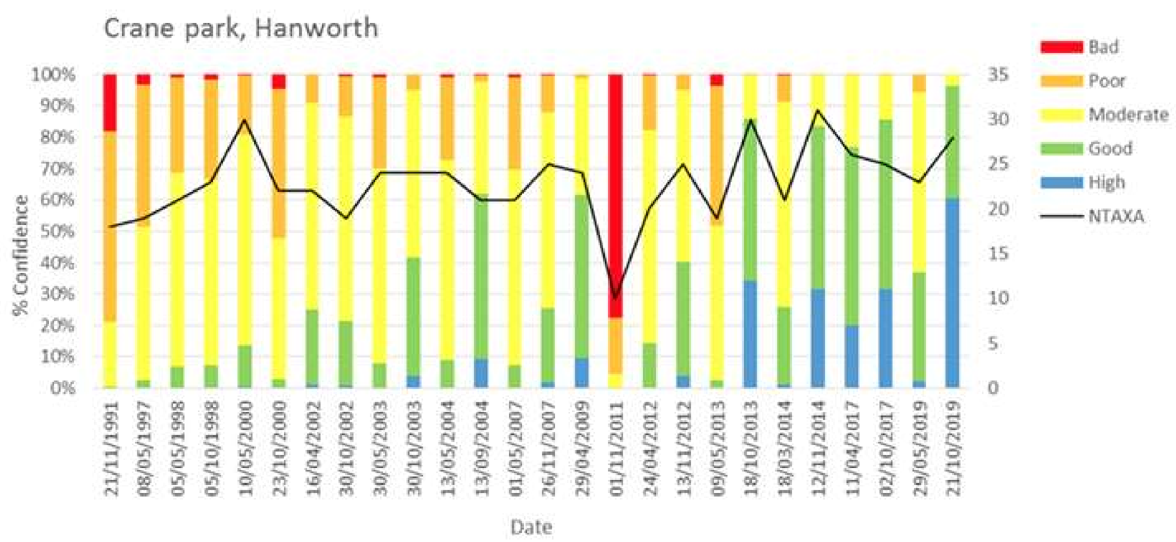


Fig 11. Percentage confidence for invertebrate status 1991 to 2019*, Crane Park, Hanworth

*Project team note: these data show good evidence for a longer term improvement in status over the 30 years from 1990. Recent data, from 2013 onwards, support the conclusions from the RMI data in this report, that the status has not improved over this period.

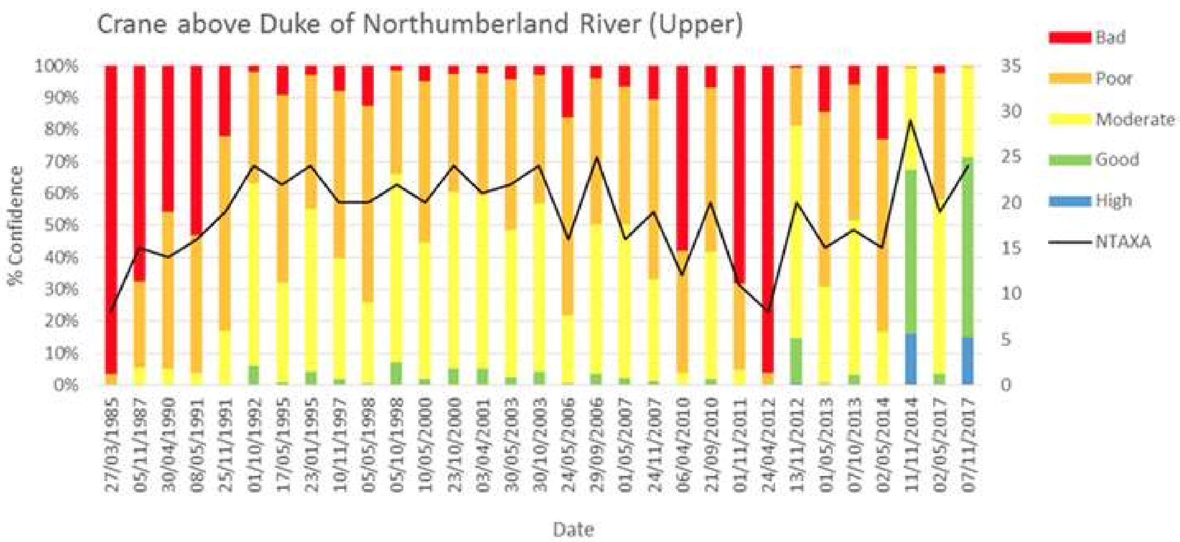


Fig 12. Percentage confidence for invertebrate status 1985 to 2017*, Crane above DNR

*Project team note: these data show an improvement in condition between 1985 and 1992 and a fairly consistent condition of poor to moderate 15 years after this. There is a drop off in condition prior to the major pollution incident in 2011 and a recovery thereafter. Conditions from 2014 and 2017 indicate an improvement to largely good status above the Upper DNR which has not been seen in the data from this project.

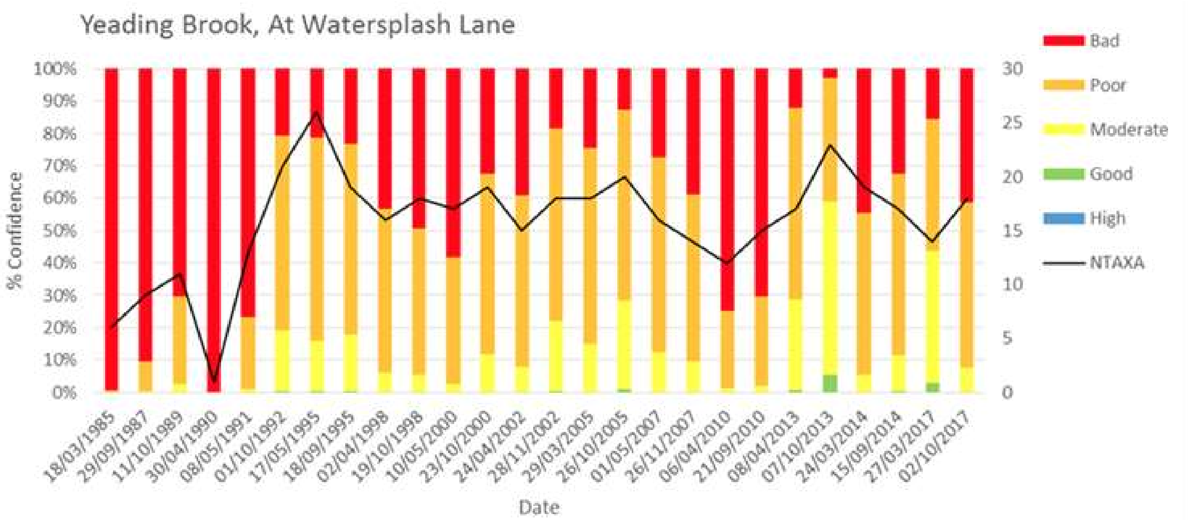


Fig 13. Percentage confidence for invertebrate status 1985 to 2017*, Yeading Brook

*Project team note: These data show initial conditions in the mid 1980's as bad. There was some improvement from 1992 onwards to between bad and poor. The river remained at between bad and poor over the next 25 years.

Table 5, 6, & 7 below shows the latest WFD data for the River Crane from the EA.

Table 5: WFD data for the River Crane for 2013 to 2016

Classification Item	2013	2014	2015	2016	2019
Overall Water Body	Moderate	Moderate	Moderate	Moderate	Moderate
Ecological	Moderate	Moderate	Moderate	Moderate	Moderate
Chemical	Fail	Fail	Good	Good	Fail
Priority substances	Good	Good	Does not require assessment	Does not require assessment	Good
Other Pollutants	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment
Priority hazardous substances	Fail	Fail	Does not require assessment	Good	Fail

All biological quality elements assessed for WFD were failing to meet Good Ecological Status in 2016. Note that the Citizen Crane project team has identified Good Ecological Status as the overall medium-term target for the river

Table 6: Further breakdown of WFD status of Crane according to key ecological and chemical parameters

Classification Item	2013	2014	2015	2016	2019
Overall Water Body	Poor	Poor	Poor	Poor	Moderate
Ecological	Poor	Poor	Poor	Poor	Moderate
Supporting elements (Surface Water)	Moderate	Moderate	-	-	
Biological quality elements	Poor	Poor	Poor	Poor	Moderate
Hydromorphological Supporting Elements	Supports Good	Supports Good	Supports Good	Supports Good	Supports Good
Physico-chemical quality elements	Moderate	Moderate	Moderate	Moderate	Moderate
Specific pollutants	Moderate	Moderate	High	High	High
Chemical	Fail	Fail	Good	Good	Fail
Priority substances	Good	Good	Good	Good	Good
Other Pollutants	Does not require assessment	Good	Good	Good	Good
Priority hazardous substances	Fail	Fail	Good	Good	Fail

Table 7: Reasons for not achieving good WFD status (RNAG) on the Crane

Reason Type	SWMI	Activity	Category	More	Classification Element
RNAG	Point source	Sewage discharge (intermittent)	Water Industry	Details	Phosphate
RNAG	Diffuse source	Urbanisation - urban development	Urban and transport	Details	Dissolved oxygen
RNAG	Point source	Sewage discharge (intermittent)	Water Industry	Details	Dissolved oxygen
RNAG	Point source	Sewage discharge (intermittent)	Water Industry	Details	Ammonia (Phys-Chem)
RNAG	Point source	Misconnections	Domestic General Public	Details	Phosphate
RNAG	Point source	Misconnections	Domestic General Public	Details	Ammonia (Phys-Chem)
RNAG	Diffuse source	Urbanisation - urban development	Urban and transport	Details	Invertebrates
RNAG	Point source	Misconnections	Domestic General Public	Details	Dissolved oxygen
RNAG	Physical modification	Urbanisation - urban development	Urban and transport	Details	Invertebrates

Notes from the Ricardo Macroinvertebrate workshop: March 2020

The citizen Crane project team were grateful for the thorough review of OHES and EA invertebrate data in a workshop led by Peter Moulder of Ricardo on 16th March 2020. A summary of the key findings are replicated below, taken from the workshop slide pack.

The key findings from the workshop were:

- Overall diversity of the River Crane catchment is poor and predominantly composed of pollution tolerant taxa across all sites
- Distinct absence of pollution sensitive taxa (Including Mayflies, Stoneflies, etc.) across all sites
- RICT analysis of HAL and EA data in agreement and show samples typically below Good across the catchment, with the exception of Crane Park. Poorest scores are between M4 and A30 (Cranford)
- There has been an upward trend in WHPT scores in recent years, which is generally good news noting this is moderately strong ($R^2 = 0.61$) and is considered significant ($P << 0.01$)
- PRIMER analysis shows a **clear change** to the macroinvertebrate community 2014 to 2015. Changes towards more grazers (suggesting more biofilm available which can be related to more diffuse nutrient enrichment). Changes away from non-scoring fly larvae (suggesting absence of their habitats)
- RICT, PRIMER and Diversity indices all indicate that diversity is much higher in the lower part of the catchment, commensurate with CC RMI scores in Y5 report
- Data show a clear indication of substantial third-party influences which are likely to affect macroinvertebrate populations, notably in upper catchment.
- Data have confirmed evidence of increased nutrient enrichment, which is nearly always accompanied by organic nutrients, commensurate with CC findings for P
- Evidence of very poor water quality, but unsure if this is dissolved oxygen or 'toxic shock' (it could be both) extensive evidence of this in CC reports, but this has not been confirmed either way.

The OHES team continue to collect data from the middle and lower Crane. The Citizen Crane team will continue to share data and ideas with them – including this report.

6. Wider Investigations and Observations

Overview

This section sets out the findings during Year 6 from other investigations and observations, either directly implemented by the Citizen Crane project team or linked to the project in some way. These include:

1. Outfall Safari: first implemented on the Crane catchment in the summer of 2016 and reported in the Year Three report
2. Road Run-off: recognised as a chronic pollution source in urban catchments such as the Crane
3. SWOP: feedback from Thames Water on their misconnections programme
4. Long term outfall surveys: started by the Citizen Crane team during Year Two and continued for the last four years
5. Pollution reporting: listing pollution events identified and/or monitored during Year Six
6. Improvement works: overview of key ecosystem improvements implemented or proposed for the catchment
7. Mass balance for phosphate and ammoniacal N: first developed in the Year Three report
8. Overall conceptual model for the river system: first developed in the Year Two report and updated every year since

Updates on each of these are set out below.

Outfall Safari

In the summer of 2016 the Citizen Crane project carried out an 'Outfall Safari' for the catchment. An App was developed to record the condition of surface water outfalls using the Thames Water reporting methodology as the starting point. This was then used by volunteer teams, who visited and reported on a total of 230 outfalls and around 35km of river corridor across the catchment over a six week period of relatively low flow. The River Crane Outfall Safari is believed to have been the first volunteer led outfall monitoring project implemented in the UK.

The main findings of the initial Outfall Safari were reported in the Year 3 report. The main developments since this time are as follows:

- All of the outfalls reported as being polluted have been investigated by Thames Water and/or the Environment Agency
- Several discrete pollution issues were identified through this process and have since been rectified
- The Thames Water SWOP was reviewed in the light of the findings of the Safari and those outfalls identified as polluted were either added to the SWOP or put onto a separate priority list for early investigation. These works have now been completed
- The Safari highlighted the grossly polluted upstream culverted channels above Newton Park and Headstone Manor. These findings encouraged TW to switch SWOP resources to focus on these areas, subsequently identifying major misconnection problems
- The Outfall Safari approach has been recognised by Thames Water, and the wider water sector, as being of high value in identifying problems as well as engaging local interested communities in monitoring and improving their river environment
- Thames Water is now working with ZSL and Thames 21 to deliver outfall safaris across their region under a seven year programme of work – which has been mainstreamed into the TW methodology for outfall management
- A second outfall safari was planned for the Crane catchment for spring 2020. This has been postponed due to the lockdown and will now be run in spring 2021. It will re-visit all the outfalls

seen in 2016 and also look at several tributaries and other sources not visited the first time. A comparison will be made between the findings from the 2016 safari and the 2021 rerun

The Outfall Safari has been a very successful programme, reaping considerable benefits in terms of our understanding of the Crane catchment and enabling more targeted responses to specific pollution issues. The approach has subsequently been adopted across the TW region and is receiving interest from other parts of the UK. The 2021 safari will provide a means to review the progress to date and a new baseline for the Smarter Water Catchment programme.

Road Run-off

Road run-off is recognised as being a significant source of chronic pollution in urban areas, including the Crane catchment. Urban drainage catchments generally include run-off from the public highway as well as from properties. Road run-off is a particular problem following extended dry periods, as particulates and oils have built up on the road surface and are then flushed into the river system alongside the accumulated detritus held in the drainage system. The main pollution types from road run-off are sediment, road salt, hydrocarbons and metals. None of these are recorded by the organic and nutrient pollution sampling undertaken by Citizen Crane. They can though be expected to have a significant and chronic negative impact on the ecology of the river and may impact the RMI scores.

The Citizen Crane project does not have a remit to investigate road run-off. However, there have been various initiatives linked to the project, starting in Year Four and continuing over the last two years. Recent progress is set out below:

- ZSL is working with Thames21 and various other parties through the Catchment Partners in London (CPiL) group to develop protocols for the identification and management of road run-off issues across London. The River Crane has been identified as one of the catchments that would trial this approach and several potential trial road outfall sites have been identified for consideration
- Road run-off from the M4 is believed to be a significant pollution source in the middle reaches – particularly as this is the busiest road crossing in the catchment. The project team has engaged with the EA, LB Hillingdon and Highways England with a view to developing an approach to mitigating the impact of this pollution source. A scheme to investigate Frogs Ditch, which receives a large part of this run-off, is currently (July 2020) being finalised with ZSL, LB Hillingdon and the EA
- In September 2018 Frog Environmental appointed a 3 year funded PhD post at Swansea University to investigate road run-off issues. The scope will incorporate site investigation works – likely to include the Crane catchment

The ways in which road run-off interacts with the wider river ecosystem will continue to be an area of interest and investigation for the Citizen Crane project. It is likely to be a key issue during Thames Water's AMP 7, linked to both Smarter Water Catchments work and the associated SuDS programme.

Surface Water Outfall Programme

The Surface Water Outfall Programme (SWOP) is managed by Thames Water's Environmental Protection Team (EPT) and has become a main practical means of identifying and rectifying chronic pollution problems identified through the Citizen Crane project. The EPT works to improve the status of the region's watercourses in partnership with the Environment Agency and other stakeholders. The EPT focus on tracing and removing pollution from foul drainage misconnections to surface water sewers, which are designed to convey untreated rainwater directly into a watercourse.

The SWOP started in Asset Management Plan (AMP) Period 3 and has increased during each period since, up to the latest AMP 6 (from April 2015 to March 2020). TW's representative on the Citizen Crane steering group also helps to manage the SWOP and provides a very helpful interface with it.

The latest data on the progress of the SWOP in the Crane catchment is set out in Table 8 below. This shows a number of outfall SWOPs have rolled over from AMP 6 into the AMP 7 programme

Table 8: Thames Water Summary of SWOP: AMP6 and AMP7 to date (September 2020)

	Outfalls	**Misconnected Properties Identified**	**Misconnected Appliances**	**Misconnected Properties Rectified**	**Outstanding Misconnected Properties**
AMP7 SWOP – Live projects	6	136	370	114	22
AMP7 SWOP – Signed off by the EA	0	0	0	0	0
Waiting List	8	0	0	0	0
Total	**14**	**136**	**370**	**114**	**22**
AMP6 SWOP – Signed off by the EA	39	470	1278	455	15

The following points are made in relation to these SWOP data:

- The SWOP is considered to be having a major beneficial impact upon the river system. 39 outfalls have been signed off and a further 6 are in progress with 8 on the waiting list. A total of 569 properties have had misconnections rectified through this process, involving over 1500 appliances
- Calculations presented in the Year 3 report indicated that the SWOP may remove in the order of 0.1 to 0.2 kg/day of P and AN from the river system for each significantly improved outfall
- In total this would amount to something in the order of 6 kg/day of P and AN over the five year AMP6 programme. This is the same order as the remaining loading within the river system
- The impact of the SWOP has increased in Years 5 and 6. This is due in part to the change in focus to the upper reaches of the catchment where major misconnections have been found, including housing blocks and school buildings, each equivalent to many individual properties
- One factor which is not yet well understood is the rate at which new misconnections are being added into the system. Without these data it is not possible to assess the net benefit of the SWOP – or whether the SWOP is even keeping pace with new misconnections. It is noticeable however that the major removal of misconnections has not as yet led to any equivalent change in the water quality or ecological value of the river system.
- Through this project Citizen Crane has requested TW and/or others undertake further research into the rate of new misconnections. We were very pleased to note that TW have recently (September 2020) committed to working in ten boroughs across London (including LB Hillingdon, LB Ealing and LB Hounslow in the Crane catchment) to visit up to 1000 properties that have been subject to permitted development and see if they are misconnected. This work could help to understand the rate of new misconnections across the catchment
- Around 90 per cent of property owners appear to be rectifying their misconnection issues within a short period of receiving notice from the TW SWOP teams. If property owners fail to rectify their misconnections, cases are being handed over to the Environmental Health Office (EHO) of the relevant Local Authority for enforcement. TW alerted the Citizen Crane project team to the fact that two councils had stopped responding to TW requests for support. These councils were

approached by the project team and one has subsequently renewed active involvement whilst the other has stated it is not able to do so for financial reasons. This matter is still being assessed by TW and the project team remains available to engage with the EHO teams and the wider council as appropriate

TW's proposals for AMP 7 set out a baseline SWOP for the five years starting in April 2020 equivalent to the SWOP total of AMP 6 (500 SWOP outfalls), with an aspirational target of 50 per cent more SWOP outfalls (750 SWOP outfalls) addressed over the region. It is anticipated this will include further measures on the River Crane. Outfall will be identified for the SWOP through the Outfall Safari, proposed for spring 2021.

Long Term Outfall Surveys

The Citizen Crane project started to monitor the condition of selected outfalls in the lower reaches of the catchment in April 2016. The survey has continued every month since, with three SWOP outfalls being ever present and others added or removed as problems emerged and were then resolved.

Assessments are made of the condition of each outfall every month, including the flow, the amount of sewage fungus present on the apron and any evidence (visual or olfactory) of pollution. The main findings are noted below:

- In each case the SWOP has considerably improved the quality of water emerging from the outfall
- In each case there has been some evidence of residual pollution – at least on an occasional basis – with flare ups of sewage fungus. TW has undertaken several investigations of these outfalls in response and identified further misconnections (either new or not identified on the initial SWOP)
- One outfall (Hospital Bridge Road) has proved particularly challenging. There have been several investigations in the last two years following formal sign off, due to evidence of misconnections being seen on a regular basis. Finally, following the threat of Local Authority enforcement action at a specific property in spring 2020, it did appear problems with this drainage catchment had been fully rectified. However, in July and August 2020 there were two further reports of pollution plumes from this outfall
- The outfalls are also occasionally the source of other pollution problems. These include reports of hydrocarbon pollution, paint, jet washing of concrete and other occasional problems witnessed and/or reported over the last year. This illustrates the risks associated with the surface water drainage system, due to the deliberate or accidental disposal of pollutants
- The project team continues to publicise the problems of misconnections and disposal of pollutants to the drainage system, as well as links to good practice information, through our social media platforms. These have been widely shared and appear to have grown the local public awareness of these issues

The outfall monitoring data set is available to TW and the project team and may prove of value as a longer-term record of the performance of outfalls that have been through the SWOP.

These data indicate the problem of new misconnections being added to the network. There are no data available as yet to assess the rate at which new misconnections are being generated (although the site visits proposed by TW to 1000 permitted development sites should help to better understand this). Informal observations though indicate that around 1 in 50 houses in any suburban West London street has scaffolding and/or a skip outside at any time, indicating extensive refurbishment taking place. Over a year this translates to around 1 in 15 houses being extensively refurbished, including some new plumbing works. Over a typical drainage catchment of 600 houses this equates to around 40 houses per annum.

The observations to date suggest that one or more of these refurbished properties is being misconnected, leading to new pollution issues, over the two-year monitoring period. Scaling this up to the Crane catchment as a whole (with say 100,000 properties) would suggest in the order of 100 new misconnections per annum being added to the drainage catchment. This rate compares closely with the total of 565 properties remediated during the five years of AMP 6 and indicates that the SWOP may only be keeping up with the rate of new misconnections.

This is only an initial first order calculation but may indicate why the SWOP is not seeing a major reduction in pollution issues in the catchment to date.

Pollution Events

Citizen Crane volunteers visit 16 sites along the river every month and are the eyes and ears of the project for these sites. The wider public are visiting the river in greater numbers than ever, with several thousand people seeing the river from parks, open spaces and bridges every day. We are encouraging volunteers and the wider public to report any pollution problems identified during their site visits - to both the EA hotline 0800 807060 and the TW incident hotline on 0800 316 9800. Broader issues around water quality and the condition of the river at sites are reported to the project steering group as well as contacts in the relevant local authority. This approach has resulted in a rapid response by the EA and/or TW to a number of pollution incidents, as well as actions to clear up littering and fly tipping for example through the relevant local authority.

A large number of pollution events have been identified and monitored through the Citizen Crane project and reported in previous annual reports. The pollution incidents identified over the last year include:

- Sewage pollution problems at Headstone Manor – seen more than once over the winter 2019/20
- Sewage pollution problems at Newton Park – ongoing at the time of writing (August 2020)
- Hydrocarbon pollution in the middle catchment – traced by the EA to an outfall near Minet Park (investigation ongoing)
- White milky silt pollution for several days in the lower Crane in summer 2020. Traced to an outfall at the Butts Farm Estate and potentially linked to housing refurbishment

In Year 5 there was a major pollution problem linked to glycol-enriched discharges from Heathrow Airport, following a short period of cold weather in February and March, which impacted the RMI scores throughout the downstream catchment. During Year 6 the new Heathrow treatment plant is understood to have come fully on line. There were no sewage fungus problems reported in this reach this winter. However, the temperature also rarely dropped below freezing, and the glycol use was probably much less than in previous years, so this treatment plant has still to be properly tested. Note that the EA is currently developing the discharge consent for the treatment system with Heathrow Airport Ltd.

Improvement Measures

Crane Valley Partnership members have been delivering a large number of river improvement measures over the last ten years and more are planned for the next five years. A summary of the key measures is provided below:

1. A large number of small and medium sized river improvement schemes have been implemented across the middle and lower reaches of the catchment since the major pollution incident in the river in 2011. More than 5 km of river and marginal habitat improvements have been delivered in total and it is considered that these will have had a cumulative beneficial impact on the river ecosystem. These improvements are also likely to have enhanced the capacity of the river to deal with pollutant inputs and operate as a self-cleaning system – by narrowing the river channel, introducing more vegetation, resulting in more oxygen in the system and more effective zones for

sediment capture and scouring. Minor repair works only have been undertaken in Year 6, although some larger scale works are planned for the next two years (see 6 below).

2. A major wetland scheme was completed in Newton Park in the summer of 2018. This is being monitored by the Citizen Crane team, as reported in Section 4 above. The scheme is currently effective in reducing the organic loading downstream of the site. There is though some concern about the amount of hydrocarbon rich sediment which is building up in the wetland and some further works are planned by LB Harrow to deal with this.

3. Another major wetland scheme is currently under construction at the Headstone Manor site at the top of the other tributary of the river. The project team intend to implement further monitoring at this site to assess its effectiveness.

4. A third wetland scheme has been constructed on the Elephant Park site by LB Hillingdon in 2019. This is on a smaller scale than the two noted above and could be a further opportunity for monitoring the effectiveness of this type of scheme.

5. There remain large areas of the river system, particularly in the middle reaches, which are not functioning well - where the geomorphology is poor and the river is heavily shaded by vegetation. The RMI scores in the middle reaches are generally very low and this is considered to be largely due to poor geomorphology. Whilst there has been further positive discussion of remediating these areas, there has been little or no practical action on the ground, over the last year.

6. There are two significant river restoration projects planned for next year - a field trial for the restoration of the Lower Crane planned for the Twickenham Rifle Club site, and marginal habitat creation along several hundred metres of toe boarded river at the Little Park site.

7. Two photographs of the same part of the lower Crane, from 1980 and 2020, are shown in Appendix C of this report as part of the discussion on geomorphology. The first photograph illustrates how the river in 1980 was heavily engineered by dredging, over widening and toe-boarding. The second photograph shows how this part of the river has narrowed and vegetated over the last forty years, becoming a much more natural and healthy looking river in the process. This change has not been managed and has actually resulted from a cessation of engineering style management.

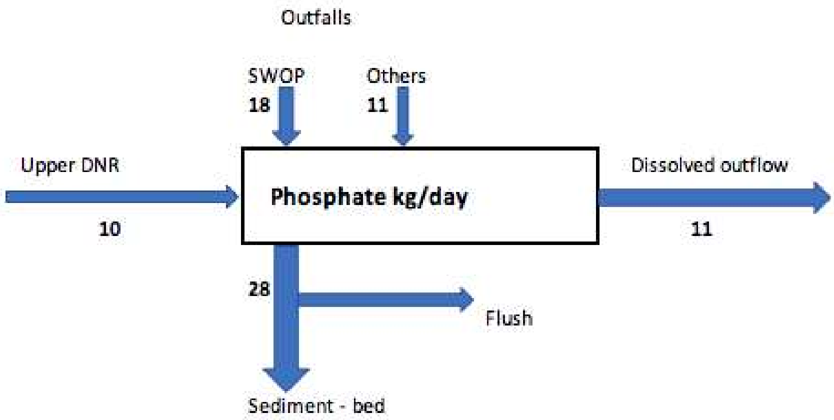
8. Evidence from other sites along the lower Crane indicates that the removal of heavy shading is a key control which allows marginal vegetation to flourish and the river to narrow. The best solution to some overly engineered river sections may therefore be to remove any excess shading and allow the river to recover itself.

9. The Thames Water Smarter Water Catchments project started in April 2020 and is anticipated to include further river enhancements and SUDS schemes. The project aims to refresh and update the existing Catchment Plan so that on the ground work can commence from April 2021. The Citizen Crane team will be included as an active part of this project, to provide real time monitoring and feedback to the programme, and help to optimise its effectiveness.

Conceptual Model of the River System

The Citizen Crane Year Two 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.

In the Year Three report this conceptual model was reviewed and updated. The Year Three report also presented an initial mass balance for P and AN, considering sources, sinks and outflows. A conceptual drawing of the mass balance is presented in Figure 14 below.



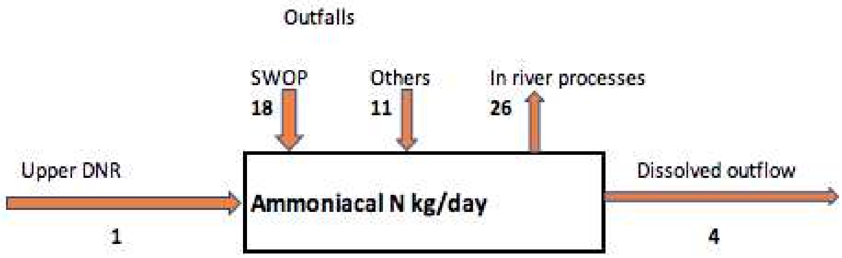


Fig 14. Conceptual model for mass balance of P and AN on the River Crane

It is anticipated that the conceptual model and this mass balance will be reviewed and updated as part of the Smarter Water Catchments programme. It is worth noting at this stage that:

- Although the SWOP has removed a large pollutant load from the river system – this has not had a major impact on the amount of dissolved pollutant that continues to flow through the system
- One possible explanation is that there are new misconnections being added to the system all the time and these are to some significant degree cancelling out the benefits of the SWOP. This is a possibility, though there is only circumstantial evidence to support it at present
- Another is that the impact of other organic pollutant sources, referred to by the broad term of “other network issues”, is much larger than initially suspected. There is some evidence, from pollution incidents in Newton Park and Headstone Manor over the last year that network problems are greater than previously thought
- A third explanation may be the impact of the inertia within the storage of the system. For example, a reduction in inputs may be balanced by less sediment uptake of P or catchment breakdown of ammoniacal N for example. Some of the estimated 50 tonnes of P within the catchment’s river sediment may also be released as inputs reduce. Under this scenario it may take a number of years of reduced inputs for the benefits to properly display themselves in the river system

There are some encouraging signs at a local level of the beneficial impacts of both the SWOP and the new wetland systems. The most encouraging sign though may be the capacity of some sections of the river in both the middle and the lower reaches to be self-cleansing – with loadings of P and AN reducing in some or all years of monitoring. Further understanding of the processes that generate this self-cleansing potential could be of particular value when identifying options for river improvement.

The Year 5 report included an assessment of the variables that impact on the ecosystem of the river. This work has been developed during Year 6, and a total of 18 variables have been identified and assessed. This work is presented as Appendix C to this report.

7. Stakeholder Engagement

Volunteers

Citizen Science volunteers continue to be the mainstay of the project, undertaking the main data collection and monitoring tasks at 16 locations across the catchment. Volunteers are also playing a key role in the logistics of the project: water quality sample collection is managed by volunteers and they are also involved with monitoring surface water outfalls and reporting their condition.

It remains essential to engage the volunteer teams as the project develops, particularly into the Smarter Water Catchments project from April 2020. Thames21 have become more involved with the project from Year 5 onwards, particularly in the upper catchment. It is anticipated that their reach and volunteer base will prove valuable as the project develops.

Local Communities

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. There are regular messages broadcast through social media about the project findings. One guided walk has been held over the last year, introducing local people to the project.

Thames Water

Thames Water has committed to supporting the Citizen Crane project up to April 2025 through the Smarter Water Catchments programme. Thames Water is a key partner on the steering group and has acted positively with developments to the SWOP and other aspects of its programme in response to project findings. Thames Water is also leading a working group on the long term management of Mogden Sewage Treatment works, which serves the whole of the Crane catchment. The work of this group will interact with the Smarter Water Catchments programme and Citizen Crane.

Local Authorities

Generally, the relationships with local authorities and the project are positive and there has been particularly strong engagement with LB Harrow regarding their ambitious programme of improvements in the upper reaches of the catchment. From Year 4 onwards there have been problems with at least one local authority EHO department that had stopped engaging with TW on the misconnections programme. The TW programme for AMP 7 is exploring approaches to resolving this issue with EHOs at a wider regional level.

Academia

In the first years of the project there were several post graduate research projects delivered in partnership with Citizen Crane. There have been no research projects delivered in the last three years. However the team remains willing to engage with academics around the use of the project data set and the catchment for related research purposes.

One major potential development is the Swansea University PhD research project, looking at road run-off problems, which is likely to engage with Citizen Crane as part of the research field work. Further PhDs have been discussed that will engage more closely with the project – though none have yet come to fruition.

The project has also been engaging with the Project Camellia team. This is a major five year work programme, including several university research teams and focused on improving urban resilience to water related issues. One key focus of the programme is the Mogden surface water drainage catchment, incorporating the Crane and Brent catchments. It is hoped that this academic resource will be linked into the Smarter Water Catchments project over the next few years. There has been initial promising collaborative work looking at the flow records for the river (as shown in Appendix B).

Wider World

The project continues to engage with the Catchment Partnerships in London (CPiL) group and has contributed to CPiL position papers on misconnections and road run-off in the last two years. There are a number of initiatives across London that are using the findings of the Citizen Crane project to inform their work programmes.

Citizen Crane was presented as part of the virtual London National Park City celebrations in July 2020.

A Citizen Crane paper was due to be presented to the River Restoration Centre annual conference in April 2020 before it was postponed.

8. Future Project Strategy

The Citizen Crane project will continue during the five year AMP 7 period and has received a pledge of funding from TW until March 2025. The project will work in partnership with the Smarter Water Catchment programme during this period. This report has been expanded to reference all the work undertaken by the Citizen Crane project over the last six years and is intended to act as a baseline view of the conditions of the river at the start of the Smarter Water Catchments programme.

In the short term the Citizen Crane team will:

- Engage with the Smarter Water Catchments team regarding the findings of the six year Citizen Crane programme and how the work over the next five years can best be integrated into the Smarter Water Catchments programme
- Update the Citizen Crane monitoring network in light of priorities over the next five years
- Consider how best to assess the value of wetlands and SUDS schemes as part of a modified programme
- Engage with volunteers about any proposed programme – and assess their interest and enthusiasm for this. Work up a strategy to engage new volunteers as necessary
- Continue with a modified form of the Citizen Crane programme
- Undertaking a second outfall safari in spring 2021
- Continue liaison with teams developing road run-off works so as to interface with these work streams as they move forwards
- Continue exploration of other opportunities – including Project Camellia for example and Cranford Park HLF project – and how these will link into the programme

The Citizen Crane project team is working with TW and the CVP Development Manager to support the Smarter Water Catchments programme. The wider team is also liaising with the other Smarter Water Catchment pilot project teams in the River Chess and River Evenlode, to ensure there is a consistent and optimised approach across the three Smarter Water Catchments.

The Smarter Water Catchment project is being delivered by Thames Water in AMP 7, from April 2020 to March 2025. In discussion, TW has indicated that these are medium to long term activities, and the programme is planned to extend through AMP 8 (i.e. to 2030).

The Citizen Crane team's over-arching aims and hopes for the Smarter Water Catchments are set out below. This list was shared with TW, at the start of the SWC programme, for discussion and development:

- The River Crane achieves Good Ecological Status
- The river is more resilient, by stopping pollution at source or creating sustainable downstream solutions, that intercept and remove pollution from the surface water drainage system
- The river and its surrounding flood plain are developed as a linked network of habitats, recognised as being of high value for wildlife and local people
- River habitats are created and managed in a sustainable way with a high degree of involvement from the local communities and other interested parties
- Local communities, numbering over half a million people in total, have an enhanced understanding of the value of the River Crane environment and their roles in managing and enhancing it

The Citizen Crane team has developed a list of activities for the AMP 7 period, which would engage the team with the wider Smarter Water Catchment objectives. This list has also been shared with TW and is set out below for discussion and development.

Table 9: Summary of potential Smarter Water Catchment activities developed by Citizen Crane

	Activity	Delivery options	Timescale
1	**Catchment[1] investigations and action**		
1.1	Evaluate the scale of contribution of the following to AN and P loading, with a focus on the upper (and possibly middle) catchment • misconnections • network defects • missing surface water caps in dual manholes • blockages • CSO's This is envisaged as a desktop study that involves collating all TW investigation records in the Harrow and Hillingdon drainage catchment. In addition to some in depth 'sub sampling' of a proportion of drainage catchment areas where systematic lifting of manholes and network investigations will give a representative snapshot of conditions and issues affecting the upper drainage catchment.	Thames Water investigation	2021
1.2	Detailed water quality investigation in the upper (and possibly also middle) catchment to identify the surface water drainage channels that bring the highest concentrations of nutrients into the river. This would be done using SONDES to systematically monitor WQ in culverts, small tributaries, major outfalls and the main river. The findings of this study will help feed into the identification of pollution hotspots	Smarter catchments project officer SWCPO*	2021
1.3	Make investment in the upper (and middle?) catchment drainage network based on the findings of 1.1 and 1.2	TW	To 2025
1.4	Map the surface water drainage network (particularly in Harrow and Hillingdon – but possibly looking at other boroughs subject to SuDS funding) and model urban diffuse pollution 'hotspots' – risk-based approach	Consultants/TW steered by citizen crane	2021
1.5	Scope options and assess the feasibility of constructing wetlands within the identified hotspots	SWCPO working with key boroughs	2021
1.6	Build wetlands, designed to improve the river condition as well as to optimise other benefits	SWCPO working with key boroughs	2021-2025
1.7	Monitor and report on effectiveness of wetlands – by development of the CC monitoring system. Note: this is already being implemented on the Newton Park system installed by LB Harrow. This work needs to include the accumulation of sediments and the long term maintenance requirements of the sites.	SWCPO	2018 to 2025
1.8	Undertake broad spectrum analysis of chemicals in the river – at Spider Park and elsewhere subject to unexplained ecological failures revealed by RMI. Interpret results in relation to ecological impact and report	SWCPO	2021

[1] The 'Smarter Water Catchments Project Officer' is likely to be hosted by CVP. This officer will report to a steering group formed through the SWC programme and liaising with the Citizen Crane team.

2	**Misconnections**		
2.1	Calculate the amount of AN and P removed by the SWOP in AMP 6	Thames Water	2021
2.2	Develop and implement a method of data collection and analysis to enable a calculation of the rate of new misconnections in the catchment. Possibly identify representative sub catchments to study for this	Thames Water	2021
2.3	Second catchment Outfall Safari. Review the findings from OS 1 and 2 and use these and other data to feed into the overall picture of catchment development	ZSL and SCPO	2021
2.4	SWOP works to remove sources of pollution, with reference to the outfall safari outputs	TW	On-going
2.5	Third outfall Safari	ZSL	2025
2.6	Work with LA EHOs to develop an improved method of dealing with misconnections that are not initially rectified	TW and LAs	2020 and ongoing
3	**Road Runoff Pollution**		
3.1	Use the road pollution hotspots map and action plans produced by ZSL, T21 and Middlesex Uni to scope and check feasibility of interventions at priority transport outfalls in the catchment	SWCPO	2021
3.2	Engage with LAs and others to assess the scope of the gutter and gully pot maintenance regime	Third party project linked to SWCPO	2022
3.3	Work with TFL and HE to install pollution intercepting interventions at these outfalls – if necessary, use Thames Water funding as match to encourage a collaborative approach	SWCPO working with HE and TFL	2021-2025
4	**Citizen Crane**		
4.1	Review the data collection approach to date and the volunteer teams undertaking these works. Develop an approach for the next five years	CC Team	2020
4.2	Identify any wider roles and opportunities envisaged by TW and other project partners	CC Team working with SWCPO	2020
4.3	Develop and implement training, recruitment and other support activities to allow these volunteer teams to meet their objectives	CC Team working with SWCPO	2021-2025
4.4	Agree and implement the appropriate support structure for CC team for the next five years	CC Team working with SWCPO	2020
5	**Crane Valley Partnership**		
5.1	Help co-ordinate activities with partners to meet SC and wider CVP objectives	CVP with SCPO and others	2020 to 2025
5.2	Engage with the wider community to enhance the value and appreciation of the Crane catchment by developing the role of the community in the SC and CVP programmes	CVP with SCPO and others	2020 to 2025

5.3	Co-ordinate an appropriate steering group structure to oversee the work programmes	CVP with CC, SWCPO and others	2020 to 2025
6	**Other Related Activities**		
6.1	Engage with Project Camellia and other academic and third party initiatives as a means of securing technical expertise in various aspects of the project	SWCPO, CC, TW et al	2020 to 2025
6.2	Review the data for pollution incidents held by TW, EA and others and report	SWCPO	2020
6.3	Continue engagement with Heathrow around the effectiveness of the treatment system and the potential for augmenting low flows in the river	SWCPO and CC team	Ongoing
6.4	Technical review of the potential impact of sediment on water quality and ecological value of the river system	External, managed by SWCPO	2020/21
6.5	Technical review of the impact of meteorological variability on the ecological value of the river system	External, managed by SWCPO	2020/21
6.6	Review of the Urban River Survey (URS) data set as a baseline for the geomorphological and habitat value of the river system (as recorded in 2016)	Natural Capital Consultants SWCPO	2020/21
6.7	Support to geomorphological and habitat enhancement measures throughout the river system – including monitoring of the impact of the enhancements and ongoing maintenance measures	CVP and SWCPO	Ongoing
6.8	Annual reporting on outcomes	CC and SWCPO	Ongoing
6.9	Annual forum to review outcomes and programme for the following year	CC and SWCPO	Ongoing

These activities have been identified by the Citizen Crane teams as priorities to improve water quality in the Crane catchment. There are overlaps, such as the installation of wetlands, and positive feedback loops that can be achieved, by hydro morphological and ecological enhancements, and improving community access. It is essential however to focus funding on removing sources of pollution into the river. Highest priority solutions are those that stop pollution at source and second are end of pipe solutions that capture pollution between the surface water drainage network and the river.

The SuDS programme is anticipated as being a major driver for improvement in the catchment – subject to funding being allocated to CVP partners. The Citizen Crane team has developed a list of issues and objectives for any SuDS programme and this can be seen in Appendix D to the report.

TW envisage that the first year of the programme will be invested in project development with the main implementation period starting from April 2021.

9. Summary and Conclusions

Six years of Citizen Crane monitoring by teams of volunteers has shown that, despite considerable efforts to reduce pollution from misconnections and other incidents (by Thames Water, the Environment Agency and others), the water quality in the river has not significantly improved and remains poor in many places.

High concentrations of sewer-related pollutants are present, particularly in the upper and middle reaches. Also, there are high levels of heavy metal and hydrocarbon contamination in the sediment throughout.

The ecology of the river is constrained in many places by engineered river channels with a lack of flow variation, low flows and siltation.

There are signs of improvement, particularly at a local level, where the installation of wetland schemes for example has created enhanced habitats and reduced pollutant loads to the downstream catchment.

The main challenges identified, along with improvements to date in some areas, are as follows:

- Sewer network: structural failure, blockages and/or misconnected properties result in organic waste and nutrients discharging to the river. The SWOP has been successful in removing loadings but much work still needs to be done over the next five years
- Poor habitat diversity and diminished flood plain in many parts of the catchment reduce the river's capacity to purify itself and support wildlife. Over widened channels - exacerbated by low flows at times - lead to excessive siltation, which smothers the riverbed habitats of animals and plants. The improvements to the lower catchment appear to have enhanced the ecosystem and its capacity for self-cleansing by removing organic pollution
- Urban run-off: carries pollutants such as heavy metals and hydrocarbons from roads and other hard surfaces into the river where they accumulate in the silt. The project team is working alongside other organisations that have developed plans for interventions to reduce this problem over the next five years
- Urban river systems are complex and there is to date only a partial understanding of how the combinations of many variables control the condition of the river. It is hoped that Smarter Water Catchments, and working alongside academic and professional partners, will greatly enhance the understanding of the system over the next five years

The Citizen Crane programme is well placed to:

- Continue to collect and analyse the base data that helps to assess the value of the river ecosystem
- Identify and report specific pollution problems
- Liaise with key partners to help optimise interventions through the Smarter Water Catchment programme and other work programmes
- Engage local communities, promoting the value of the river system and their role in enhancing it

This work will be refined and developed, in consultation with volunteers and partners, over the next five years with the overall aim of achieving good ecological status for the river system.

Appendices

Appendix A: Water Quality Data

Site 1 - Headstone Manor	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.39	0.40	0.34	0.58	0.40	0.26	0.39
Ammonia Concentration Median (mg/l)	0.33	0.76	1.06	2.78	1.38	1.15	1.24
Phosphate Loading Median (Kg/day)	0.60	1.02	1.19	1.54	0.87	1.56	1.13
Ammonia Loading Median (kg/day)	0.79	1.94	3.79	6.88	2.48	6.13	3.67
Cumec Median	0.03	0.03	0.05	0.03	0.02	0.05	0.04
Number of Flow Data Returns	9	10	9	5	12	11	9

Site 2 - Roxbourne Park	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.36	0.46	0.34	0.46	0.29	0.22	0.35
Ammonia Concentration Median (mg/l)	0.22	0.13	0.15	0.13	0.12	0.12	0.14
Phosphate Loading Median (Kg/day)	2.33	2.85	2.06	2.72	1.87	3.02	2.48
Ammonia Loading Median (kg/day)	1.70	4.20	1.51	1.34	0.73	1.24	1.79
Cumec Median	0.07	0.07	0.08	0.12	0.07	0.12	0.09
Number of Flow Data Returns	10	7	10	10	11	11	10

Site 3 - Ickenham Marshes	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)		0.48	0.27	0.25	0.28	0.18	0.29
Ammonia Concentration Median (mg/l)		0.56	0.22	0.13	0.22	0.10	0.25
Phosphate Loading Median (Kg/day)		0.43	1.50	1.05	2.49	3.72	1.84
Ammonia Loading Median (kg/day)		0.60	1.17	0.55	1.14	3.10	1.31
Cumec Median		0.01	0.06	0.04	0.08	0.13	0.06
Number of Flow Data Returns	0	6	7	6	11	8	6

Site 4 - Newton Park West	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.31	0.38	0.39	0.54	0.34	0.23	0.36
Ammonia Concentration Median (mg/l)	1.23	1.68	2.13	2.12	0.59	0.64	1.40
Phosphate Loading Median (Kg/day)		0.50	0.47	0.70	1.18	1.63	0.90
Ammonia Loading Median (kg/day)		1.29	1.64	3.95	3.16	5.24	3.06
Cumec Median		0.02	0.01	0.03	0.03	0.10	0.04
Number of Flow Data Returns	0	5	8	3	7	6	5

Site 6 - Yeading Brook Meadows	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.22	0.33	0.26	0.35	0.28	0.21	0.27
Ammonia Concentration Median (mg/l)	0.10	0.14	0.20	0.17	0.21	0.08	0.15
Phosphate Loading Median (Kg/day)	4.47	4.49	5.68	5.56	1.47	2.35	4.00
Ammonia Loading Median (kg/day)	1.66	2.02	4.77	2.18	1.32	0.92	2.14
Cumec Median	0.29	0.16	0.24	0.22	0.07	0.08	0.18
Number of Flow Data Returns	9	11	12	9	12	6	10

Site 7 - Minet Park	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.21	0.24	0.20	0.24	0.21	0.26	0.23
Ammonia Concentration Median (mg/l)	0.48	0.29	0.30	0.25	0.23	0.15	0.28
Phosphate Loading Median (Kg/day)	6.77	4.43	3.78	4.41	4.29	6.09	4.96
Ammonia Loading Median (kg/day)	18.20	5.78	5.32	5.76	5.75	2.79	7.27
Cumec Median	0.27	0.21	0.18	0.27	0.24	0.20	0.23
Number of Flow Data Returns	1	11	11	11	12	10	9

Site 8 - Cranford Park	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.18	0.18	0.17	0.18	0.16	0.14	0.17
Ammonia Concentration Median (mg/l)	0.21	0.26	0.34	0.27	0.17	0.14	0.23
Phosphate Loading Median (Kg/day)	6.95	7.47	4.92	4.83	1.28	3.84	4.88
Ammonia Loading Median (kg/day)	8.79	8.26	5.47	5.18	1.67	4.64	5.67
Cumec Median	0.43	0.49	0.42	0.41	0.14	0.37	0.38
Number of Flow Data Returns	10	4	5	12	12	12	9

Site 9 - Donkey Wood	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.13	0.15	0.15	0.18	0.16	0.14	0.15
Ammonia Concentration Median (mg/l)	0.08	0.08	0.10	0.05	0.09	0.10	0.08
Phosphate Loading Median (Kg/day)	6.93	5.51	3.73	3.45	3.67	5.58	4.81
Ammonia Loading Median (kg/day)	4.89	3.55	1.69	1.25	2.25	6.43	3.34
Cumec Median	0.55	0.35	0.28	0.29	0.27	0.58	0.39
Number of Flow Data Returns	10	11	11	11	12	11	11

Site 10 - Donkey Wood (DNR)	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.20	0.21	0.18	0.22	0.23	0.26	0.21
Ammonia Concentration Median (mg/l)	0.04	0.04	0.07	0.05	0.04	0.05	0.05
Phosphate Loading Median (Kg/day)	7.72	9.48	4.03	4.10	4.58	8.50	6.40
Ammonia Loading Median (kg/day)	1.50	1.26	1.75	0.93	0.62	1.21	1.21
Cumec Median	0.53	0.46	0.29	0.22	0.26	0.35	0.35
Number of Flow Data Returns	6	10	11	9	12	11	10

Site 11 - Crane Park Island	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.17	0.18	0.18	0.19	0.18	0.22	0.18
Ammonia Concentration Median (mg/l)	0.03	0.04	0.06	0.12	0.10	0.08	0.07
Phosphate Loading Median (Kg/day)	16.61	13.66	13.64	9.46	7.96	15.63	12.83
Ammonia Loading Median (kg/day)	2.12	2.21	3.68	3.80	3.44	4.68	3.32
Cumec Median	1.15	0.76	0.89	0.60	0.47	0.80	0.78
Number of Flow Data Returns	10	12	12	10	12	10	11

Site 12 - Kneller Gardens/Mill Road	Y1	Y2	Y3	Y4	Y5	Y6	AV Y1-6
Phosphate Concentration Median (mg/l)	0.18	0.16	0.18	0.19	0.18	0.17	0.17
Ammonia Concentration Median (mg/l)	0.05	0.05	0.06	0.07	0.05	0.05	0.05
Phosphate Loading Median (Kg/day)	12.66	8.94	11.53	13.89	8.94	14.80	11.79
Ammonia Loading Median (kg/day)	3.12	4.92	4.04	2.74	2.59	2.90	3.39
Cumec Median	0.90	0.83	0.82	0.76	0.60	1.00	0.82
Number of Flow Data Returns	11	9	9	8	10	8	9

Appendix B: Flow Data Analyses

The data analyses and flow duration curves on the following pages have been produced by the British Geological Survey (BGS) as part of the Project Camellia. They indicate a significant change in the nature of the flow response in the River Crane system pre and post 2015. BGS continue to investigate this issue and the project team remains in contact with them with a view to understanding possible causes and implications for the river system.

River Crane Flow Duration Curves – (Preliminary Results)

The report will contain the long term analysis of the Flow Duration Curves (FDCs) for the River Crane. Daily river flow data were obtained from The National River Flow Archive (NRFA) website (nrfa.ceh.ac.uk). For the two largest catchments Crane at Cranford Park (CP) and Crane at Marsh Farm (MF), the daily rainfall data was downloaded (from the same source) to analyse the climate variability for the Crane.

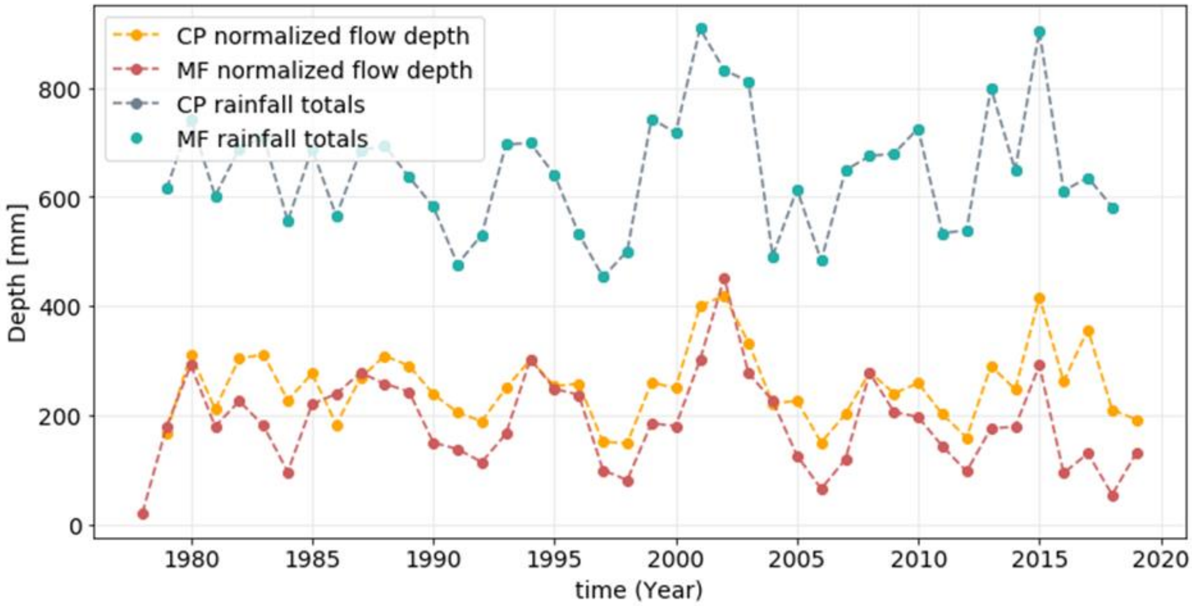


Figure 1. Annual totals for rainfall and river flows for CP and MF

The climatic variations represented by annual rainfall totals were calculated and compared with variation in annual flow depth obtained by calculating the total annual volume of water at the station divided by the catchment area. The annual rainfall totals and annual flow depths are plotted in Figure 1.

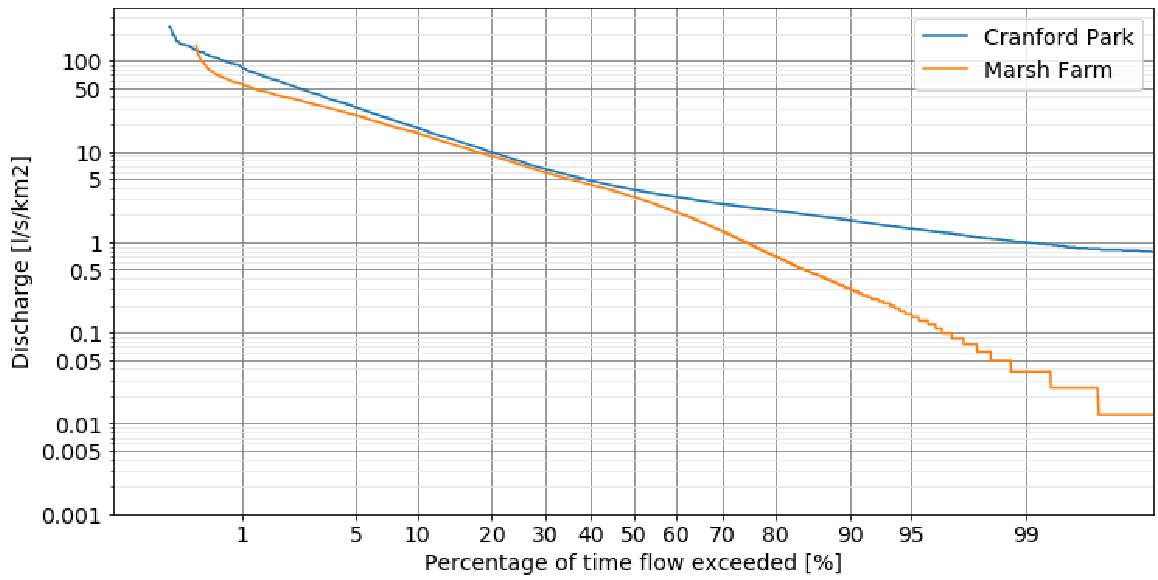


Figure 2. FDC for MF and CP stations, flows are normalized by catchment areas

From the two FDC's (Figure 2) it can be seen that for high flows, that is for exceedance probabilities lower than 50%, the two rivers behave the same and have similar discharge values. For low flows, values of discharge are much lower at the MF stations than at the CP station.

The BGS's report will also include for both CP and MF stations the long term FDC's comparing

1. The whole record FDC (Figure 2) compared to the FDC's for the period before and after 1998. The two periods have approximately the same length of around 20 years.
2. The whole record FDC (Figure 2) compared with FDC's for the decadal periods of 1980, 1990, 2000, and 2010.

The two comparisons (before and after 1998 and the decadal divide), showed an interesting shift in the FDC's. It appeared that both the after 1998 period and decades of 2000 and 2010 has shifted towards lower values where the 2010 shift seemed the most pronounced. This is why the changes in rainfall were examined. The report will include two additional figures:

1. Changes in rainfall totals aggregated for a) 1 year, b) 5 year, and c) 10 years periods.
2. Influence of the chosen start year for rainfall totals aggregation. Two start periods of aggregation one 1980 and the second one 1985 and their influence on the results of the 10 year aggregation were examined.

By examining the rainfall data it was noticed that the last three years in the record, 2015, 2016, and 2017 were particularly dry. This is why it was decided to look into the influence of the last three years of record on the FDC's.

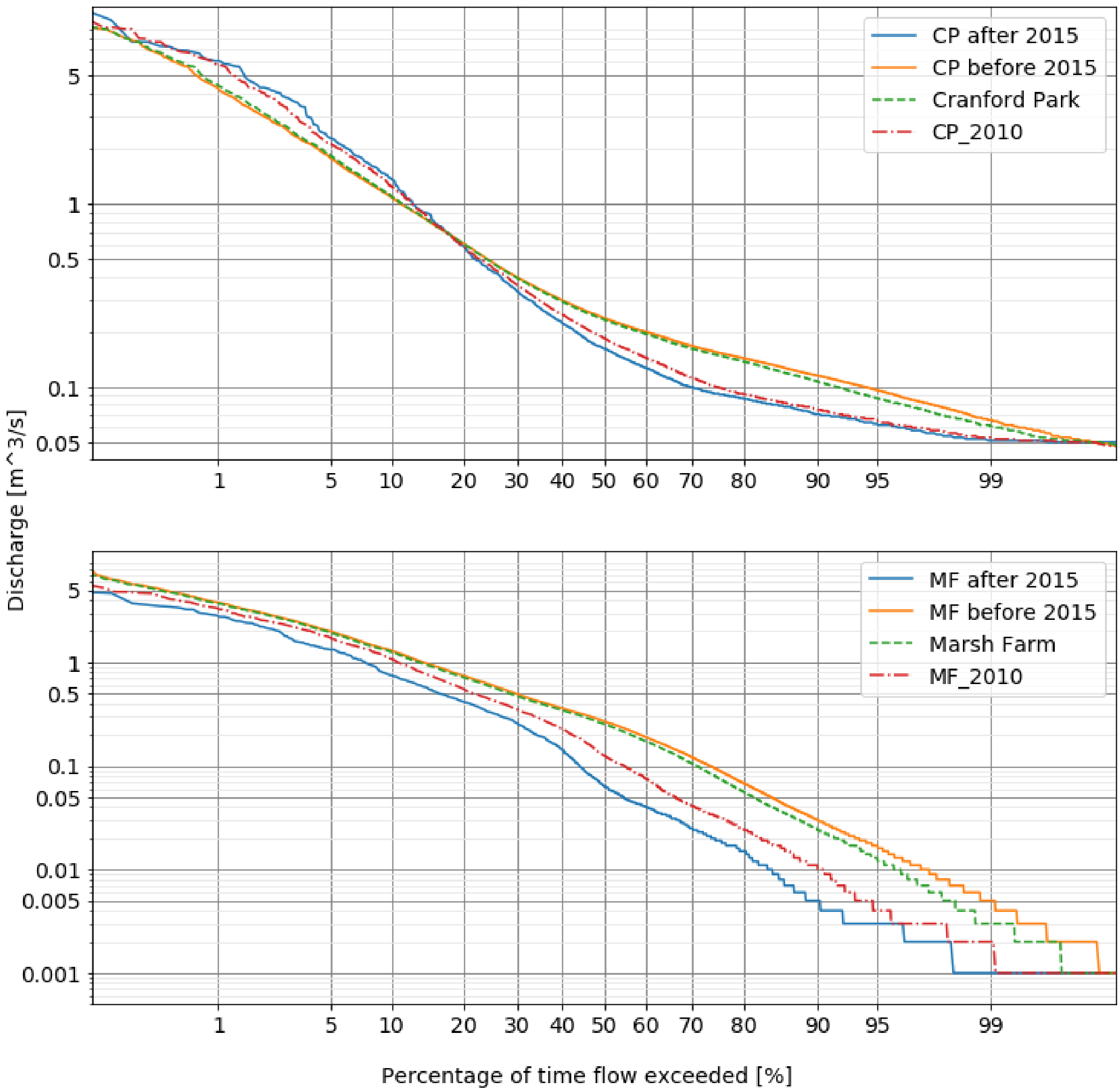


Figure 3. FDCs comparing the influence of 2015, 2016, and 2017 low rainfall years on the overall behaviour of the Crane's FDCs

The river flow records are divided into two periods one before 2015 and one after 2015 and their FDC's were computed. Results are plotted in Figure 3, where the FDC computed for the full river flow record (represented by the full name of the station in the figure legend) as well as the FDC, computed for the 2010 decade are plotted. Interestingly for the CP station, it seems that the shape of the 2010 decade's FDC is heavily influenced by the last three year of data (as the shape is almost identical as the CP after 2015).

To further study the changes to the river flows over time and the impact of climate on the flows, the data was further cleaned. Missing data points were removed by removing the whole year if it had too many consecutive river flow data points missing or the values were infilled if there was up to three consecutive river flow data points missing (information on missing data will be part of the report). Additionally, yearly FDC's are computed for water years (water year starts in November of the current year and ends in September of the following year). This was done to study characteristic flows. Characteristic flows were extracted from each year's FDC, like the flows that are exceeded 10, 50 and 95% of the time (termed respectively Q_{10}, Q_{50}, and Q_{95}) These are shown in Figure 4.

Please note that these are only the preliminary results.

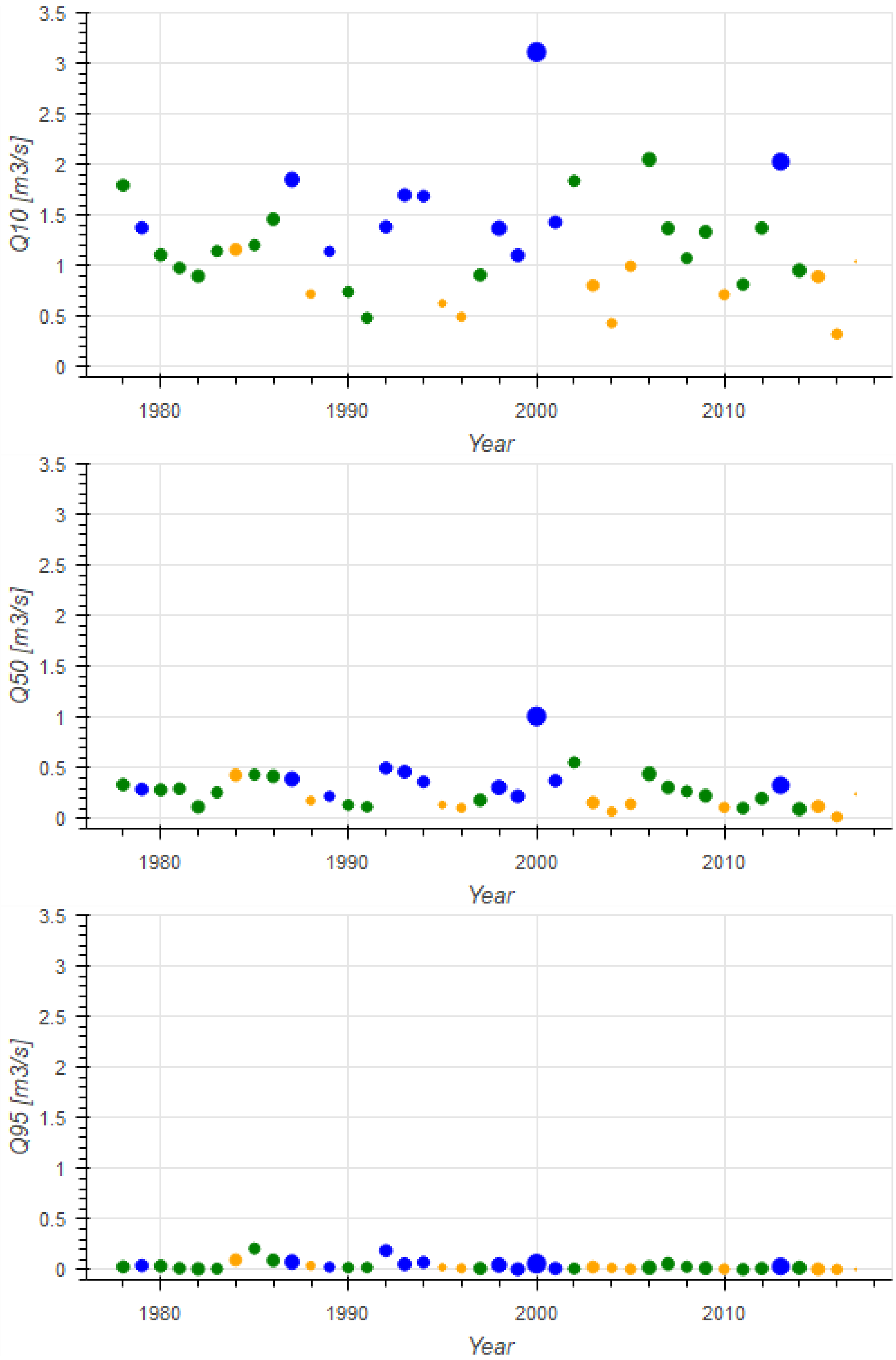


Figure 4. Changes in river flows Q10, Q50, and Q95 over the years (flows are extracted from the yearly FDC)

Figure 4 shows changes over time of three characteristic flows (Q_{10}, Q_{50}, and Q_{95}), where the colour of the circles relates to the rainfall annual mean. The colour scheme is as follows, the blue colour represents the years where the rainfall yearly mean is above the 75th percentile of all rainfall yearly means. The orange colour represents the rainfall yearly means that are below the 25th percentile of all rainfall yearly means. The green colour is for all the yearly means that are in between the 25th and 75th percentile. The size of the circle represents the total rainfall depth fallen in a water year.

Appendix C: Review of the Variables that may Influence the Ecosystem of the River Crane

Introduction

This review considers the key variables that may be affecting the condition of the river – particularly as evidenced through the long term data set being collected by the Citizen Crane project.

The Citizen Crane project has invested considerable time and effort evaluating the condition of the River Crane and working with partners to improve the river system over the last six years (since April 2014). The results to date indicate that the base conditions of the system with respect to water quality and RMI have not changed significantly over this five year period. There have been some encouraging signs regarding water quality in the upper catchment in the last year, but it continues to be poor. The RMI data show if anything a decline in overall river condition, though there is a minor uptick in Year 6.

This overall outcome suggests that the root causes of the poor to moderate condition of the river system have not been greatly influenced over this six year period – or possibly that improvements in some areas have been counterbalanced by problems in others – despite considerable investment by TW and others, through the Crane Valley Partnership, to enhance the river system.

This review assesses the actual and potential controls on the existing and future river condition. These are listed as follows:

1. Surface water outfalls, misconnections and TW's surface water outfall programme (SWOP)
2. Network issues
3. CSOs
4. Leakage
5. Road run-off
6. Pollution events
7. Heathrow
8. Sediment
9. Meteorology and run-off
10. Upper Duke's River
11. Geomorphology and river habitat
12. SUDS and other interventions
13. Pesticides and herbicides
14. Increase in fish
15. Impacts to other life stages of invertebrates
16. Other pollutant risks to invertebrates
17. Changes to runoff and infiltration
18. Impact of non-native species

The current understanding of each of these components is summarised below along with an evaluation of (a) how they may have changed over the last six years and (b) how they may be changed by the Smarter Water Catchment (SWC) and associated programmes.

Surface water outfalls, misconnections and the SWOP

Background: There are around 230 surface water outfalls in the catchment – as recorded by the first outfall safari in 2016. Misconnected properties affect around 3 to 5 per cent of the housing stock. The AMP 6 SWOP sought to remediate 50 surface outfalls in the Crane catchment. The Citizen Crane project and the outfall safari helped to identify the most polluting outfalls and the SWOP was re-configured to deal with these.

Misconnections introduce pollution from bathrooms and kitchens in particular and include typical sewage pollutants. Note that the Crane does not have any sewage works discharging to the catchment (with the exception of the discharges upstream in the Colne catchment which are then transferred into the Crane via the Upper Duke's River). The main sources of sewage in the system then are from misconnections, plus network issues and CSO's - see also below.

Approach: misconnected properties have been considered to be a key organic pollution source in urban areas and these were therefore targeted in the AMP6 programme. The Crane catchment received a lot of attention, with 50 of the 250 SWOP projects across the Thames Region being carried out in this one west London catchment.

Changes over the last 6 years: the SWOP has investigated 53 outfalls (to summer 2020). 569 of the 606 polluting properties have been rectified and a total of 1578 polluting appliances have been removed from discharging to the river system. The total amount of organic material removed by this process has not been formally calculated – though a first order calculation through this report indicates in the order of 5kg/day of P and AN removed from the surface water system – which is equivalent to the amount currently recorded in large parts of the river. The river condition must therefore be better than it would have been without the efforts of the SWOP.

However, the organic pollution and ecological quality of the river have not significantly improved over the five year period of the SWOP. This suggests that (a) misconnections are not as important a control on the river condition as first thought; (b) there is a delay in the recovery following their removal and/or (c) new misconnections are being added to the system at a comparable rate to their removal.

TW acknowledge there is a problem with the 7 per cent or so of misconnections which are identified and then not resolved. This is primarily because some at least of the Council EHOs are not responding to the issue with follow ups and prosecutions.

Proposals for the next 5 years:
1. The total number of outfalls to be investigated in the Thames Region AMP 7 SWOP is to be increased from 500 to 750 (target only). The numbers in the Crane catchment have not yet been decided.
2. A second outfall safari is scheduled for spring 2021. This will help to evaluate the changes in outfall condition since 2016 and target outfalls for the SWOP
3. The Citizen Crane monitoring will continue to record any changes in the river condition
4. Some means is needed to properly evaluate the numbers of new misconnections being added to the surface water drainage network. This may also help to optimise an approach to publicising the issue and reducing the number. We will propose this is included in TW's smarter water catchment (SWC) programme
5. Efforts are enhanced to publicise the problems of misconnections, encouraging the public to remove them from the system and avoid creating new ones
6. Thames Water are proposing to work closely with the council EHOs to improve the system of resolving and enforcing misconnection removal

Network Issues

Background: "network issues" is a catch all term for failures of the sewerage system that lead to sewage effluent entering the surface water drainage system, and from there into the river. There are various links, and potential links, between the two systems including: dual manholes with ineffective barriers in place; broken or defective rodding caps; leaking sewers that can be drained by a local surface water drain; sewer blockages that lead to overflows into the surface water system; etc.

There is considerable anecdotal evidence of cross connections between the two systems that cause pollution problems in urban rivers, but the scale of the issue is not yet well understood. It is believed that Middlesex County Council drainage engineers in the 1960's are understood to have resolved some surface water pollution issues by connecting into the foul network. In 2019, LB Harrow engineers reported 209 dual manholes in the River Brent catchment in their borough, along with many missing or defective rodding caps.

Network issues are likely to cause sporadic pollution problems in response to high effluent flows or blockages for example. These are unlikely to be properly recognised by the existing Citizen Crane monthly monitoring network, although they may explain occasional very high concentration levels seen in the data. They can be (and have been) identified by Citizen Crane and others visiting the river and reporting pollution problems.

A brief review of continuous ammonia data collated by the Environment Agency in the middle reaches of the river, and recorded in the Year 3 report, revealed peak ammonia levels at an order of magnitude higher than the background for a few hours to a day at a time, every month or so. This would be the type of record expected from a network issue.

Approach: there have been some investigations of network issues in the Brent catchment, where significant problems have been found. TW has reported that the problem is not as significant in the Crane catchment, but the project team has not seen any investigations undertaken to support this view.

Note that recent data reported by TW as part of the SWOP showed that 99 "other issues" were identified in the Crane catchment during the AMP 6 SWOP. These include: gully dividers (where the surface and foul gullies are next to each other and the foul can flow into the surface when blocked); blockages; defects; and missing surface water caps. It would be helpful if TW were to review these findings in more detail, which together make up around 20 per cent of the issues identified by the SWOP, and may be having a disproportionate impact upon the river condition.

Changes over the last six years: the issue has not been fully investigated so the team is not aware of any changes over the project period. Professionals in the sector have indicated that this could be a significant issue in the catchment and needs to be investigated further. As the SWOP proceeded, without any appreciable improvement in the baseline river condition, this argument has become stronger. There is a specific issue presently in the Newton Park area which has been attributed to network issues.

Proposals for the next five years:
1. TW to engage fully with the network issue as part of the SWC programme
2. Further investigation and evaluation of the "other issues" identified by the AMP 6 SWOP
3. Consideration given to any differences in the nature of the Crane and Brent drainage catchments which might explain the differences in numbers of cross-connections reported
4. The AMP 7 SWOP to include systematic logging and evaluation of "other issues" identified during the SWOP process
5. Continuous 15 minute monitoring sondes to be deployed at various locations across the catchment to measure the variations in ammonia and other key parameters. Use these data to trace any network or other issues identified

Combined Sewer Overflows (CSO's)

Background: There are three CSO's in the Crane catchment. One of these (at the A4 crossing in the middle reaches of the river) was the source of the major pollution event in 2011 that killed virtually all of the river life downstream to the Thames. Notwithstanding this, there has been little or no investigation of the impact of CSO's on the river ecosystem as part of the Citizen Crane project.

Approach: the issue has not been investigated

Changes over the last six years: TW has pledged to monitor the discharges from its CSO network across the region. The project team understands that this was due to be implemented this year 2019/20 in the Crane catchment, although it may have been delayed due to the pandemic. The project team has not seen any outputs from monitoring of the CSOs.

Proposals for the next five years:
1. TW to engage with the CSO issue as part of the SWC programme
2. Monitoring data from the CSO's to be shared and reviewed
3. Sondes deployment (see above) to be mindful of the location and potential impact of CSOs

Leakage

Background: the TW water supply system as a whole has around 600Ml/day of total leakage, much of which is within London. This is generally considered to be a bad thing, resulting in greater than necessary abstraction from sources and wasted resources in treating and pumping the water. However, the project team is not aware of any consideration been given to date about the potential benefits of leakage for the baseflow in urban river systems like the Crane, and the impact of reducing leakage upon these river systems.

Approach: the issue has not been investigated

Changes over the last six years: TW has pledged to reduce leakage, and the total has reduced over the last five years, with targets for a further reduction during AMP 7.

Proposals for the next five years:
1. TW to consider the impact of leakage (and leakage reduction) on urban river systems as part of an overall urban water balance

Road Run-off & Urban Diffuse Pollution

Background: Many of the 230 surface water outfalls in the catchment are draining road run-off into the river system. Road run-off contains transport related pollutants, including hydrocarbons, heavy metals from brakes and tyres, as well as salt and de-icer following cold weather periods. Road run-off may also include significant amounts of herbicide from roadside weed control. The amount of pollution that enters the river system is a function of (a) the amount and nature of the road traffic within the drained road sections and (b) the maintenance regime for road and gully pot cleaning.

Road pollution often enters the system as an initial flush when heavy rain follows an extended dry spell. This can lead to oxygen sags in the river and consequent fish kills. These have been seen at regular intervals in the longer term record on the River Crane and other London rivers.

Approach: this issue has not been a part of the brief for the Citizen Crane project. However, the team has engaged with parallel projects; (a) looking at road run-off issues on a London wide basis and (b) seeking to provide pollution control measures at the M4 crossing, believed to be the most polluting road source in the catchment.

Changes over the last six years: not known. There have been no fish kills related to road run-off in the Crane over the last six years that the team is aware of. Volunteers have reported flushes of dirty water following heavy rainfall events and build-ups of polluted sediment in some locations. Local major roads have also been reported with large amounts of grey sediment in the gutters and little evidence of gutter clearing. There is little doubt that road run-off is closely linked to large volumes of polluted sediment downstream of some key road outfalls, including the M4.

Proposals for the next five years:

1. Continue to engage with parallel projects, investigating and seeking to reduce pollution in road run-off
2. Link TW's SWC and SUDS programmes to road run-off management work so as to optimise outcomes for the river
3. Seek (through these parallel projects) further information on the gutter and gully pot maintenance programme across the catchment, as a likely major control on the amount of pollution entering the river system

Pollution Incidents

Background: pollution incidents are a feature of most river systems, where a pollutant escapes into the river and causes a pollution plume along with the potential for ecosystem damage and fish kills. A long term record of fishing in the Crane, obtained by FORCE, revealed significant and major pollution incidents as a feature of the river for at least thirty years.

Approach: the project volunteers have been going to the river every month for the last five years. Many of the volunteers visit a lot more regularly. Around 6000 leaflets have been given out to the general public about the project, and these include information on how to report pollution incidents. This approach has increased greatly the eyes and ears on the river, as well as encouraging the reporting of pollution incidents. Pollution incidents are also publicised through social media. One example in summer 2020 was seen around 30,000 times through various postings, leading to front page coverage by the local press and interest from local politicians.

Changes over the last six years: there has been no systematic analysis of pollution incidents over the last six years. However, the project team is aware of around 20 significant to major incidents identified over this period, many by project volunteers and several during the outfall safari. These have all been investigated, and many have been resolved, by EA and/or TW staff. The use of the TW hot line in addition to the EA number has improved the response to pollution incidents in the view of volunteers and the project team, due to the additional resources of TW staff and their ability to attend incidents in a short time frame.

In the view of the project team, this enhanced approach to identifying and rectifying pollution issues has led to more pollution incidents being identified, and the length of time these incidents are active being greatly reduced. This will have resulted in a significant reduction in the impact of pollution incidents on the river, at least in those parts of the river which are visible to the public.

Proposals for the next five years:

1. Review the data for pollution incidents held by the EA and TW
2. Enhance the public engagement about pollution incidents and reporting through the SWC programme

Heathrow

Background: around a third of the Heathrow Airport site drains into the Crane catchment. This drainage passes through the eastern balancing reservoirs before entering the river. For the most part this is believed to be beneficial to the river system. FORCE is in discussion with Heathrow about whether the amount of input could be increased, particularly during extended dry weather periods.

However, following cold periods (several days and nights close to or below freezing), the inflow contains a major pollution source in the form of glycol from aircraft and runway de-icing. This interacts with the river to form extensive blankets of filamentous algae (known as "fungus") on the river bed, which smothers the invertebrate life in the river, as seen by significant troughs in the downstream RMI scores following cold periods in several recent years.

A paper from the early 1970's*, on the condition of rivers across London, reported that the outflow from Heathrow had been problematic since the 1960s at least, due to the addition of glycol for de-icing. Heathrow had then implemented an oxygenation system to combat the problem. This indicates that this has been a long term problem at the airport.

It is possible that the issue has been there for many of the intervening years and had not been reported. Records seen by the project team do though indicate that the amount of glycol being used at Heathrow has increased significantly in recent years and this may have breached a tipping point for the river and the existing run-off management system.

Note that RAF Northolt is potentially a further significant source of glycol during cold periods. FORCE and CVP are engaged with RAF Northolt to discuss pollution and other environmental issues. During a meeting in early 2020 RAF Northolt reported glycol use of 40,000 litres in 2019. Some attenuation and filtration is present but there is no active treatment system in place.

Approach: the volunteer teams for sites 10, 11 and 12 downstream of the Heathrow outfall have been recording the impact of these discharges and liaising with Heathrow over the project period. Heathrow has recently invested around £20m in improvements to the balancing reservoirs and a new treatment system for glycol. This was fully operational for the first time in winter 2020.

Changes over the last six years: the river has been badly affected by fungus related to glycol from the airport in the winter and spring of at least three of the last six years. This resulted in reductions in the RMI score over several months and there is some concern about a possible cumulative effect, as the RMI has tended to reduce at these sites over the entire monitoring period.

The investment by Heathrow in an enhanced management system and new treatment works is warmly welcomed by the project team. The system was fifty per cent operational in winter 2019 and there were still fungal blooms in the river downstream. Heathrow acknowledge that it may need some fine tuning over the next few years to optimise its beneficial impact upon the river. The system is thought to have been fully operational in winter 2020 – but there were no extended cold periods during this very mild winter to properly test the functioning of the system.

Proposals for the next five years:
1. Continue to monitor the river downstream of the Heathrow outfall
2. Continue to engage with Heathrow so as to optimise the benefits and minimise the negative impacts of the Heathrow outfall on the river system.

Sediment

Background: there are very large volumes of sediment in the river system. Initial investigations into the condition of this sediment (including by MSc students working with the project team during year 3) indicate that some or most of it is polluted; including high levels of hydrocarbons, heavy metals and phosphate for example.

Sediment can be bound into the river bed through time and the actions of marginal plants. It can also be flushed out of the system in response to heavy rainfall events. It may also be a source of dissolved pollutant through gradual release over time. Sediment will also build up in any SUDS and wetlands schemes developed in the catchment.

Approach: there is limited understanding at present on the role of sediment on the water quality of the river or the value of the ecosystem. The poor quality of river sediment has though been a limitation on the remediation of parts of the river, due to the legislative controls regarding the disposal of hazardous sediment.

Changes over the last six years: there have been limited works to remove the sediment load in the river over the last five years. Polluted sediment pollution build-ups in the moat at Headstone Manor have required occasional dredging at high cost over many years. The last dredging exercise was carried out in early 2019 and removed around 2000 cubic metres of organic sediment from the moat.

A mass balance for the catchment in the Citizen Crane Year 3 report included a first estimate of 50 tonnes of phosphate in the sediment within the river system, working by extrapolation from the analyses of sediment collected by an MSc student at various river bed sites.

The first major wetlands scheme developed in the catchment has been the Newton Park wetland, opened in 2018. This will inevitably build up a store of sediment over time. A site visit in early 2020 recorded a build-up of several centimetres of hydrocarbon rich sediment in the first wetland pond. This has subsequently been investigated by LB Harrow and contractors but the source has not been identified.

Proposals for the next five years:

1. Further consideration of the importance and impact of sediment upon the river system, including a technical review of the findings to date
2. Build the findings of this review into the actions over the SWC and SUDS programmes
3. Liaise with LB Harrow about the sediment accretion in the Newton Park wetlands scheme and the approach to mitigating this, including investigations as to the amount and nature of the sediment
4. Set up a monitoring scheme to assess the amount of sediment accreting in the new Headstone Manor wetland scheme
5. Further investigate the amounts and nature of sediment across the catchment

Meteorology

Background: the amounts and distributions of rainfall across the catchment are the fundamental controls on the river condition. These controls will vary over time. Extended dry periods will enhance the concentration of point source pollutants, whilst flood events will flush sediment and can lead both to network problems and road run-off issues. Both are forecast to become more common through climate change, and there is some anecdotal evidence of this already occurring in the catchment. In addition, the lower catchment is vulnerable to pollution events linked to cold weather and glycol use at Heathrow (see above).

Run-off is a related variable, as this can change as a function of the nature of the ground the rain falls upon, and the means by which this is drained. This is considered further below.

Approach: to date the project team has observed rainfall reports and used these to evaluate potential low flow and high flow risks. Monthly flow data are also a useful means of recognising low flow issues in the catchment.

Changes over the last six years: there has been considerable variation in the climate over the last six years; with extended periods of dry weather, cold weather and major rainfall events; all of which have affected the condition of the river. It is not possible to be definitive about the impacts. However, there was an extended period of relatively low rainfall in Year 5, and this may have partially masked any recovery in river condition over this period. The flood flows in the river during the winter of Year 6 may have been a major cause of the network issues and sewage pollution seen in the upper catchment.

Proposals for the next five years:

1. Meteorology is clearly a given that has to be managed and accepted. However, it would be very useful to better understand the controls that the weather has on water quality and RMI data sets so that the data outputs can be better interpreted. This is another area where specialist technical support would be helpful.
2. Discussions with academic institutions through Project Camellia and other routes have indicated the potential for statistical analysis of rainfall and flow data to identify key patterns and controls. It is hoped that these discussions will lead to further assessment and support over the next five years.

Upper Duke's River

Background: the Upper Duke's River transfers water into the River Crane from the River Colne to the west. This is an artificial channel that has been operating since the sixteenth century and was constructed to supplement river flows and support water mills along the Lower Crane and Lower Duke's Rivers.

Approach: Citizen Crane monitors the river flow and RMI, as well as taking water quality samples, at the base of the Upper Duke's River where it enters the River Crane (Site 10). These data have indicated the importance of the inflow from the Upper Duke's, as the RMI scores have been highest in the catchment, both within the Upper Duke's at Site 10 and the downstream River Crane monitoring sites 11 and 12.

The Upper Duke's has a relatively high P loading compared to the Crane (thought to be sourced in part from upstream sewage works on the River Colne) and a low AN loading. The positive changes in RMI scores indicates the relative importance of AN compared to P as an ecological control.

Changes over the last six years: the P loading of the Upper Duke's River has remained relatively consistent over the last six years, at between 4 and 8 kg/day. This loading is sufficient to double the overall P loading of the River Crane downstream. The flow through the Upper Duke's has reduced significantly in recent years. Although the flow increased in Year 6, this increase was not as significant as might be expected from the rainfall increase. Given the apparent importance of this inflow to the character of the river downstream, this is a major concern. The issue has been raised with Heathrow (and the EA), and Heathrow consultants are now also monitoring the flow rates as part of data gathering linked to the Third Runway scheme. Note: this monitoring may have been put on hold from February 2020, when the Third Runway plans as a whole were put on hold, following Judicial Review and the subsequent impacts of the pandemic.

Proposals for the next five years:

1. Further analysis of the data from the Upper DNR to characterise the flow and water quality conditions in this river
2. Continued dialogue with Heathrow and the EA to ensure an appropriate flow continues to be transferred into the River Crane
3. Discussion with TW and the Colne Valley Partnership about P levels in the Colne

Geomorphology and river habitat

Background: river geomorphology has a major control on the RMI score in the river. There are extensive parts of the river, particularly in the middle reaches, where it has been straightened, widened and deepened over the last hundred years. This has resulted in a slow and homogenous system, often with an extensive silt load, and an ecologically poor and uniform environment, which would generate low RMI scores almost regardless of the water quality.

The river is in this condition due to being heavily engineered as an urban managed channel for much of the 20th Century. River improvement works have been reversing this process, along small and cumulatively significant stretches of the river, over the last 20 years.

River habitat is related to geomorphology, in that it is often poor where the river is heavily engineered. However, factors like over-shading and a lack of marginal habitat can in some cases be independent of geomorphology. Habitat can influence water quality as well as RMI – in that, as the habitat improves, more oxygen is introduced into the river, marginal plants intercept and sequester sediment, and plants can also remove P and break down AN.

It is interesting to note the profound changes in the river geomorphology in parts of the lower catchment over the last forty years. The previous dredging regime had left the river overwide with a flat base and toe boarded margins. In places the river has narrowed greatly as the previous engineered maintenance regime was stopped, resulting in the width reducing by half in places. The two photos below show the same stretch of river – in Crane Park just upstream from Site 12 – from 1980 and 2020

The Lower Crane looking upstream from A316 bridge in winter 1980. Note the uniform wide channel and marginal toe boards

The Lower Crane looking upstream from the same A316 bridge in summer 2020. Note the narrowed channel, within the toe boarding, and extensive marginal and river bed vegetation.

It is important to note that this narrowing has been a largely natural process, in response to dredging activities stopping around 40 years ago. There has been some introduction of marginal plants but no major renovation works have been undertaken on this reach of the river.

Elsewhere there has been little change in condition and the original toe boarded margins remain. The reasons for this are not properly understood but may be related to the presence and absence of shading. Where there is no shading it is easier for marginal plants to establish and start to narrow the system to a more natural size and shape.

Approach: the project team has become more aware of the importance of geomorphology and habitat for the RMI scores, and potentially also the water quality of the river. In particular, the water quality data have revealed reaches of the river (particularly in the lower river below the Upper Duke's confluence) which are self-cleansing, able to remove part of the P and AN load from the system. This self-cleansing ability is considered to be a largely a function of the high geomorphological and habitat value of these reaches of the river.

The project team has not directly engaged in habitat monitoring or improvement measures but has supported these activities. It is interesting to note that much of the habitat improvement shown in the 2020 photo above has occurred naturally, as a result of the cessation of dredging works that used to be carried out by the old Greater London Council. In other parts of the lower catchment, active enhancement works have helped to speed this process, though the removal of shading may be the most effective means of facilitating beneficial change.

Changes over the last six years: in 2016 CVP undertook a detailed geomorphological survey of the river using the "Urban River Survey" (URS) methodology. There have been a raft of river improvement works along the river over the last 5 to 10 years, many of them funded through the TW River Crane Improvement Fund. There has been no detailed work to directly assess the impact of these works on the river ecology, although there are clear habitat and aesthetic benefits, particularly where these works continue to be maintained and enhanced.

The project team has monitored the effect on the RMI and water quality of the major new wetland system installed at Newton Park in 2018. The 18 months of data collated to date indicate a measurable improvement in water quality, and recent indications of an improvement in RMI, as a result of this installation. Reductions in P of around 20 per cent and AN of around 50 per cent are being achieved.

A new wetland scheme was installed in Elephant Park in 2019 and a major new scheme is being installed in Headstone Manor in 2020.

Proposals for the next five years:
1. Continued support for schemes to enhance the geomorphology and habitat value of the river
2. Encouragement and support of before and after investigations, evaluating the benefits to the ecosystem of each river improvement scheme
3. Incorporate such before and after monitoring into the SWC programme
4. Review of the URS data set, use this as a baseline for evaluation of further works over the next five to ten years, and schedule a further URS survey during the SWC period
5. Note that TW are producing a baseline natural capital assessment for the river at the start of the SWC

Sustainable Drainage Schemes (SUDS)

Background: SUDS are a means of managing run-off, reducing peak surface water flows and reducing flood risk, removing pollutants, and enhancing the habitat and aesthetic value, of a run-off management scheme. To date there is little or no SUDS implementation within the Crane catchment, though some recent developments have included SUDS proposals, and the Newton Park wetlands could be described as a SUDS scheme. TW has proposed large scale SUDS as one of its key means of managing run-off. A programme of works for AMP 7 includes potential SUDS investment for 65 hectares of run-off benefit across the region. It is envisaged that some of these works may be delivered in the Crane catchment. SUDS may also be adopted as a means of delivering the SWC objectives, as well as to control pollution from urban run-off as part of programmes referenced above.

Approach: this issue is not part of the current brief for the Citizen Crane project. There have though been initial discussions on how SUDS may work on the Crane, how they could be implemented and the benefits properly measured and optimised. This work is referenced in the SUDS note in Appendix D of this document.

Changes over the last six years: no major SUDS specific schemes implemented to date – although Newton Park, Headstone Manor and Elephant Park all have SUDS elements to them.

Proposals for the next five years:
1. Monitoring of existing wetland schemes to be enhanced to provide baseline data and experience for future SUDS schemes
2. SUDS are proposed through AMP 7 and may also be a significant element of the SWC approach
3. The locations and designs of SUDS are selected with reference to the baseline conditions in the river and with a view to best enhancing these conditions
4. SUDS schemes to incorporate appropriate baseline and post scheme monitoring

Pesticides and Herbicides

This issue, along with the following five, have not been evaluated as part of the Citizen Crane project to date. They have been flagged up here for future awareness and potential investigation.

Pesticides and herbicides can enter the ecosystem through airborne or waterborne applications and transfer. They are believed to be having a major detrimental impact upon invertebrate numbers globally and may therefore also be impacting upon the RMI data sets at a local level.

One significant route for the entry of pesticides into the river system is from flea control treatments for dogs. Given the large number of dogs entering the Crane watercourse, particularly in the lower reaches and around the monitoring sites, this could be a major un-assessed impact.

Increase in Fish

In April 2014, at the start of this project, the river was in the early stages of recovery from two major fish kills. There were no mature fish in the river system and a major fish re-stocking exercise (with yearling fish) followed in late 2014. Consequently, the invertebrate life in the river may have benefitted artificially from the lack of predators. Now (2020) there is a larger diversity of fish numbers and sizes and fish will tend to suppress the invertebrate population of the river. It has been noticeable for example that current RMI monitoring at Site 12 nets many more fish than in the early years of the project.

Impacts to other Life Stages of Invertebrates

These impacts would include the pesticides referenced above as well as the lack of adult stage habitat and the restrictions to adult migration. Adult stages of most of the RMI species migrate by flight. The potential for upstream flight is restricted across the catchment by bridges and lighting for example. In the upper catchment these restrictions are compounded by culverted reaches of the river, such that the Newton Park and Headstone sites for example are rather isolated from better performing sites.

Some insects are easily fooled into laying their eggs outside of the watercourse, by materials such as polythene, for example.

Other Pollutant Risks to Invertebrates

There are a wide range of other pollutants that are only just being recognised as a risk to invertebrates. These include pharmaceuticals and micro-plastics in the river ecosystem for example.

Changes to Runoff and Infiltration

Changes to the amount of hard standing in a catchment, plus other changes (for example to the local shallow groundwater regime), can influence the amount of and nature of the runoff and base-flow entering the river, thereby increasing the risks of floods and low flows, both of which can adversely affect the ecosystem value. The loss of soft vegetated areas in front gardens to hardstanding is recognised as a major issue across London, with the equivalent of 2.5 Hyde Parks reported as being lost every year to this practice (LNPC, 2020).

The work presented by BGS in Appendix B of this report indicates potential changes to the streamflow over the last ten years which may be a function to changes in run-off and infiltration.

Impact of Non Native Species

Non-native species can develop mono-cultures that deliver less habitat benefit. They may also out-compete them and introduce new diseases etc. There is a general concern e.g. from Buglife about the impact of non-native species on the native ecosystem. London is particularly vulnerable to non-natives given its proximity to the continent and the amount of imports arriving through the capital.

Littering/fly-tipping?

Summary

This report has set out the findings from monthly monitoring of key river variables (AN and P concentration; river flow; AN and P loadings; and RMI) at between 11 and 16 locations on the River Crane over the last six years. One of the over-riding findings is that the river condition has not improved significantly (according to these parameters), despite the major efforts from TW's SWOP and other improvement programmes over this period.

This section of the report has gathered together the available information on eighteen variables which either do or may influence the river condition. The project team's current knowledge about each variable is set out in turn along with the efforts made over the last six years to assess and, where appropriate, beneficially influence its impact, along with proposals for how this process can be developed over the next five years. These findings are summarised in the table below.

Issue	Importance	Change in last 5 years	Priority for next 5 years
Misconnections	Originally thought to be high – but now in question	Major improvement works in AMP 6 – but no major change in river condition. Initial estimates indicate the rate of new misconnections may be as high as the remediation rate.	Continue SWOP; understand the rate of new misconnections; increase the public engagement; increase engagement of the council EHOs
Network Issues	Not known – believed to be very important on the Brent	Not addressed – though several pollution incidents attributed to them	Needs to be a focus – even if only to rule it out as a key issue
CSOs	Not known	Not addressed	See above
Leakage	Not known	Not addressed	To be considered as part of an overall water balance for the system
Road run-off	Not a control on organic pollution but could be significant for ecological value	Not addressed directly	Major opportunity for monitored improvement linked to other work programmes
Pollution events	Significant – particularly major events (see 2011)	Good evidence for improvement in the early recognition and removal of issues before they become major	Continue with this work + analyse the data from EA and TW records
Heathrow	A significant negative impact on the ecosystem for several months a year for several km downstream of the outfall (cold winter periods only).	Pollution problems assessed and noted. Major investment by Heathrow coming on stream but not yet properly tested or optimized	Optimise the treatment system. Explore opportunities for low flow enhancement

Issue	Importance	Change in last 5 years	Priority for next 5 years
Sediment	Not known – though there is plenty of polluted sediment in the river system	Not addressed	Needs technical expertise to evaluate its potential importance
Meteorology	Fundamental	Evidence that reduced rainfall in Year 5 impacted the river condition	Needs technical expertise to evaluate its importance
Upper Duke's	Recognised as key to benefitting the lower reaches	Reduced flows over the five years a cause for concern. Contributes half the P load to the lower catchment	Essential to ensure flows are protected in the future
Geomorphology and river habitat	Fundamental	Evidence of enhanced conditions (particularly in the lower reaches) due to improvements in the last five to ten years	Further river improvement works, particularly in the middle reaches, along with better methods of evaluating and optimising the benefits
SUDS	Not yet known	The Newton Park system implemented with promising early results	Work needed to optimise design and maintenance for environmental benefit
Pesticides and herbicides	Not yet known	Not addressed	Subject to information from other parties
Increase in fish	Not yet known	Not addressed	Subject to information from other parties
Impacts to other life stages	Not yet known	Not addressed	Subject to information from other parties
Run-off and infiltration	Not yet known	Not addressed	Subject to information from other parties
Non Native species	Not yet known	Not addressed	Subject to information from other parties
Litter/fly-tipping?			

Table C1. Summary of key river variables, their importance and recorded change

This table illustrates how the understanding of how the River Crane ecosystem operates has developed over the last six years. Whilst the works to date have not made a major beneficial difference to the ecosystem it can be stated confidently that works such as the SWOP and early pollution identification have stopped it from deteriorating further. In addition, the information gathered, and the promise of a major programme of works under the Smarter Water Catchments programme, give considerable grounds for optimism that substantial progress can be made over the next five years.

Nevertheless, the large number of variables remains daunting, and not all can be considered in the SWC. Developing a better understanding of the relative importance of these variables in controlling the ecosystem value will be of key importance to managing the next five years of the project.

There is an opportunity, through the Project Camellia initiative, to bring specialist academic support to the project. This may be of value to many aspects of project development, including new modelling approaches for the Crane River ecosystem. This could provide a means to better understand the relative importance of these variables and model the impact of various interventions.

Appendix D: Delivery of SUDS in AMP 7

Note: these ideas and suggestions are based on internal review and discussion by the Citizen Crane project group and are intended for discussion and development by any and all interested parties. This is version 1 and was produced in June 2019 and sent to Thames Water for consideration and feedback.

Overview

AMP 7 & 8 could see a significant amount of funding from water companies for new SUDS. These systems will serve to create more storage areas within urban catchments and to smooth out the hydrograph, reducing peak flows and potentially easing strain on key assets. The new SUDS can (and should) also serve to improve water quality and the ecological and chemical status of our rivers. These new assets will also have the potential to deliver ecological benefit and amenity value within the asset itself as well as downstream.

Several water companies, including Thames Water and Anglian Water, have set aside funding in AMP 7 for new SUDS and stated that these projects will not be delivered via their framework contractors. Instead funds are likely to be diverted to Local Authorities, the Third Sector and other delivery partners, who will work in partnership with the water company to design, build, manage and maintain these assets throughout their design life and then potentially decommission/ rehabilitate these assets at the end of their design life.

There is great potential to deliver a significant benefit to urban catchments through funding these new assets but realising that opportunity over a >20-year time frame is a challenge, and risks being a missed opportunity without an appropriate strategy in place from the start, which allows for refinement and change with experience.

Challenges

- Optimising the opportunity for river catchments
- Availability and application of best practice guidance for designs to support water quality improvement and maintenance
- Availability of data to inform prioritisation of interventions (where the most benefit can be delivered)
- Availability and application of methodologies to support scoping/ identification of SUDS opportunities and associated constraints
- Achieving a consistent funding structure appropriate for good long-term asset performance i.e. separation of funding into CAPEX and OPEX, plus contingency
- Achieving engagement and support from all local stakeholders – including local communities

Points for Discussion

1. How can stakeholders support the development of a strategic approach (regionally or nationally) to realise the greatest long-term benefit from new SUDS assets in terms of ecology, water quality, water quantity and amenity value? At what scale could this be optimised?
2. How can stakeholders create a framework whereby recipients of funding are obliged to take a TOTEX view of any new asset they create?
3. If TOTEX for a new SUDS is e.g. 20-25 years, prior to requiring a major re-fit or decommissioning, how can both planned and reactive funding required for assets be structured in this time frame?
4. How can these new assets be designed, built and maintained without major replication of work and wasted money? Where are the scaling opportunities?
5. What models of management, operation and maintenance best ensure a proper level of engagement with all interested parties including (or especially) local communities?

6. What is the optimum scale for a more joined up approach to deliver true efficiency and value? e.g. How could monitoring and maintenance contracts be managed in an efficient way regionally?
7. Will there be a critical mass of new assets over AMP 7 to warrant consideration of some centralised functions to support value and realisation of long-term benefit?
8. Is there an opportunity to divert funds to existing SUDS that may be suffering from lack of maintenance or may not have maintenance plans in place? This may not get as much good press as a new system but in some cases will represent a better investment.
9. How could the creation of new assets nationally fit into the 25-year Environment Plan and could this open up projects to different funding sources over life span of the asset to support long term maintenance?

Potential Solutions

1. An initial literature and best practice review nationally and internationally for SUDS – considering not only design and operation – but management options, environmental and socio-economic valuations.

2. For utility companies, and any other grant awarding body giving money for SUDS schemes, to sign up to a code of conduct or way of working that ensures the recipients of funding take a TOTEX view of the new asset and;

    a) create a bidding framework that qualifies bidders in terms of competencies/ responsibility / understanding TOTEX
    b) Create a funding award structure that recognises TOTEX
    c) Ensures a maintenance contract (suggest 3 years, *or 5 years to fit with AMP period and tie in funder to maintenance?)* is tendered and awarded as part of the capital delivery of the project

3. Identify which parts of a new SUDS are site specific e.g. ground investigation and long-term access assessments, and which elements are common to all new SUDS. Separate these out and work with key stakeholders to develop a tool kit for all elements that are common to all systems to eliminate replication of work. Work out how to simplify decision making, reducing replication of resource intensive work. Figure out what we can standardise and at what scale.

4. Investigate the most appropriate scale at which to pool resources and consider the centralisation of certain functions in order to design, build and maintain new assets efficiently.

5. Investigate who is willing to take long term ownership / liability for new assets and gain a full understanding of their respective risk profiles.

6. Monitor. Create a standard ecological and water quality monitoring tool kit and SUDS adoption process (for monitoring) for Citizen Scientists. If we monitor, we can fine tune the OPEX budget and this will feed into efficient allocation of funds over the life of asset and start quantifying benefit of respective system designs.

7. Consider at the outset specifically how local communities can be engaged in the design, development and maintenance of these assets and build this into the process

8. Put a collection of systems in place to make sure poor designs that do not lend themselves to ease of long-term maintenance don't make it past the first hurdle.

Further Considerations

- Could value be delivered via some sort of centralised body acting regionally or nationally that could act as a neutral, value orientated design hub (or could positions be funded in an existing, appropriate body).

- Could a central body help develop and deliver tools to support identification of the SUDS opportunities, support selection of appropriate/ effective designs for each location and support development of tools for Citizen Science monitoring and fine-tuning of maintenance schedules during the operation of the asset.
- Could a centralised body support tendering process for contracts and perhaps even support contract management and commissioning services (probably via an approved list of contractors) - could this approach help deliver wider catchment objectives regionally or nationally?
- Could a central function hold (and invest?) OPEX budget and release funds strategically based on different inputs from monitoring data/ incidents and match funding opportunities?
- Could design risk and liability be managed in a different way?

All comments and views welcome.