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Lower River Crane Restoration

Feasibility and Options appraisal

Green Corridor

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Document history

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Client signoff

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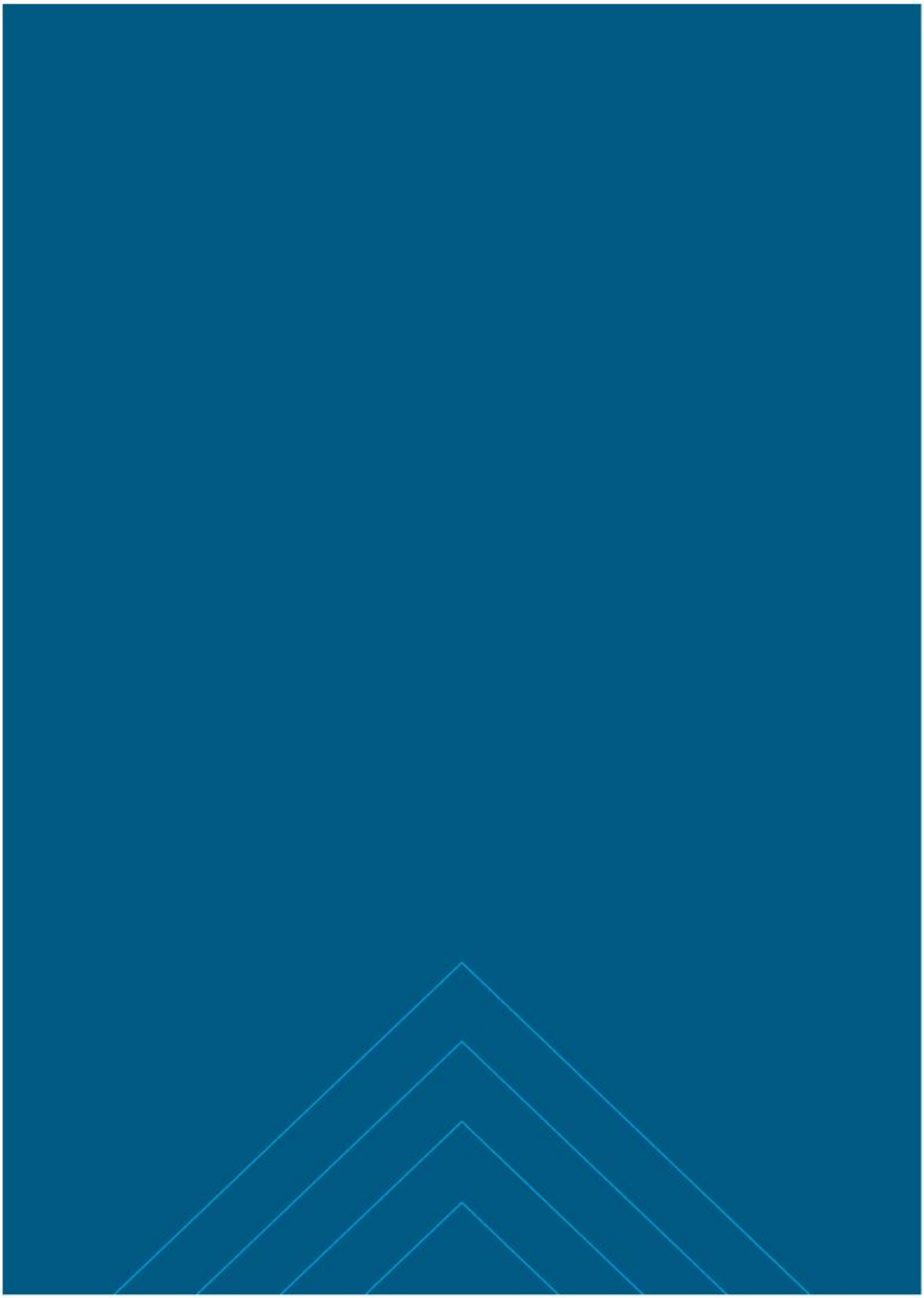


Executive Summary

The Lower River Crane in west London, has been previously channelised into a concrete, trapezoidal channel for historic flood alleviation purposes. This change occurred during the Twentieth Century at various stages. This new, largely straightened planform replaced the original highly meandering one. Throughout the Lower River Crane's course, it goes through many open areas. Unfortunately, it is now generally aligned to the edge of the parks and is often visually lost from the current landscapes.

Opportunities to improve the riverine environment of the Crane catchment were increased when the Crane Valley Partnership (CVP) became a fully functioning catchment partnership in 2013. In 2017, the CVP funded a project to develop a Landscape Vision for Lower River Crane. This work was undertaken by Astronaut Kawada. The output from this project was a high-level vision for the restoration of the Lower River Crane but it did not examine the feasibility of any proposals in detail.

The aim of this report is to undertake a feasibility assessment and options appraisal of the initial concept vision developed by Astronaut Kawada. The report outlines more defined options, and spatially specific scenarios, along this theme. The initial stage of this work was the undertaking of a site visit held by a multidisciplinary team to discuss the proposals in more detail and identify clear opportunities and constraints. Following this visit, an internal options workshop was held to determine the broad principles for the project. A series of baseline studies have followed which have included:

- a geo-environmental desk study;
- an ecological baseline assessment (using available information and the site visit);
- an engineering review (which as well as the site visit also reviewed a constraints map which was developed following a utility services search);
- a high, level structural review of all the weirs that currently exist along the Lower River Crane (using information from a site visit and review of existing information):
- a geomorphological assessment (using historical information as well as information obtained from the site visit); and finally,
- a landscape assessment (using available information and the site visit).

An assessment of the key international, national and local legislative drivers (which included a review of local plans) was also undertaken to ensure that any options developed would be aligned to the appropriate strategies. The information gathered from these various studies and reviews was used to develop viable restoration options. Three options were ultimately developed that could be taken forward across the 3 km reach of the Lower River Crane, namely:

- Option 1 – Instream measures – proposed where space is severely constrained;
- Option 2 – Bank reprofiling – proposed where there is some more space to remove the hard protection and batter the slope but not sufficient space to allow for full restoration; and,
- Option 3 - River restoration (with variations) – proposed where there is sufficient space in the adjacent area to fully move the channel and develop a more naturalised, self-sustaining profile.

An initial opportunities map was developed for the Lower River Crane largely based on information gleaned from a utilities map and a geo-environmental desk study. The practical options proposed at each location aimed to avoid having to move utilities and avoid any areas that could have any significant land contamination issues (which are both likely to be very expensive to change). By doing this process, high costs associated with each of these issues can be avoided. Spatially specific scenarios were then developed throughout the Lower River Crane based on the options detailed above. The options, and spatially specific scenarios, were discussed at an options workshop on 28th November 2018 where interested parties were consulted to determine their views on the proposals. The views were taken on-board and the various proposals amended accordingly. At this stage, all viable proposals that have been developed in various locations are being taken forward. The exact nature of the work that gets undertaken in each location will be subject to further discussions that would define the preferred option in each area.

For each of the scenarios detailed, indicative costs (at this feasibility stage) were developed. This provides costs for taking each of the options forward through detailed design and then construction. An overall Natural Capital Assessment has also been undertaken to assess the value of the environment and how the changes proposed will enhance the overall natural capital value. Recommendations for further work to progress each of the scenarios have been detailed in the final sections of the report.

1. Introduction

1.1. Lower River Crane

The Lower River Crane from its diffluence with the Duke of Northumberland's River in Twickenham (TQ 14959 73290) down to the confluence with the River Thames in Isleworth (TQ 16676 75386) has been previously channelised into a concrete, trapezoidal channel for historic flood alleviation purposes. This has occurred gradually throughout the 20th Century. There are a series of small weirs along the Lower River Crane that now act to retain flow. The new straightened planform replaced the original meandering form which has now been largely filled in. Alongside the change to the river course, there has been rapid growth within the catchment with significant changes in the existing infrastructure. Much of the area around the Lower River Crane is now urbanised outside any urban parks. The changes to the catchment have altered the way in which the channel responds to rainfall. The increased urbanisation leads to a flashier response within the river following any significant rainfall events.

Current projections suggest that the population of the Crane catchment will grow by 15% over the next 20 years. This along with major expansions proposed for Heathrow and ambitious development projects throughout the Boroughs of Richmond on Thames and Hounslow puts existing infrastructure, some of which is already failing or at capacity, under increased pressure. Organisations such as Thames Water are already planning initiatives such as Thames 2100, Twenty-4-Twenty and 'Smarter Water Catchments' looking to establish a long-term sustainable programme for its services provision that includes schemes that can provide wider community benefits such as green infrastructure projects that provide natural capital, ecosystem services and social wellbeing.

The Lower River Crane is also significantly controlled by the Mereway Weir at the upstream extent of the river at the diffluence of the Duke of Northumberland's River. The Duke of Northumberland's River is an artificial channel which was originally cut to provide water to Syon Park. The source of the water is from the River Colne. Historically, much of the normal flow was taken down the Duke of Northumberland's River with the Lower River Crane becoming dry during the summer time. A certain water level was needed to be reached before flow went down the Lower River Crane. The Environment Agency has recently made subtle changes to the tilting weir to change the split of flow down both channels. The Flow Improvement Project was started in November 2017, with the lowering of the weir. This alteration has had significant positive impacts over the last year with continuous flow being provided down the Lower River Crane. Monitoring to assess the potential impacts down the Duke of Northumberland's River and Lower River Crane took place throughout the year. These data are currently being analysed with the results made available later in 2019. The weir will also be replaced within the next three years, with a fish pass included as part of the design.

There has been increasing pressure over the last few years to restore the Lower River Crane to improve the biodiversity value. The Crane Valley Partnership (CVP) was established in 2005 with the goal to improve the water quality and biodiversity of the Crane catchment. Since 2013 the CVP has functioned as a Catchment Partnership under Defra's catchment-based approach. The Partnership consists of various regulatory bodies and local interested parties. The five mission statements of the Partnership are as follows:

- raise awareness and support action for conservation, restoration and new approaches to design and management of the river valley.
- to help communities take a sustainable approach to managing and improving the River Crane and its tributaries.
- to improve and protect the biodiversity of the area.
- to maximise the use of the river corridor as a resource for healthier living and educational activities for local people.
- to promote connectivity along the river corridor.

The group has been very active on the Lower River Crane and the Duke of Northumberland's River. Channel improvement works have already been undertaken on the Duke of Northumberland's River. Improvements are illustrated in Figure 1-1. Alongside this work a 'Landscape Vision for the Lower River Crane' was commissioned by the Partnership and developed by Astronaut Kawada Architecture. This set out a high-level restoration vision for the Lower River Crane. Further details are provided in Section 1.2.

Atkins, part of SNC-Lavalin Group, was commissioned in August 2018 to undertake a feasibility assessment and options appraisal of this initial concept vision. This report describes this work and the steps undertaken to develop a restoration plan for 3 km of the Lower River Crane taking into account all the various constraints and opportunities that were identified. The work sought to assess the feasibility of the vision previously developed. It provides more detailed options which could be taken forward in specific areas. Where constraints limited the scope of the restoration options, alternative, more refined, options were developed that would improve the habitat within the channel but would retain the river in the current alignment.

Figure 1-1 – Habitat enhancements undertaken on Duke of Northumberland's River

Initially a large desk study (Section 3) was undertaken to review the existing conditions of the survey area. This included: i) a geo-environmental desk study; ii) an ecological baseline assessment; iii) an engineering review; iv) a structural review of the weirs; v) a geomorphological assessment; and finally, vi) a landscape assessment.

Options development was taken forward and this is detailed in Section 4. More detailed, spatially specific, restoration plans are illustrated in Section 5 across the whole length of the Lower River Crane. To ensure that the project is supported by the steering group, each of the key options and spatial plans were discussed at an options workshop on 28th November 2018 with interested parties. Costings were developed for each of the spatially specific plans and these are detailed in Section 6. A Natural Capital Assessment was undertaken to attempt to estimate, in monetary terms, the impact of the restoration plan on ecosystem services provision at the sites, to contribute to the economic assessment of the scheme. Details of this assessment are outlined in Section 7. Finally, key findings and recommendations for further work have been detailed in Section 8.

1.2. Landscape Vision for the Lower River Crane

The Landscape vision developed by Astronaut Kawada Architecture aimed 'to demonstrate the natural link between the River Crane and the River Thames, with a much improved 3 km river corridor linking with the rest of the River Crane Catchment.' The report was completed in March 2017. For the Lower River Crane, the Crane Valley Partnership would like to see:

- a more natural river full of plants, fish and wildlife, running through re-landscaped parks and open spaces, with improved facilities;
- an accessible riverside path all the way from Kneller Gardens to Northcote Nature Reserve; and,
- more space in the river channel for water, to reduce the risk of flooding.

The landscape vision identified four key areas within the study area. The descriptions and potential restoration opportunities in each of these areas are detailed below:

- Mereway Nature Park and Craneford Way Recreation Ground – Substantial opportunities for naturalisation and improvements to the river and surrounding landscape exist within this area.
- Twickenham Rough and Twickenham Town Centre – Opportunities revolve around in-channel enhancements, rather than full restoration, and access improvements.
- Moormead and Bandy Recreation Ground (Moormead Park) – There are opportunities to create an attractive visitor experience by integrating the river with the park landscape.
- Cole Park Island – Opportunities exist for naturalising the river and opening it up for public access.

1.3. Public consultation

Stakeholder engagement to the landscape vision was undertaken between 23 November 2017 and 8 January 2018 through questionnaires. The consultation process received 202 responses. Overall, the consultees were supportive of the proposals with 72% of the respondents being fully supportive of the proposals set out in the vision. Some of the key themes that people wanted to see were the improvement of instream and marginal conditions of the river along with improvements to access for both people and cyclists. Currently only certain sections of the 3 km of channel outlined in the vision is connected via public access, but long sections are not connected. Of those people who did not support the vision the main reasons expressed were with respect to a loss of privacy and concerns that actually encouraging increased access may in itself be detrimental to wildlife

and diversity. There is a clear balance that needs to be achieved in delivering the vision on the ground to ensure that the various sensitivities can be fully addressed in any of the schemes that go forward into the detailed design phase.

2. Study Area

2.1. Lower River Crane

The Lower River Crane extends from the diffluence of the River Crane with the Duke of Northumberland's River to the western side Twickenham down to the confluence of the River Thames in Isleworth (Figure 2-1). At the start of the Lower River Crane the channel flows in an east-north-east direction. It flows past Mereway Nature park going under the railway line before flowing along the edge of Craneford Way playing fields and through Twickenham Rough. After Twickenham Rough, the channel flows into the centre of Twickenham where it is heavily constrained. Downstream of the station the Crane emerges into Moormead Park. In Moormead Park, the channel is constrained along the western perimeter edge and is largely isolated from the park itself. It starts to flow more in a northerly direction through the park and downstream. After Moormead Park, the channel flows at the back of houses until it crosses under Chertsey Road. Immediately downstream of the Chertsey Road, the river flows into an area known as Cole Park Island. Along the right bank of the channel an island is present between the present course and an old remnant course of the channel. The old course has recently been cleared out to enable more flow to go around it. The end of the Lower River Crane study is delineated by the crossing of Northcote Road. Downstream of this point the channel is fully tidal.

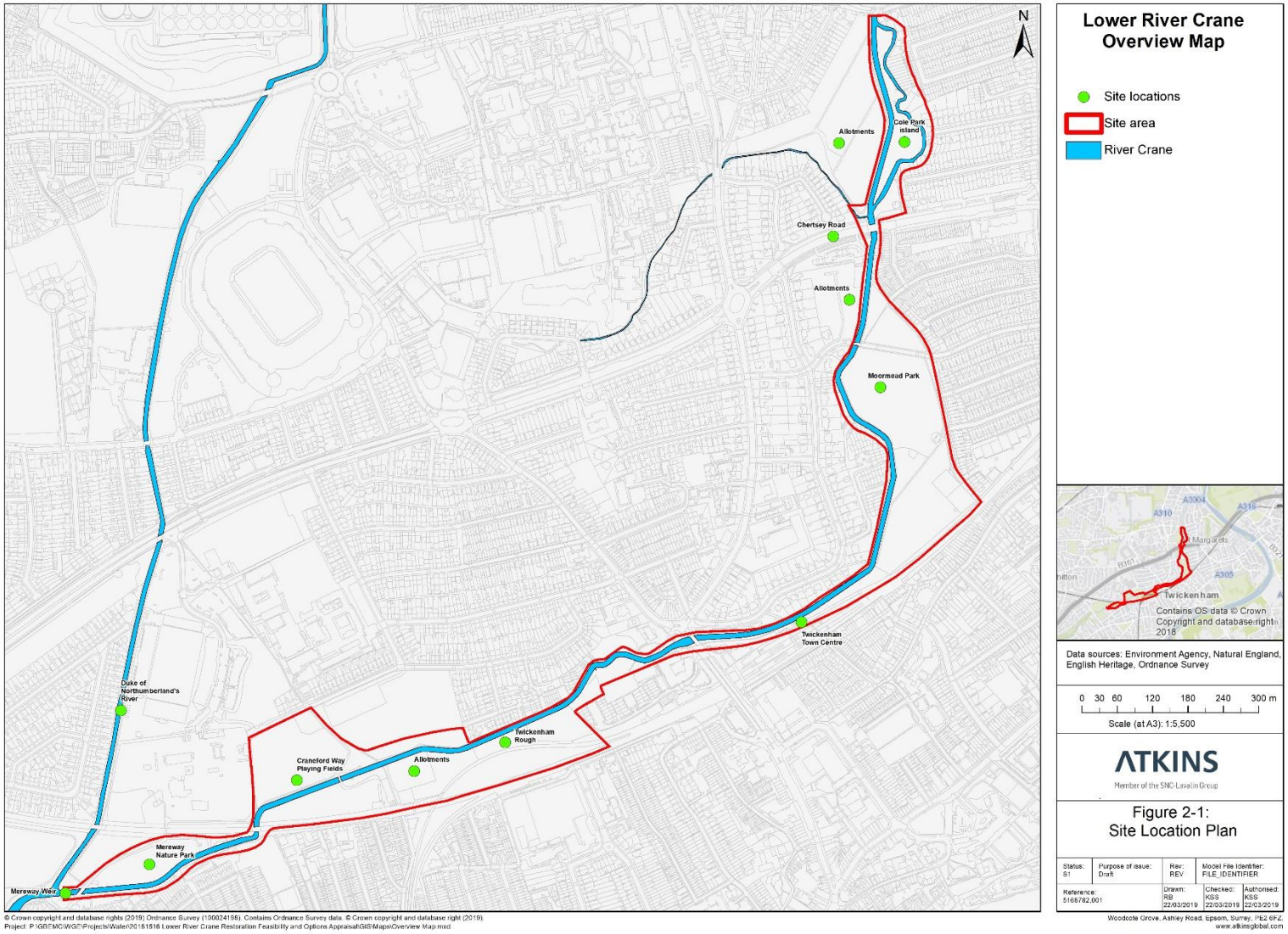


Figure 2-1 – Site location plan

3. Desk Study

3.1. Introduction

To assess the feasibility of the initial landscape vision developed by Astronaut Kawada Architecture a variety of separate, but related assessments were undertaken as part of this project. These included:

1. a geo-environmental desk study;
2. an ecological baseline assessment;
3. an engineering review;
4. a structural review of the weirs;
5. a geomorphological assessment; and finally,
6. a landscape assessment.

Each of these studies are detailed below in Section 3.2 to Section 3.6. A separate utilities search was also undertaken, and this is referred to in the engineering review.

3.2. Geo-environmental desk study

A geo-environmental desk study was undertaken to inform a feasibility assessment for restoring a 3 km reach of the Lower River Crane between Twickenham and St Margarets with the objective to identify potential land quality risks and constraints associated with the restoration proposal. A summary of this report is detailed below. The study area includes the river channel, surrounding soft landscaping and publicly accessible recreational areas of open space along the 3 km reach of the River Crane. Surrounding land is predominantly residential, but also includes commercial business estates, a railway line, allotments and Twickenham Railway Station.

The original River Crane followed a natural meandering course until the late 1890s when alterations and diversions were made to construct a concrete channel during the construction of the London and South Western Railway line and Twickenham Railway Station. Review of historical maps from the area along the study area and 2 km upstream have not identified significant industrial legacy that could represent a major source of contamination and a risk to river water quality. However, the land immediately surrounding the current river channel includes current commercial activities and has historically been used for railway activities and landfilling.

The deepening sequence of geology comprises superficial deposits of Kempton Park Gravel (Principal aquifer) located above approximately 48 m thickness of London Clay Formation (unproductive stratum) bedrock. Made ground is expected to be located above the superficial deposits where historical development and historical river diversion works have been undertaken. Superficial deposits comprising Alluvium, Head and Taplow Gravel Member are mapped upstream of the study area and the Langley Silt Member is mapped to the south of the river. Potential localised deposits of Alluvium are also indicated to overlie the Kempton Park Gravel within study area. Groundwater in the River Terrace Deposits is not abstracted locally for use and the quality of the water is likely to commensurate with urban groundwater and of limited resource potential. The relevant reach of the Lower River Crane is classified as having a ‘poor’ overall quality and there are no authorised discharges within the study area. Four non-statutory Sites of Importance for Nature Conservation are present within the site boundary. However, no statutory designated sites are located within 250 m.

Potential constraints associated with the scheme are predominantly associated with potential contamination in shallow soils and sediments due to previous phases of development and landfilling. The site in its current layout is unlikely to represent an unacceptable risk to site users and nearby residents. However, construction groundworks required for the regeneration of the River Crane site have the potential to mobilise dusts to air, generate waste soils, mobilise sediment to surface water and create preferential pathways to shallow groundwater. Appropriate construction and materials management will therefore be required during the construction phase to reduce exposure and releases of contaminated soil, sediment and dusts. Imported soils will also need to be validated as chemically suitable for landscaping in public open spaces.

Intrusive ground investigation works will be required to evaluate the physical and chemical characteristics of the ground along accessible areas of the current River Crane route and the route of potential future reprofiled channels and landscaping. These investigations will allow the characterisation of the soil, groundwater, surface water and ground gas environments and enable the update and reduction of uncertainty in the current Conceptual Site Model. The assessments will also allow appropriate mitigation strategies for the construction and post-construction phases.

The ground investigation information might also provide ground conditions information that allows the design team to select the most advantageous reprofiled river channel route based on construction costs, benefits and environmental sustainability.

3.3. Ecological Baseline Assessment

3.3.1. Walkover Survey

A walkover survey of the survey area was undertaken by the project team, including an aquatic ecologist on 6 September 2018 to support the desk study. This section provides a habitat description based on survey observations.

The River Crane within the survey area is a heavily modified river, with an artificial channel including a concrete bed, concrete banks and significant straightening of the channel planform. Due to this modification the river has limited habitat complexity to support aquatic species. Water depth within the Lower River Crane is typically shallow (<50 cm where not impounded), and flows are predominantly smooth and uniform. However, the channel is subject to a rapid rise in water levels during flood periods.

At the upstream limit of the survey area, some small fish were observed immediately downstream of Mereway weir, although the species was not identifiable from the bank. Despite fish presence, the water levels within the river downstream of the weir were low and deemed sub-optimal for larger fish species.

At Craneford Way playing fields, the river channel is over-widened and straightened and has a series of small weir structures built into the channel bed. Due to the artificial nature of the river bed and banks and the subsequent absence of a suitable growing medium, macrophyte growth is restricted at this location. During the walkover survey, marginal macrophyte growth was limited to a few isolated patches of reed sweet grass (*Glyceria maxima*) at the edge of the channel. Occasional riparian trees overhang the river channel providing patches of shade. However, the majority of the reach through Craneford Way playing fields is open which has resulted in the growth of filamentous algae.

Downstream of the playing fields the river is more shaded as it flows behind residential properties through Twickenham Rough. Riparian trees provide some addition of woody debris to the channel, increasing habitat diversity. The river then goes under a bridge below London Road before flowing into Moormead Park. During the walkover survey, a kingfisher (*Alcedo atthis*) was observed along the river corridor immediately downstream of the station.

At Moormead Park, the river remains similar in-channel profile to the upstream section at Twickenham Rough, however the channel is more heavily shaded. Through Moormead Park, flows were very slow during the walkover as a result of an impoundment caused by a weir just downstream of Hill View Road, coupled with over-widening of the channel.

Further downstream, the River Crane at Cole Park Island is similar in character to the reach flowing through Craneford Way playing Fields. The channel is open, and the accumulation of filamentous algae was observed. A side channel splits (which originally formed the main channel) off from the main course to the east of the island and has a more naturalised planform. The main channel, which was widened and deepened, remains heavily modified with concrete bed and banks restricting macrophyte growth.

3.3.2. Desk Study

3.3.2.1. International and Nationally Designated Sites

The desk study identified four sites with European or National statutory designations within 2 km of the survey area. These are: Richmond Park Special Area of Conservation (SAC), Site of Special Scientific Interest (SSSI) and National Nature Reserve (NNR); Syon Park SSSI; Ham Lands Local Nature Reserve (LNR); and, Isleworth Ait LNR. No statutory designated sites are located within the proposed Lower River Crane restoration area itself or associated with the River Crane further up or downstream.

3.3.2.2. Non-statutory Designated Sites

There are 30 non-statutory Sites of Importance for Nature Conservation (SINCs) within 2 km of the survey area, with four of these situated within the boundary (Table 3-1). The SINCs within the survey area are all on, or directly connected to, the River Crane and therefore may be affected by the proposed scheme. SINCs are recognised by the Greater London Authority and London borough councils as important wildlife sites.

Table 3-1 – Sites of Importance for Nature Conservation within the survey area

Type of SINC	Site Reference	Site Name	Summary	Grid Reference
Local Importance	RiL10	Twickenham Junction Rough	Just west of Twickenham station, the railway lines divide leaving an 'island' of undisturbed habitat. The site contains a mix of rough grassland, tall herbs, scrub and young woodland. The old brick walls supporting the railway embankment support an interesting fern community including three species scarce in London (wall-rue (*Asplenium ruta-muraria*), maidenhair spleenwort (*A.trichomanes*) and black spleenwort (*A. adiantum-nigrum*)).	TQ 156 734
Local Importance	RiL25	Moor Mead Recreation Ground	Recreational park alongside the River Crane comprised of amenity grassland, running water, scattered trees, semi-improved neutral grassland and tall herbs. The site supports a fair range of common bird species.	TQ 164 740
Borough Grade II Importance	HoBII07	The River Crane at St Margaret's	A section of the River Crane, lined with trees and shrubs that runs through allotments. The river is divided into two channels and kingfishers are frequently seen. This site includes the river at Chertsey Road and the tidal limit at Northcote Road, below which it is included in the River Thames and tidal tributaries Metropolitan Site.	TQ 163 746
Borough Grade II Importance	RiBII18	The River Crane at St Margaret's Richmond Side	A short section of the River Crane, just upstream of its tidal limit. The river is divided into two channels, lined with trees and shrubs. Kingfishers are frequently seen.	TQ 164 746

3.3.2.3. Water Framework Directive

The Lower River Crane is located within the Crane surface water body catchment (water body ID GB106039023030). Table 3-2 outlines the current WFD status of the water body as provided on the Environment Agency's Catchment Data Explorer website[1]. The Crane is not designated as an artificial or heavily modified water body (A/HMWB) under the WFD because despite being obviously modified and significantly straightened, the watercourse does not require this planform to be maintained for the provision of alternative uses e.g. flood protection or navigation purposes. The Crane water body currently has an overall status of Poor, with an ecological status of Poor (including biological quality elements) and chemical status of Good.

[1] Environment Agency Catchment Data Explorer website – https://environment.data.gov.uk/catchment-planning/ [Accessed 21/12/2018]

Current WFD status indicates that the River Crane is characterised by poor ecology which is, at least in part, due to the significant modification observed along the river. Within the survey area, the concrete lined channel is likely to significantly limit both instream and riparian habitat quality. The range of aquatic species that can be supported are thus restricted.

The downstream receiving water body is the Thames Upper (water body ID GB530603911403) transitional and coastal water body (TRaC).

Table 3-2 – River Crane (GB106039023030) current WFD status

Classification Item	Current Status (2016 unless stated otherwise)
Overall water body	Poor
Ecological	Poor
Supporting elements	Moderate (in 2014)
Biological quality elements	Poor
Macrophytes and phytobenthos combined	Poor
Fish	Moderate
Invertebrates	Moderate
Hydromorphological regime	Supports Good
Hydrological regime	Does Not Support Good
Physico-chemical quality elements	Moderate
Acid neutralising capacity	High
Ammonia (phys-chem)	Good
Biochemical oxygen demand (BOD)	Good
Dissolved oxygen	Moderate
pH	High
Phosphate	Poor
Temperature	High
Specific pollutants	High
Triclosan	High
Copper	High (2014)
Zinc	High (2014)
Chemical	Good
Priority substances	Good
Other Pollutants	Good
Priority hazardous substances	Good

3.3.2.4. Macroinvertebrates, Macrophytes and Fisheries data

Environment Agency routine monitoring sites were identified within 2 km of the survey area using data.gov records. Recent[2] data (less than five years old) have been reviewed to provide baseline information for fish, aquatic invertebrate or aquatic macrophytes.

Two fish-monitoring sites with recent survey data were identified within 2 km of the survey area; one of these is located within the survey boundary. Table 3-3 provides details of the species present and numbers caught.

[2] Only recent data are reported within this feasibility and options appraisal. Data more than five years old are not considered to provide a representative example of current species composition due to the potential for significant changes in habitat during the interim period. Although not reported, professional judgement has been applied throughout the desk study and older datasets. were reviewed to check for any anomalies within recent monitoring. The recent data reported are considered to provide appropriate background information on the species potentially present in the River Crane within the study area.

The recent Environment Agency monitoring recorded nine fish species within 2 km of the survey area. These are predominantly common species, widespread throughout the UK. However, the notable species European eel (*Anguilla anguilla*) was also present. European eel is a Species of Principal Importance as covered under section 41 (England) of the NERC Act (2006) and also designated as Critically Endangered on the IUCN Red List (2010). Despite this designated status, European eel was present only in very low abundances during monitoring surveys, and eel passage is restricted by numerous barriers to migration as observed during the walkover. It therefore is considered that a substantial population of European eel is unlikely within the River Crane. European eels are known however to negotiate their way up the various weirs on the Lower River Crane to Mereway Weir which they cannot pass. However, the European eel can pass up the Duke of Northumberland's River from the River Thames through to the remainder of the Crane catchment upstream. Nonetheless, it should be considered that a low abundance of European eel may be present within the study area and precautionary methods of working may be required during the proposed restoration works.

In addition to European eel, the notable species bullhead (*Cottus gobio*) is present within the River Crane. Bullhead is designated as a Non-Priority Annex II species under the Habitats Directive (the European Community adopted Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, amended 2003). Whilst a species of European interest, the presence of bullhead within the River Crane is not considered to be notable within the context of the wider catchment as records of the species are present in other local rivers, namely the Duke of Northumberland's River.

The remaining fish species recorded during the recent Environment Agency monitoring are not designated as notable or of conservation concern, except for stone loach which is listed as a species of Least Concern on the IUCN Red List (2010). Meaning it is not considered to be endangered or rare.

Table 3-3 – Background fish data

Date	Species	Number caught
Crane Park (within 2 km) Site ID 17310 TQ1441972974		
10th September 2014 no. of runs = 3; survey area 700m^2	Chub (*Leuciscus cephalus*)	83
	European eel (elvers) (*Anguilla anguilla*)	1
	Minnow (*Phoxinus phoxinus*)	100 to 999
	Stone loach (*Barbatula barbatula*)	10 to 99
	3-spined stickleback (*Gasterosteus aculeatus*)	10 to 99
15th September 2015 no. of runs = 1; survey area 700m^2	Bullhead (*Cottus gobio*)	10 to 99
	Dace (*Leuciscus leuciscus*)	31
	Gudgeon (*Gobio gobio*)	47
	Chub	10
	Stone loach	10 to 99
	Minnow	100 to 999
	3-spined stickleback	10 to 99
28th October 2016 no. of runs = 3; survey area 950m^2	Dace	48
	Chub	40
	Gudgeon	2
	Roach (*Rutilus rutilus*)	1
	European eel (> elvers)	1
	Minnow	100 to 999
	Bullhead	100 to 999
	Stone loach	10 to 99
	3-spined stickleback	100 to 999
	European eel (elvers)	1
Marsh Farm (within the Site) Site ID 70524 TQ1534573451		
12th October 2017 no. of runs = 1; survey area 814m^2	Stone loach	3
	3-spined stickleback	2

One macroinvertebrate monitoring site with recent macroinvertebrate survey data is located within 2 km of the Site[3]. Recent survey data from this site are presented in Table 3-4 along with relevant biotic metrics.

Macroinvertebrate monitoring data from the River Crane indicate the presence of a moderately diverse macroinvertebrate community with number of scoring taxa (No. Taxa) ranging from 19 to 26 in 2014. BMWP

[3] Environment Agency macroinvertebrate monitoring site ID 33880, located approximately 1.75 km from the Site boundary.

(British Monitoring Working Party) scores are indicative of good to high water quality, with the likely presence of a range of pollution sensitive and pollution tolerant taxa (as indicated by the ASPT (Average Score Per Taxa) scores).

Additionally, LIFE (Lotic-invertebrate Index for Flow Evaluation) scores are indicative of communities generally adapted to slow flow conditions (Species LIFE of 6.75). Field observations support this conclusion, with flows typically slow and shallow throughout the survey area, however it should be noted that the macroinvertebrate monitoring site has different habitat characteristics to the channel within the survey area. Areas of slow flowing water were observed upstream of weir structures and bridges throughout the Lower River Crane, and there were a number of reaches where wetted widths were notably reduced compared to the channel width (which has been artificially over-widened), namely at points through Craneford Way playing fields.

Table 3-4 – Background macroinvertebrate data

Biotic Metric	Crane Park Hanworth Site ID 33880, TQ1324372850	
	18/03/2014	12/11/2014
BMWP	92	138
ASPT	4.84	5.31
No. Taxa	19	26
Family LIFE	6.59	6.41
Species LIFE	6.75	6.75

Notes: BMWP is the Biological Monitoring Working Party score. ASPT is Average Score Per Taxon. LIFE is Lotic-invertebrate Index for Flow Evaluation score.

One Environment Agency macrophyte monitoring site is located within 2 km of the survey area[4], approximately 1.75 km upstream at Crane Park. Results from the most recent survey here in 2014 indicate that the river has a moderate number of functional macrophyte groups (eight) at this location. This is indicative of a watercourse with some level of habitat diversity. However, the dataset does not provide information on percentage cover or abundance. Observations from the walkover survey indicate that macrophyte cover was low within the survey area and the WFD status of the macrophyte and phytobenthos combined element is also at poor.

No recent (<5 years old) RHS (River Habitat Survey) data is available on the River Crane for the Site or within 2 km of the Site. However, results from Urban River Surveys (URS) at Craneford Way playing fields (22 August 2018) and Cole Park Island (22 August 2018) are available. Both the stretch of the River Crane at Craneford Way playing fields and the concrete channel at Cole Park Island returned Stretch Habitat Quality Index (SHQI) scores of 12, which is below average. These stretches were very heavily engineered and had complexity classes of low and very low, respectively. The URS results suggest the River Crane should be targeted for rehabilitation e.g. through altering level and/or type of reinforcement and through increasing channel sinuosity where possible. An additional URS at Cole Park Island on 6 September 2017 undertaken on the natural channel to the east of the main channel returned a SHQI of Good (6), with a high complexity class.

3.3.2.5. Other Species

A number of protected species and species of conservation concern have been recorded within 2 km of the survey area. Details of key species groups identified from the desk study that may need to be considered within the planning application process are provided below. Only notable species records from the last 10 years are included. It should be noted that exact locations of records are unknown and therefore species listed may or may not be present. Further survey may be required to determine species presence and to inform mitigation prior to the works.

3.3.2.5.1. Bats

Eight species of bat have been recorded within 2 km of the survey area. These are serotine (*Eptesicus serotinus*), Daubenton's (*Myotis daubentonii*), lesser noctule (*Nyctalus leisleri*), noctule (*Nyctalus noctule*), brown long-eared (*Plecotus auratus*), Nathusius's pipistrelle (*Pipistrellus nathusii*), soprano pipistrelle (*Pipistrellus pygmaeus*) and common pipistrelle (*Pipistrellus pipistrellus*). The River Crane is likely to act as an important foraging corridor, particularly for the Daubenton's species. Moreover, riparian trees could provide roosting potential, although as yet, no detailed survey has been undertaken to identify this. Consideration would

[4] Environment Agency macrophyte monitoring site ID 33880, located approximately 1.75 km upstream of the Site boundary.

need to be given to the potential presence of bats within the river corridor prior to any restoration works. Further surveys may be required to determine species presence and population abundance located within the survey area, to identify any associated constraints and inform any requirements for mitigation and precautionary methods of working.

3.3.2.5.2. Otters and Water Vole

The desk study returned one record of European otter (*Lutra lutra*) from 2017 within 2 km of the survey area. The precise location of this record is not known, therefore it is unknown if this record exists along the River Crane or is associated with another watercourse, such as the River Thames or the Duke of Northumberland's River. Nonetheless, given the mobile nature of otter, it should be considered that the species may utilise the River Crane for feeding. No otter holts were observed along the River Crane during the walkover survey. Further surveys may be required to determine species presence within the study area, to identify any associated constraints and inform any requirements for mitigation.

Records of European water vole (*Arvicola amphibious*) also exist within 2 km of the survey area, with the most recent record from 2017. However, due to the modified nature of the River Crane, notably the extent of concrete banks, the river within the project area is not considered suitable habitat for the species. It is probable that these records are associated with habitat either up or downstream of the survey area or on another watercourse within the 2 km. An information board at Mereway Nature Park, immediately upstream of the survey area, indicates water vole are present within the River Crane at Kneller Gardens and therefore may utilise other parts of the river for feeding. Although habitat is generally considered not suitable for water vole within the Lower River Crane, further detailed survey may be required to determine any species presence to identify any associated constraints and inform any requirements for mitigation.

3.3.2.5.3. Great Crested Newt

The desk study returned one record of great crested newt (*Triturus cristatus*) from 2017 within 2 km of the survey area. Since the Lower River Crane is a running watercourse it is not considered suitable habitat for newts, however, further surveys may be required to determine species presence and population abundance located within the survey area associated with other habitat features, such as ponds, to inform mitigation requirements.

3.3.2.5.4. Birds

The desk study returned several records of birds with associated designations for protection and conservation including six species of Principal Importance (as designated under the NERC Act Section 41), namely cuckoo (*Cuculus canorus*), reed bunting (*Emberiza schoeniclus*), spotted flycatcher (*Muscicapa striata*), house sparrow (*Passer domesticus*), tree sparrow (*Passer montanus*) and turtle dove (*Streptopelia turtur*). Further detailed survey may be required to determine species presence within the Site, to identify any associated constraints and inform any requirements for mitigation and precautionary methods of working prior to works.

3.3.2.5.5. Invasive Species

The following key invasive species have been identified within 2 km of the survey area[5]:

- Parrot's-feather (*Myriophyllum aquaticum*) downstream of the survey area on the River Crane (2002-2003).
- Japanese knotweed (*Fallopia japonica*).
- Signal crayfish (*Pacifastacus leniusculus*) upstream of the Lower River Crane (2013).

No invasive species have been identified within the survey area within the desk study. This does not preclude their presence, especially for those species associated with riverine habitats. Anecdotal evidence through the workshops has suggested that some Japanese knotweed has been found on the Cole Park Island.

Additional surveys would be required to identify which, if any, of these species are present within the survey area and what necessary mitigation measures would need to be employed during any restoration works, in relation to removal and disposal of waste and control of spread.

[5] Dates refer to the most recent record of the species as provided by eCountability Ltd on behalf of GiGL. Only invasive aquatic species that have been recorded within the River Crane have been listed above. Invasive species within other local watercourses, such as Zebra Mussel (*Dreissena polymorpha*), Canadian waterweed (*Elodea canadensis*) and Nuttal's waterweed (*Elodea nuttallii*) have been excluded from the report. However, this does not preclude their presence from the survey area and the potential for additional invasive species will need to be considered a potential constraint to any proposed works. Appropriate management procedures to reduce the risks associated with invasive species will need to be outlined prior to any works.

3.3.3. Ecological baseline summary

The Lower River Crane is a significantly modified river with an artificially straightened planform, comprising a concrete bed and banks, resulting in limited habitat diversity. Water depth throughout the Lower River Crane was typically shallow during the walkover survey and flow diversity poor. In-channel vegetation was notably scarce and riparian vegetation was often restricted to overhanging trees and terrestrial grass and scrub species. Only a few patches of marginal macrophytes were observed within the study area at Craneford Way playing fields. Nonetheless, the watercourse provides a continuous 'green and blue' corridor throughout a predominantly urban environment.

Four sites with statutory designations are located within 2 km of the study area. However, none of these are associated with the River Crane or located within the proposed restoration area itself.

The desk study identified 30 SINCs within 2 km of the study area, four of which are located within the study area and associated with the River Crane. Relevant measures would need to be adopted as part of the scheme to avoid any deterioration in the status of these sites. However, it is considered that the scheme will act to enhance the biodiversity of these sites through improving habitat suitability for a number of species within the Lower River Crane. Any measures may also need to be balanced against changes to the wider environment particularly where any proposed restoration scheme alters the nature of existing green space.

There are a number of records of protected and notable species within the survey area and the wider 2 km search. Additional surveys would be required to determine the presence/absence of these species and to inform any requirements for mitigation prior to required planning applications and subsequent construction works.

There is potential for invasive plant species to be located in the survey area and for these to be disturbed during the proposed works. Relevant mitigation measures and disposal measures would need to be adopted as part of the scheme.

3.3.4. Ecological opportunities

Since the existing condition of the river is heavily modified (re-sectioned and re-enforced), all proposed options provide substantial opportunities to improve the ecology of the river through improving physical habitat and flow character. Any amendments to the river form will also need to be balanced against changes to the wider environment particularly where recreation is concerned which may change significantly where any restoration scheme is proposed.

Observation of the neighbouring watercourse, the Duke of Northumberland's River, during the walkover survey demonstrated that even simple measures to improve in-channel habitat complexity can be highly effective, even within a heavily modified urban stream. At this location, the addition of coir rolls at the base of the banks narrowed the channel to increase flow velocities and provide improved marginal habitat.

The potential options for the Lower River Crane outlined in Sections 4–5 gives the opportunity to incorporate river restoration designs to enhance riverine ecology within the survey area.

3.4. Engineering Review

3.4.1. Concrete channel construction

Much of the river as it passes through the study area is a concrete, trapezoidal channel. It is understood that works to straighten and deepen the river were undertaken from the 1920s in an effort to alleviate flooding, and the concrete channel is typical of many UK urban watercourses. The proposed river restoration options considered by this study includes the concrete channel being removed in places. To aid detailed design and costing, it would be useful to obtain as-built drawings or other design information if available, or records from more recent asset surveys. In particular, details of wall or bed thickness, or the presence of reinforcement, would be useful. Breaking out the existing concrete structure will generate a significant volume of waste material. To avoid off-site disposal (and hence achieve cost savings) it may be feasible to reuse this waste material as aggregate or fill in the proposed designs. This should be considered as the project progresses to the next phase. In other areas, where the channel is being realigned, there may be opportunities to retain the existing concrete structure and infill it. This would need further assessment in the next phase of the project, but such an approach could help reduce costs and help manage project risk (e.g. impact on nearby structures).

3.4.2. Drainage and Flood risk

There are various surface water drainage outfalls that discharge into the river through the study area. Any changes to the river alignment will need to take account of these, with modified outfalls forming part of the final scheme design. As the project progresses to the next phase, records should be sought from Thames Water and/or the local authority to confirm the nature of these outfalls, determine whether they are still needed and establish an appropriate solution. Potentially, there could be opportunities to combine any modifications resulting from the river restoration with local drainage upgrades. Similarly, there could be opportunities to introduce SuDS (Sustainable Drainage Systems) in the park, with end of pipe SuDS features bringing water quality, fluvial runoff attenuation and amenity benefits. Opportunities to link up with other projects and initiatives should be explored in the future. For example, Thames Water is developing ‘Smarter Water Catchments’ to work collaboratively and take a catchment management approach to help address surface water flooding and poor, quality discharges from combined sewer overflows (CSOs). Working together may help the proposals to be progressed or present other ideas within the catchment. Similarly, a high-level review of opportunities to retrofit SuDS has been undertaken by the Greater London Authority with individual London boroughs. It would be beneficial to see how this knowledge can be used during the next phases of the project, to identify how SuDS measures can be integrated into the landscape adjacent to the river to support the overall design vision. The impact on flood risk from any river works or landscaping within the river corridor will need to be considered. Currently areas around Craneford Way playing fields, Moormead Park and Cole Park are all within Flood Zone 2 as defined by the Environment Agency flood maps (Figure 3-1). This means that the land has a medium risk of flooding having between a 1 in 100 and 1 in 1,000 annual probability of river flooding. A flood risk assessment will need to be undertaken to demonstrate that the proposals do not have an adverse impact on flood risk; ideally the schemes will benefit flood risk management through the study area. The Environment Agency Crane Hydrological model is due for review and update. This will be used by the restoration project as a baseline against any design options to be assessed.

3.4.3. Construction Access

Access for construction vehicles (plant and materials deliveries) is likely to be a major constraint during construction as well as the management of the recreation areas and disposal of any arisings. The proposed restoration schemes have been considered one by one below.

Mereway Nature Park

Construction access in this area is relatively good.

For works to restore the channel immediately downstream of the Kneller Road bridge (downstream of Mereway Weir) the river can be accessed via the existing Environment Agency compound and slipway off Kneller Road. This may also be a suitable location for a site compound or alternatively it may be possible to use the old Mereway Day Centre site.

Kneller Road would also provide further access for work within the nature park area to the north of the channel, such as footpath improvements and landscaping.

Craneford Way Playing Fields

This site would be accessed from Craneford Way. There are existing gates from the road into the playing fields (for grounds maintenance), which should be adequate for construction vehicles.

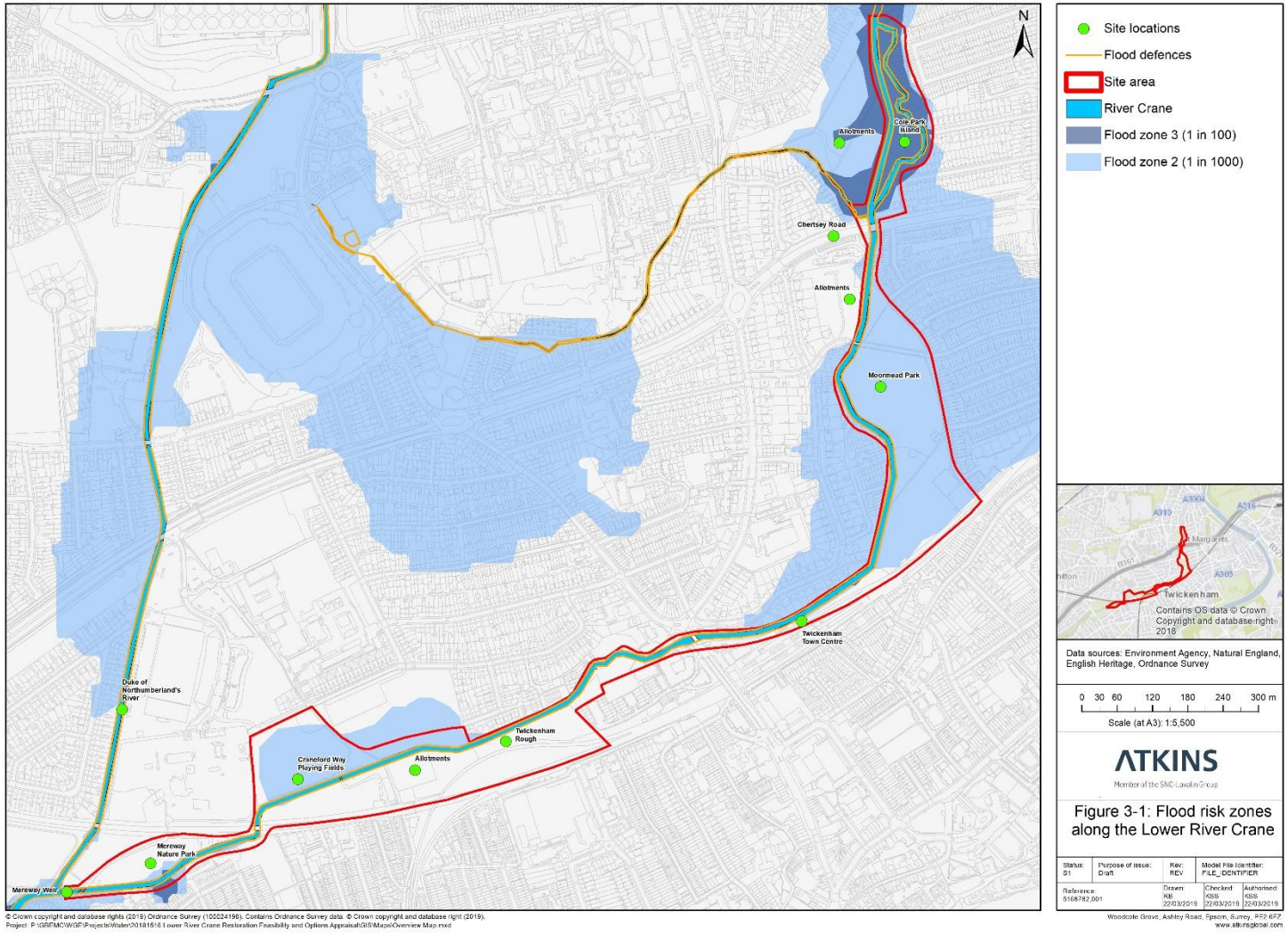


Figure 3-1 – Flood zones on the Lower River Crane (using EA flood maps)

Access to the site is relatively good although it should be noted that this is a largely residential area.

Although it is recognised that this is an important amenity area, it should be feasible to create a temporary site compound within the playing fields area. Close to the football pitches is an area of hardstanding which may be suitable, being close to the road (to facilitate deliveries) and to avoid damage to the grassed areas.

Working within a public park and close to both a children's play area and college, it will be important to develop a traffic management plan and ensure safe working practices.

Twickenham Rough

Access to the proposed working area is best coming from Craneford Way playing fields, where there are existing gates from Craneford Way. Vehicles would then need to cross the playing fields to access the river opposite the allotments.

Access to the site from the south is constrained by the presence of the railway lines.

The other alternative would be to access the site via the new footpath that has been created, linking Twickenham Rough with the town centre, although this would not be ideal.

The potential site compound area identified above for the Craneford Way playing fields area could potentially be adopted for Twickenham Rough works. Another possible scenario would be to see if there is an opportunity to use the shooting club site. The bridge across the river would need to be appraised before confirming it is suitable for construction vehicles.

Again, working within a public park and close to both a children's play area and college, it will be important to develop a traffic management plan and ensure safe working practices.

Moormead Park

It is assumed that access to the site would be from Moormead Road, at the eastern edge of the park, or Hillview Road to the north. There is good access from the road although it must be remembered that this is a largely residential area.

Once within the park, vehicles could track to the proposed working areas in and close to the channel.

Potentially there is likely to be suitable area in the park that could be used as a temporary site compound.

As with most of the other sites, the proposed works are within a public park that feature a children's play area, sports facilities and footpaths. It will be important to develop a comprehensive traffic management plan and ensure safe working practices.

Cole Park Island

It is anticipated that construction access to this site would be from Northcote Road at the northern end of the site, where there is a gate used by the allotments. Although this is a largely residential road, there is relatively good access from the main A310, Twickenham Road.

Alternatively, there may be a scenario to access the site through the allotments, from Twickenham Road.

There may be a suitable area that can be used as a temporary site compound within the allotments, although no obvious clear areas have been identified. Another option might be to enquire whether to utilise the green space close to the main allotments entrance, at the junction of Twickenham Road and Crane Avenue.

3.4.4. Buried Services

A buried services search has been undertaken to support this report. A summary of key findings in the main areas that have the potential for river restoration is detailed below. The high-level assessment as part of the feasibility study has identified the following services as most likely to be a constraint or be affected by the proposals.

- Mereway Nature Park – there is a gas main close to the railway line, power cables through the Nature Park and a Thames Water asset under the river.
- Craneford Way playing fields – a Thames Water asset runs across the playing fields as well as numerous power cables across the river.
- Moormead Park – there is a Thames Water main towards the north of the site and an electricity cable alongside the path.
- Cole Park Island – there is an electricity cable close to the channel.

As the project moves to the next phase of design and planning, further checks should be undertaken. This is likely to involve further consultation with the relevant utility companies and potentially on-site investigations. At that stage, the need for service diversions should be reviewed in partnership with the asset owners. If this is likely then opportunities to alter the design may be preferable, to reduce costs. Where services are laid at such

a depth that they are not affected by the proposed work, checks should be undertaken to ensure that the proposals do not hamper access to the assets.

3.4.5. Health and Safety considerations

As the project progresses, and with reference to the Construction (Design and Management) Regulations (CDM), the following health and safety issues should be given appropriate attention.

- Working in an urban park:
  - Careful traffic management to protect members of the public from vehicle movements, especially near the football pitches, children's play areas and footpaths.
  - Good signage and fencing to keep members of the public out of working areas.
  - Measures to minimise theft and vandalism and avoid the risk of pollution or sharps injuries.
- Working in and around water:
  - Measures to control risk of drowning (especially given the flashy nature of the river) and hygiene issues (e.g. leptospirosis).
  - Pollution prevention controls.
  - Maintaining the standard of flood protection during construction.
- Buried services.
- Working close to a live railway.
- Invasive plants and contaminated land.

3.5. Structural Condition Survey

3.5.1. Introduction

A one, day site walkover of the Lower River Crane between Kneller Gardens and Northcote Road was undertaken to assess each of the weirs located within the Lower River Crane with the focus on weir removal. Each of the 15 barriers, or weirs, were assessed for their structural condition, ease of removal, ease of access to site and assessment of any increased risk to bank or bed stability as a result of removing the weir. The weir identification is based on the London Wildlife Trust Report on weir removals (London Wildlife Trust, 2016).

It should be noted that this assessment is not an in-depth inspection of each weir but rather a high-level assessment with comments made from observations taken during the site walkover. For this reason, assessments of silt and water levels could not be made, nor could assessments of structures or parts of structures be made where the entire structure could not be observed from the river bank. The construction of the bank walls was ascertained to be concrete. The banks look to vary in construction and could be precast or cast in-situ in their entirety or they might be reinforced concrete lower sections with separate blocks on top. This is an important element to understand when designing new construction works, access and construction works. At some point in the future work is likely to be required to maintain the structural integrity of the concrete walling and as this arises opportunities to improve the channel should be sought using more sustainable solutions.

At the end of each assessment, the weir has been assigned a RAG (Red-Amber-Green) rating, this can be seen in Figure 3-2.

3.5.2. Assigned Red Amber Green (RAG) Rating

Each weir has been assigned a RAG rating based on the perceived ease of removal as accessed both from the site visit findings and an assessed way of removing or modifying the weir structure in the future. The assigned rating has been presented at the end of each section in the format as below:

Rating	Description
Red	Hard to remove the weir.
Amber	Unable to determine how easy to remove the weir.
Green	Easy to remove the weir.

A summary of the RAG rating is shown in Table 3-5.

Typically, with the exception of the river's main upstream control weir Mereway Barrier 4, the weirs will be easy to remove or are perceived to be easy to remove, once access to the site location and access in to the river have been achieved – resulting in a Green rating. Amber ratings are used where the weirs could not be viewed with any clarity and therefore could not be rated. A Red rating is used where the expectation of works greater than a simple weir break out is likely, for example where the concrete bed, concrete wall or main control structure may need to be exposed, investigated and/or replaced is likely.

It is understood that the main control structure of Mereway Barrier 4 (Red rating) is to be replaced. What is not known is whether this will be a total replacement of the whole structure or a simpler replacement of the mechanical and electrical elements and consequently could attract Red or Green ratings, respectively.

The weir structure of Mereway Barrier 3 (Red rating) appears to have moved vertically and horizontally indicating that the concrete bed is failing. The left bank wall also shows signs of distress indicating undercutting and settlement. This could also be manifesting on the right bank from where access for this visit was achieved. Total removal of this weir would require further site investigation resulting in bed and bank replacements or repairs. The access to this structure is very limited from the right bank due to existing buildings and any bank repairs could be compromised due to the closeness of the existing building. Access should be achievable by cutting through existing vegetation on the left bank or from a slipway that exists on the left bank between Mereway Barrier 3 and Mereway Barrier 4 and achieving access along the river.

Table 3-5 – RAG summary

Weir	RAG Rating
Tidal Crane Barrier 3	Green
Tidal Crane Barrier 4	Green
Tidal Crane Barrier 5	Green
Tidal Crane Barrier 6	Green
Tidal Crane Barrier 7	Green
Tidal Crane Barrier 8	Amber
Twickenham Barrier 1	Amber
Twickenham Barrier 2	Amber
Twickenham Barrier 3	Green
Twickenham Barrier 4	Amber
Twickenham Barrier 5	Amber
Mereway Barrier 1	Green
Mereway Barrier 2	Green
Mereway Barrier 3	Red
Mereway Barrier 4	Red

3.5.3. Engineering Constructability

The number of variations in scope and the number of indeterminates make reporting on potential cost estimates problematic. Further too, the costs will depend on whether any weir work forms part of a larger scope such as forming berms within the river to improve flow velocities for the betterment of the habitat.

The cost of engineering works will largely be driven by the ease with which the works can be carried out, the ease of access to each site that can be achieved and how many sites are to be engineered within a single contract. The range of construction works required at the weirs could vary from breaking out short sections of the weir crest, removal of part of the width for part or full depth of the structure or the total lowering or removal from bank to bank. The former options being easier and at less cost than the latter options.

Removing the former small sections of the crest elements could be achieved by simply walking in to the river at low flow / shallow depth or installing scaffolding in the river to gain man access and obtain break out using light weight compressed air tools and leaving broken out material in the river. It should be noted that the industry avoids the use of hand-held air tools and it would be preferable to get small tracked plant in to the river which would then involve dredging and water tight damming around the working area.

Removing the full width of weir as standalone projects could involve further assessments of bed and bank stability (potentially involving ground investigations and concrete coring of the walls), full stability design assessments prior to any site work to guide construction enabling works as well as the detailed design. Site work could include a river closure or by damming half of the river at a time. If construction plant cannot enter the river, then large long reach plant would be required. Long reach plant needs lead in time due to availability, clearer programme and hire periods and are expensive. Small construction plant will reduce costs substantially, but this would result in the project being constrained to limited weir removal works such as removing the weir on the side of the river that can be easily accessed.

An unknown and potentially substantial cost would be associated with silt removal or dredging. If the weirs need to be worked on in dry conditions the river will either need to be drained (requiring fish rescue) or dammed off, for around fifty percent at a time. The river bed is assumed to be concrete, so to create a dam, silt would need to be removed on the line of the dam and at the weir area to enable the dam to be assembled. Typically, the silt is likely to slump back in to the trench that needs to be dug making this a complicated, drawn out and expensive activity.

Ease of these construction problems could be achieved by closing the total river flow, allowing the river to remain static within each stretch between weirs and then just drain down for the weir to be worked on. Extensive fish rescue might be avoided but cannot be ruled out.

Works within the river between weirs may include river ‘realignment’ where sections or all of the river length is filled in with a middle meandering river formed between areas filled in with soft or hard materials. If such works were to be carried out the cost of weir works would be small in comparison. This would be partly due to the extensive enabling works, dredging and disposal works that would likely be required for the ‘restoration’ works.

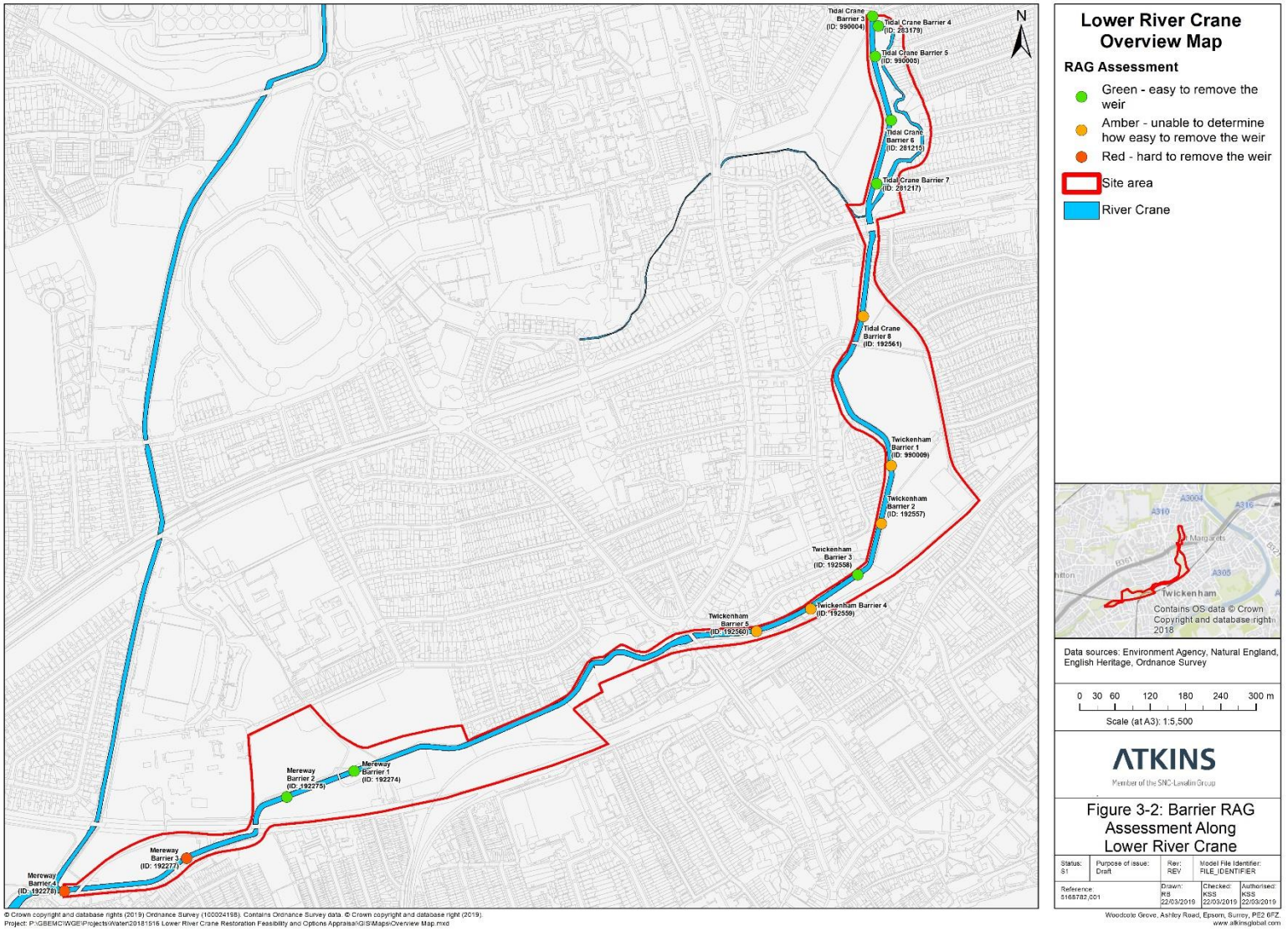


Figure 3-2 – RAG Rating of barriers along the Lower River Crane

3.6. Geomorphological Assessment

3.6.1. Introduction

A geomorphological walkover survey was undertaken on 6th of September 2018 from the confluence of diffluence of the River Crane with the Duke of Northumberland's River down to the downstream limit at Cole Park Island. The information collected was used to develop an understanding of the geomorphological form and processes of the river. This was used to assess how the geomorphological functioning of the system could be improved and support in the determination of the most appropriate alignment of a new channel. Before this was undertaken an analysis of the historical planforms was made across the Lower River Crane and this is detailed in the section below.

3.6.2. Historical Channel Analysis

To determine the changes that have been made to the Lower River Crane in the last 150 years a study was undertaken of historical maps of the area. A number of different maps and aerial photographs were uncovered in the Envirocheck Report (Landmark, 2018) covering the period between 1869 and 2018. The maps and aerial photography are of varying accuracy and clarity making some of them difficult to interpret, geo-reference and compare. Some of the minor changes in planform may be apportioned to georeferencing errors so only the significant changes have been discussed below. The maps from each of the years did not always cover the whole area either, which didn't allow for consistency of assessment. For ease of comparison the maps were georeferenced using ArcGIS and the bank lines of the channels at different years traced. Aerial photography from 1945 was also taken from Google Earth Pro to allow for the minimising of the potential timeframe in which most of the works took place.

Maps of the four areas along the River Crane where work is proposed to be done are shown in Figure 3-3 to Figure 3-6. Different combinations of years were represented in the four maps to allow for clarity of display as putting all the years that were georeferenced onto the map created confusion with many lines. In each map four years were chosen, two were the same in all maps, the first and most recent maps from 1869 and 2018. The other two were dependent on when changes were made to the channel in that area, one covering the channel outline before the change, and one after.

In Area 1 the channel appears to have retained the semi-natural planform for much of its length up to at least 1869, the first year there is a map covering the area (Figure 3-3). By 1940, although the channel is in approximately the same place, some of the sinuous nature of the channel seems to have been removed and it has become straighter. The major changes to the planform of the river were undertaken in the period between 1940 and 1945. During this time, the channel was highly straightened, removing any remaining traces of sinuosity and most significantly removing the large meander in the central/eastern part of Area 1. Since 1945 there have been no significant changes to the planform of the channel.

Area 2 is split into two distinct sections. In the western part the channel was sinuous in 1869 and 1940, but as in Area 1 it had been straightened by 1945, probably for making more space for growing food too (Figure 3-4). The eastern part of the channel was straightened from at least 1869.

Apart from the most southerly part of Area 3, which has been straightened since at least 1869, the channel retained a semi-natural, highly sinuous planform until some point between 1898 and 1920 (Figure 3-5). At this point the rest of the channel was straightened and it was all moved to the western edge of Moormead and Bandy Recreation ground.

Most of the works on the channel in Area 4 were done at some point between 1940 and 1945 (Figure 3-6) as in Areas 1 and 2. The alterations to the channel diverted the water from the semi-natural sinuous channel into a straightened channel with flow control structures. This was probably done to get water through the system as quickly as possible, potentially to protect adjacent housing and food growing areas. Although the main flow of the River Crane was moved to a new channel, the original channel was also retained. No further changes have been made to the planform of the channel since 1945. A small section of the channel was straightened between 1869 and 1940, at the upstream extent of the sinuous section in Area 4. This was probably done to protect properties that now exist in that location.

The assessment of the old maps and aerial photography has allowed for a greater understanding of the previous planforms of the channel and the timings in which they were changed. From the analysis it appears that the channel in Area 3 was changed first, at some point prior to 1920 but after 1898. These alterations consisted of straightening the channel and moving it to allow for more continuous space in what is now park but was previously allotments. In the other three areas the changes happened later, between 1940 and 1945, although the type of change was the same, a straightening of planform.

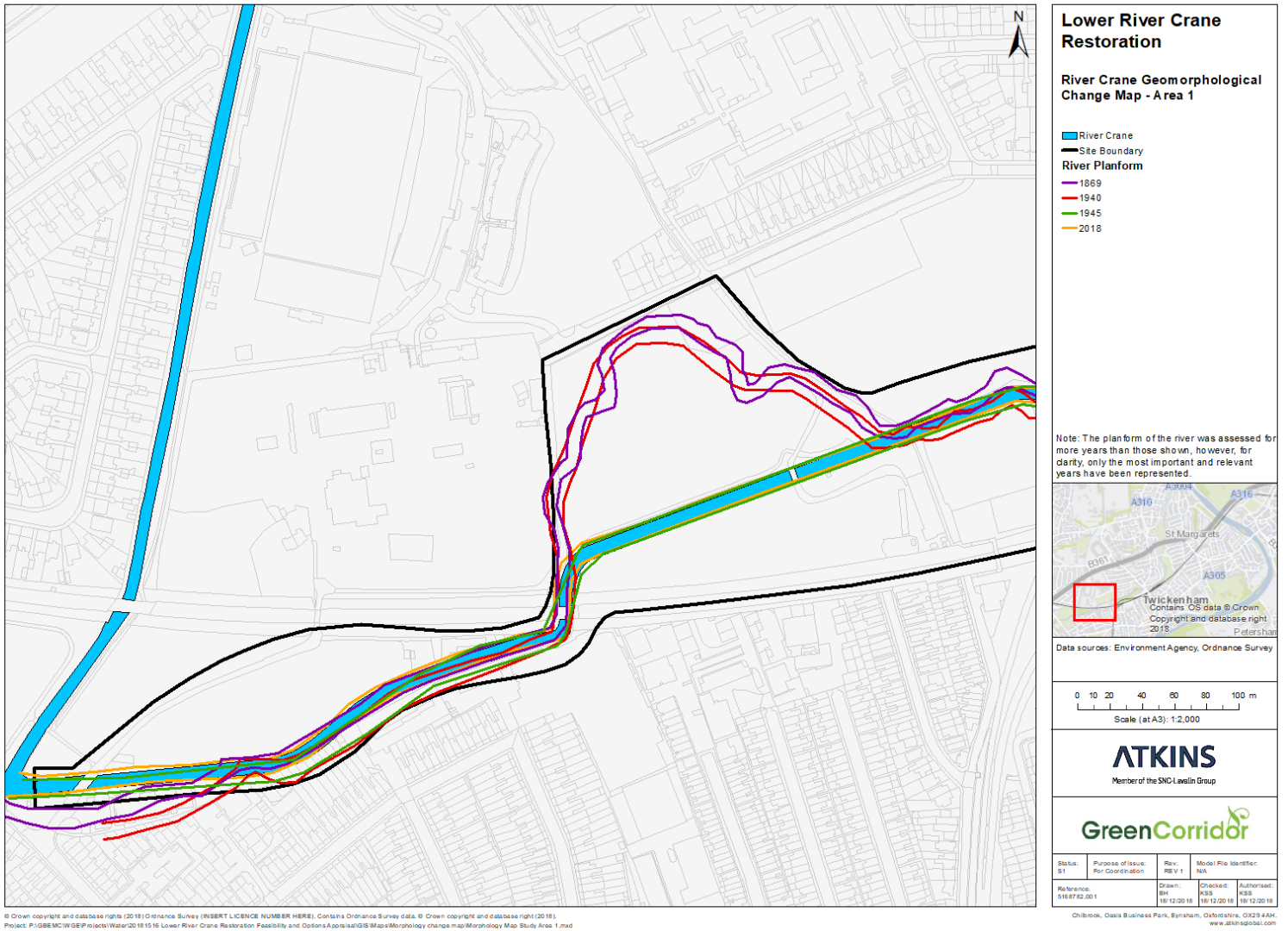


Figure 3-3 – River Crane geomorphological change map Area 1

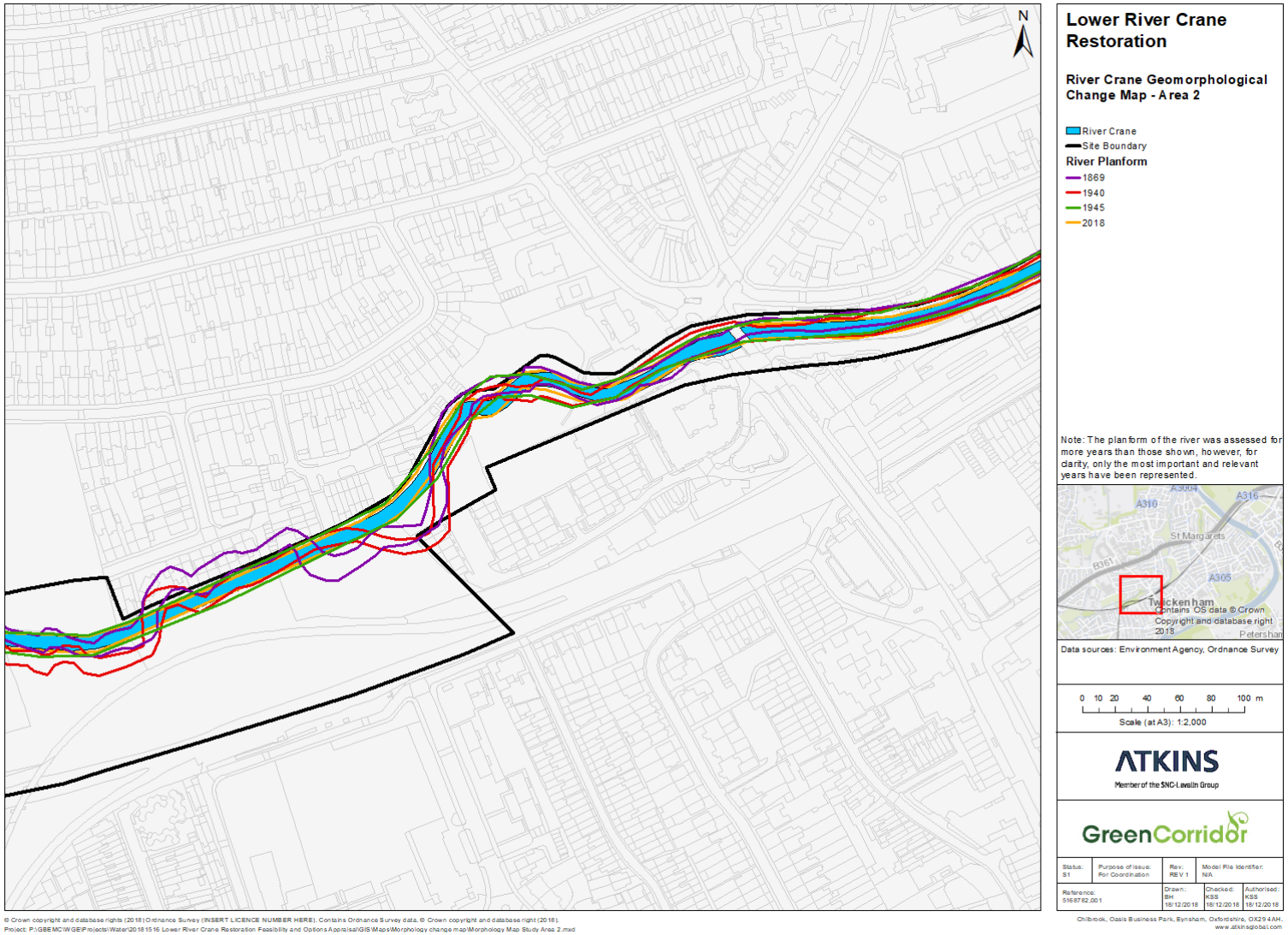


Figure 3-4 – River Crane geomorphological change map Area 2

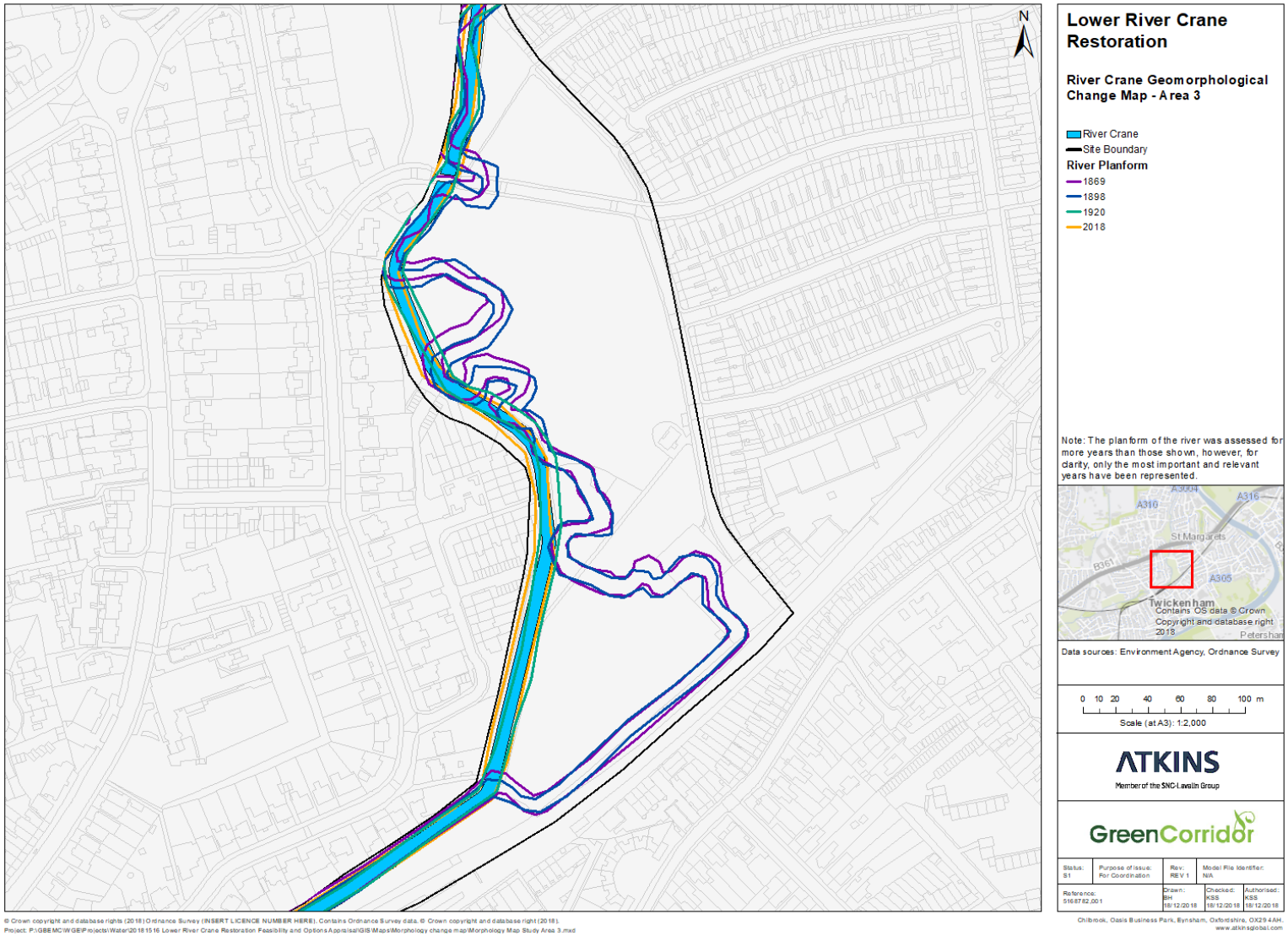


Figure 3-5 – River Crane geomorphological change map Area 3

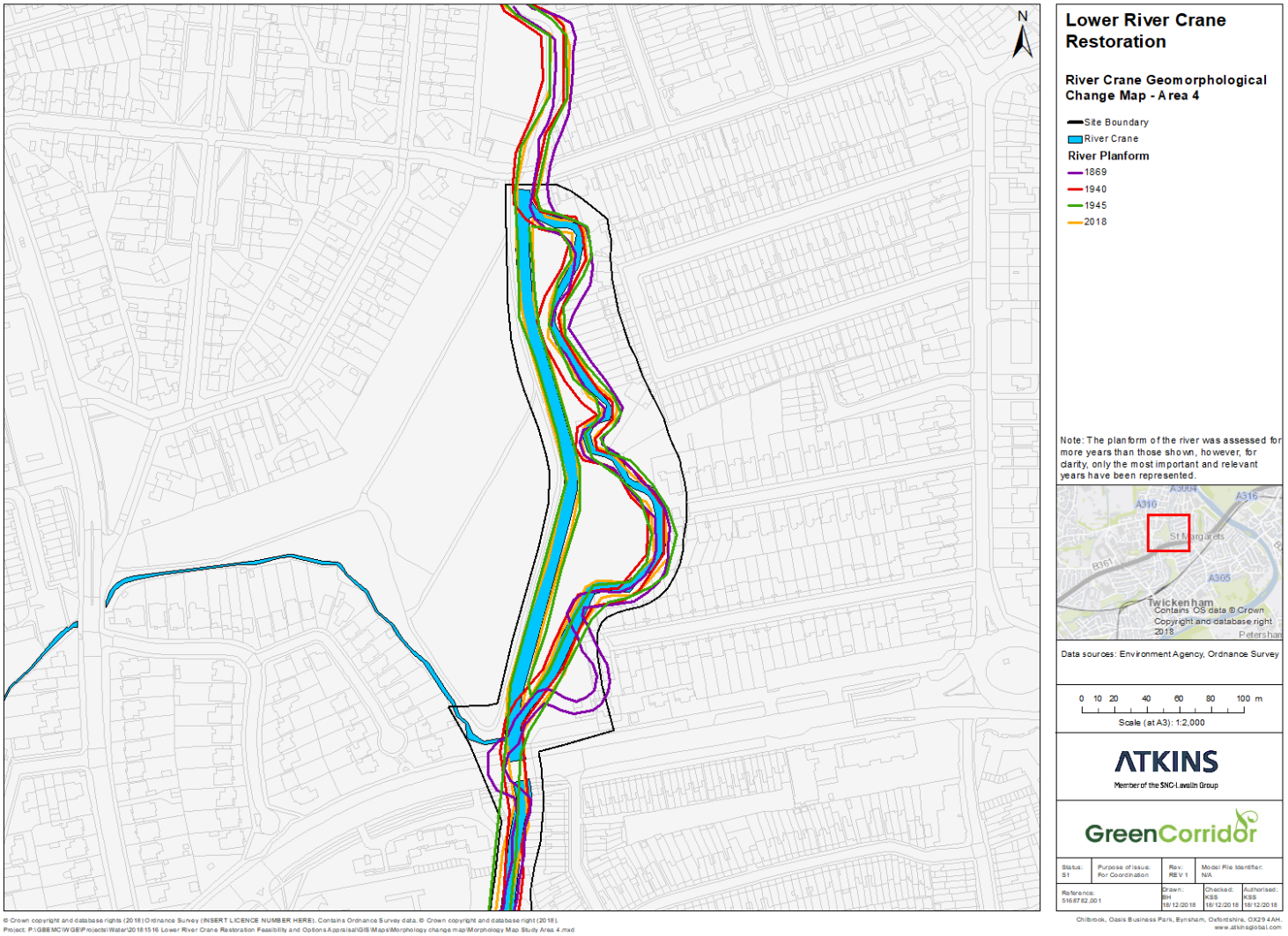
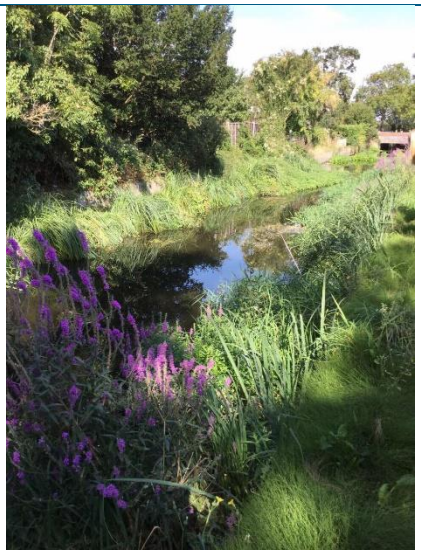


Figure 3-6 – River Crane geomorphological change map Area 4

3.6.3. Walkover survey

The details of the walkover survey are illustrated below in Table . The channel is concrete lined covering both the bed and banks throughout the 3 km reach surveyed.

Table 3-6 – Geomorphological walkover survey

Duke of Northumberland's River Areas where the habitat has already been enhanced were visited along the Duke of Northumberland's River. Improvements included localised narrowing through planting and some localised tree thinning which proved to be successful in improving the habitat.	
Mereway Weir The Mereway weir controls the flow split between the Lower River Crane and the Duke of Northumberland's River. During the day of the survey a reasonable amount of flow was coming over the structure.	
Mereway Nature Park The channel is heavily shaded along the Mereway Nature Park along the left bank. There remain opportunities for bank reprofiling along the right bank when there is redevelopment of the Mereway Day Centre.	

Craneford Way playing fields The channel has been previously straightened through the playing fields. The area is used for recreation. A footpath runs alongside the channel but because of the dense vegetation, and the fencing, only glimpses of the channel was possible.	
Craneford Way playing fields This footpath runs alongside the River Crane.	
Craneford Way playing fields This view upstream of a bridge crossing shows how dense the vegetation is along both banks of the River Crane. The water is flowing slowly through this section of channel.	

Craneford Way playing fields – Environment Agency gauging weir The Environment Agency gauging weir is built within the bed of the channel. The elevation of the bed appears significantly lower downstream of the structure.	
Twickenham Rough This photograph marks the start of the new footpath that goes past the allotments and down to the centre of Twickenham.	
Twickenham Rough This is part of the recently constructed footpath into the centre of Twickenham. The area adjacent to the footpath behind the fence, which is heavily vegetated, lies between this feature and the River Crane.	
Twickenham Town Centre In the centre of Twickenham, the channel is heavily constrained. This view upstream of the main road bridge shows recent development along the right bank (left side of this photograph) and a heavily vegetated section along the left bank.	

Twickenham Town Centre This section of channel lies between the centre of Twickenham and Moormead Park. It is a heavily constrained reach and is heavily vegetated along both banks. The railway station exists behind the right bank (looking downstream). There are numerous weirs within this reach.	
Twickenham Town Centre This section of channel lies between the centre of Twickenham and Moormead Park. It is a heavily constrained reach and is heavily vegetated along both banks. There are numerous weirs within this reach.	
Moormead Park Within Moormead Park the channel has been constructed along the western edge of the park. It is behind the densely vegetated right bank (on the left of this photograph). The footpath is lit with a row of street lamps.	
Moormead Park The footpath runs along the edge of the park and then by the edge of the play area.	

Moormead Park This is the more open section of the park. The channel is hidden behind the dense vegetation to the left side of this photograph. It runs along the western edge of the park all the way around it.	
Cole Park Island Cole Park Island is located downstream of Chertsey Road. The island is located on the right bank (left side of the photograph) and is covered by a mixture of scrub, trees and informal gardens. The allotments are located along the left bank (right side of this photograph). A series of weirs exist within this section of this channel.	
Cole Park Island A track exists along the allotment side of the River Crane along the left bank. The allotments are set behind this track. The island is on the right side of the photograph.	

3.6.4. Opportunities

Opportunities for improvements in river habitat are greatest within the various parks along the course of the Lower River Crane. There exist significant scenarios for restoring the channel into more central locations within these green spaces making the river becoming integral part of the recreational focus. There are less opportunities within constrained reaches because of space and various utilities that are present in these locations. Thus, actions in these locations are limited to either instream measures (where banks cannot be altered) or bank reprofiling where space allows.

3.7. Landscape Baseline

3.7.1. Introduction

The corridor of the Lower River Crane is a hidden asset, which is not easily accessible from either the wider urban area of central Twickenham or from within the adjoining spaces. The corridor is located within the

National Landscape Character Area (NCA) 115, Thames Valley and it exhibits many of the aspects of the general descriptions, low-lying and flat set within an area with river lain sands and gravels on London Clay. The rapid development surrounding the river corridors has left the Lower River Crane with a lack of cohesiveness. Along many sections the channel is entirely isolated in a fenced corridor, a utilitarian concrete lined flood channel accompanied by parallel runs of utilities and flood defence controls such that the river itself is completely contained in an urbanised element. The channel is overshadowed by unmanaged tree growth. In places it has become a barrier to movement and no longer easily recognised a river. Changes in the Mereway Weir that has provided more flows this year have given the river life, movement and an audible presence, even in the quite built up sections, it is visible from bridges and there are glimpses from boundaries of open spaces.

The river corridor passes through two London boroughs, Richmond and Hounslow, their relevant documents include the following:

Richmond Borough's Public Space Design Guide (2006) considers the River Thames but there is no reference to minor rivers within the borough, however it does make reference to the interface and opportunities for waterside access, relationship to the spaces and the issue surrounding riverside footpaths and bank ownership as key considerations, all applicable to the consideration of future design objectives for the Lower River Crane. The character types identified, Urban Parkland, Urban Hard, Residential are all of relevance and can be considered in the context of this study. Guidance set out in Section 9.4, Page 4 includes:

- *"Avoid blocking riverside views.*
- *Avoid urbanising pastoral areas.*
- *Avoid using carriageway' solutions on towpaths and river paths.*
- *Coordinate new signage with existing signs.*
- *Relate proposals to the character of the surrounding riverside e.g. urban elements should generally not be used in pastoral areas.*
- *Ensure that historical precedent along the riverfront informs improvements and is incorporated wherever possible.*
- *Reduce the visibility of parked cars and set back car parking from the riverside where possible.*
- *Ensure that riverside locations are wherever possible accessible to all."*

Within Hounslow borough the River Crane's northern extent is located within the Cole Island stretch, the northerly-most segment of the study area upstream of the tidal zone of the river.

The River Crane forms a wooded northern boundary to the Hanworth character area. Reference is made to the river as it passes through the recently improved Crane Park. The open spaces along the River Crane act as a natural boundary between the distinct settlement area associated with Hounslow and Richmond. The study notes the footpaths and waterside access along the River Crane and the potential to extend the network to Feltham and Hounslow Heath to the west. It also notes the barrier created by the Chertsey Road (A316), which is of significance to this section of the river and study area.

The Lower River Crane can be described as a series of reaches with their relationship to the adjacent urban areas/parkland:

- Mereway Nature Park.
- Craneford Way playing fields.
- Twickenham Rough.
- Twickenham Town Centre.
- Moormead and Bandy Recreation Ground.
- Cole Park Island.

3.7.2. Character reach 1 – Mereway Nature Park

Character – Mereway Nature Park is located at the western-most end of the study area, at the diffluence of the River Crane and the Duke of Northumberland's River. It is closely located to Kneller Gardens and forms a continuation of the park resources, with adjoining nature conservation areas. These areas are managed to achieve habitat objectives with interpretative trails. Largely scrubby in character, this extent of river is defined by a semi-industrial character of the land uses to the north of the railway line which forms a physical barrier to the riverside. Access to the waterside is not possible, however there is an access and some loops into the

adjacent nature conservation areas running along the left bank. Management of these areas is varied with different degrees of regrowth. Overall the appearance of the section of the riverside spaces is natural with scrub regeneration and bramble predominating and some higher tree canopies which together create a well-wooded character.

Visual Qualities – Visibility of the river corridor is possible from Kneller Road, which crosses the river from the adjacent residential area. Within the Mereway Nature Park area the river is not visible, and the overgrown vegetation disconnects the space from the river.

Development Context and Connections – here is a derelict vacant site on the right bank and comprises a site which is a former Day Centre, residential areas of Barneby Close, Rowntree Road and Gould Road. Further downstream the right bank comprises small to medium scale employment uses. The left bank is bounded by the railway line beyond the Nature Reserve with larger scale employment uses beyond which are not visible and the footpath serves as an access to isolated riverside properties. Potential future development sites include the former Greggs and the Mereway Day Centre which could be an opportunity to create a riverside walkway along the right bank and achieve new pedestrian connectivity.

Overall the character of this section is dominated by the Mereway Nature Park and there is no opportunity to interact with the river, nor is there the sense of proximity to the river corridor. Proposals could extend to consider the parkland users and deliver substantial benefits beyond the river restoration possibilities.

3.7.3. Character reach 2 – Craneford Way Playing Fields

Character – An area of mixed character, with a series of different uses adjoining the riverside including recreation uses at Craneford Way playing fields, allotment grounds and Twickenham Rifle Club with extensive open areas. Throughout this section of the river corridor there is a sense of openness and a series of crossing points, only one is used as part of the footpath network within a parkland context. The river is located at a lower level but is visible and there is potential for more interaction or riverside activity along this entire section on both sides of the river. Historically the river meandered through this space and formed a loop, this is now not traceable on the ground. The current use is sports provision, despite the wet ground conditions. Within the park, levels along the northern edge have been raised previously and there is a play area located in the north-eastern corner of the park. A substantial portion of this stretch of the riverside open space serves as playing fields for the nearby Richmond College.

Visual Qualities – The riverside is visible from the open space in Craneford Way playing fields and there is potential for views from the footpath that is located parallel to the river corridor on the left bank and crosses the river before it continues south adjacent to allotment gardens/rifle club.

Development Context and Connections – There are a number of under-utilised areas located along the river corridor. Potential future development sites include the area downstream of the railway line which could be an opportunity to create a riverside walkway along the right bank and achieve new pedestrian connectivity along the right bank which include an isolated area of open land, part of the Twickenham Rifle Club. The left bank comprises the Craneford Way playing fields with Craneford Way and the associated residential areas, Richmond upon Thames College and the Harlequins rugby grounds. There are connections to Public Rights of Way.

Overall this reach of the river has an open recreational character and could be developed to be of benefit to the local community with increased access to the riverside edge and review of the Craneford Way playing fields uses to integrate the river with the park.

3.7.4. Character reach 3 – Twickenham Rough

Character – An enclosed wooded section of the river contained between the allotment garden located at the western end and the railway lines to the south and along the right bank are exhibited including a recently implemented footpath. To the north housing overlooks the river corridor and the recently completed riverside walk is screened from the housing. This section of pathway is closed to manage the flows of pedestrian traffic to/from the rugby events and at night to discourage access. The river itself is not easily reached as part of this space.

Visual Qualities – The river is not visible along this stretch of the River Crane. Properties located on the left bank will have visibility of the riverside with their boundaries adjoining the retained concrete bankside.

Development Context and Connections – There are no current sites to be redeveloped along this section of the river.

Overall – This section of river is contained and constrained by the presence of housing. Improvements to the riverside way have been undertaken and there is a limited opportunity to increase the riverside activity or visual connection.

3.7.5. Character reach 4 – Twickenham Town Centre

Character – A narrow corridor, enclosed by tree cover and not accessible between Twickenham Station and Moormead Park. The river is located at a much lower level relative to the surrounding area and is not an obvious feature in the hard-urban context with a wide wooded walkway, with elements of railway heritage set within the undergrowth. The wooded habitat is of value to the bird populations.

Visual Qualities – There are two crossing points with potential views along the river corridor, the first, London Road, is a main approach to Twickenham Town Centre and the second serves as a pedestrian route across the river and leads to a rail pedestrian overbridge connection between Cole Park Road and Mary's Terrace/Beauchamp Road.

Development Context and connections– The west of London Road, the riverside has been largely redeveloped. The development has facilitated a new pedestrian path which forms a new link to Craneford Park and making it possible to now walk along the River Crane, albeit not next to the river itself. Twickenham Station is presently being redeveloped and this will provide a riverside path in an easterly direction to connect with Moormead Park which will enhance the visitor and commuter experience by providing an alternative route for non-motorised users.

Overall – There is potential to change the experience of the river which is presently enclosed and overgrown. This section is key as it is located close to a key point of arrival at Twickenham Station and presents the opportunity to offer alternative connections to wider neighbourhoods.

3.7.6. Character reach 5 – Moormead and Bandy Recreation Ground

Character – This section of the river corridor is removed entirely from its context, fenced on both sides. The wider area is a substantial urban parkland surrounded by late 19th century housing to the east which connects with the park's eastern edge. This is a reasonably high-density edge with long distinct terraces and small plots. To the western residential area is lower in density with larger plots with the rear gardens forming the left bank riverside boundary. The right bank adjoins Moormead Park and this is fenced, there are service routes located within and alongside the river corridor above and below ground. There are several veteran or mature trees within this largely wide and flat open space which do break up the space, defining main connections across the space.

There is little inter-visibility between the housing at Cole Park, the river and Moormead Park beyond. The historic alignment of the river meandered across this open space, however there is no trace of this now. There is a play area within the park which is municipal in character but could be updated or relocated away from the riverside edge, perhaps as part of a park wide review. There are three small sized 11x11 football pitches and a smaller sized pitch and four tennis courts located in the south-eastern corner of the park. Park uses are predominantly for sports pitch purposes. There is a disused pavilion within the site which is presently being considered for alternative community uses.

Visual Qualities – The Moormead parkland context is attractive and offers an open area while the river adjacent is barely visible and therefore this section of river is almost completely hidden with the exception of a bridge which serves as an entrance to the park via Cole Road.

Development Context and Connections – There are no development sites adjoining the river corridor. The disused pavilion could be refurbished as part of the scheduled works within the park.

Overall – This site presents great potential for change and integration of the river within the parkland context. Proposals could extend to consider the parkland users and deliver substantial benefits beyond the river restoration possibilities.

3.7.7. Character reach 6 – Cole Park Island

Character – This section of the river passes between allotment gardens and an island which is essentially informal open space. There is a backwater section of the River Crane which appears to meander along the original route. Additionally, Whitton Brook joins this section of the River Crane. The allotment gardens and orchard area are well used and provide visual interest within this section of the river corridor. The Cole Park Island is informally used by residents as an extension to their dwelling plots and the island itself does provide a buffer to their gardens which meet the riverside with an open edge.

Visual Qualities – The river is visible from the allotment gardens and from the bridge at either end of this stretch, the Chertsey Road (A316) and Northcote Avenue at the northern most extent of the study area.

Development Context and Connections – There are no potential development sites adjoining this section of the river corridor. This section of the riverside is not publicly accessible beyond the allotment users and local residents that adjoin the riverside edge. The A316 is a dual carriageway configuration at this point and a

separate feasibility would be required to ascertain whether a surface level crossing could be achieved in addition to the pedestrian overbridges located along this route.

Overall – The character of the original river is possibly the most naturally distinct for this section of the corridor albeit with the main river course being in a heavily engineered and visible concrete channel.

4. Options Development

4.1. Strategic Context

4.1.1. Key International Legislation

Water Framework Directive

On 23 October 2000, the EU WFD (Directive 2000/60/EC) was finally adopted. This was transposed into English and Welsh law in 2003. The main objectives are as follows:

- to enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands which depend on the aquatic ecosystems;
- to promote the sustainable use of water;
- to reduce pollution of water, especially by 'priority' and 'priority hazardous' substances; and
- to ensure progressive reduction of groundwater pollution.

In 2009 the Environment Agency (competent authority responsible for implementation of the Directive) in England and Wales published the first round of River Basin Management Plans (RBMPs). These management plans are required to be developed every six years. Within each of the RBMPs a series of water bodies are defined. Actions to improve, and then maintain, these water bodies at Good Ecological Status, or Good Ecological Potential (in A/HMWBs) is required. The water body along the Lower River Crane is located in the Crane surface water body (water body ID GB106039023030). The assessment for this water body has been previously detailed in Table . The Crane is not designated an A/HMWB. Despite being obviously modified and significantly straightened, the watercourse does not require this planform to be maintained for the provision of alternative uses e.g. flood protection or navigation purposes. Currently the WFD status of the River Crane is characterised as Poor which reflects the Poor ecology which is, at least in part, due to the significant modification observed along the river. Within the study area, the concrete lined channel is likely to significantly limit both instream and riparian habitat quality. The range of aquatic species that can be supported are thus restricted.

Floods Directive

In November 2008 the Floods Directive came into force. This was transposed into English and Welsh law in the Flood Risk Regulations of 2009 and then consolidated in the Flood and Water Management Act of 2010 as the latter Act did not meet the deadline for transposition. The Act establishes that flood risk will be managed within the framework of National Strategies for England and Wales and Local Strategies for each Lead Local Flood Authority area. The Act aims to create a more simple and effective means of managing the risk of flood and coastal erosion. It also aims to help improve the sustainability of water resources and protect against potential droughts. The Act was driven by the Floods Directive but also incorporates recommendations from the Pitt Review following the floods of 2007. The management role for local flood risk that covers flooding from an ordinary watercourse, surface run-off or groundwater has now been given to County and unitary Lead Local Flood Authorities (LLFAs) and they are accountable for ensuring effective management of these local flood risks.

4.1.2. National Strategies

DEFRA- Making Space for Water (2005)

Making space of water is a national strategy for implementation of a more holistic approach to managing flood and coastal erosion risks in England. It sets out a vision for what the new strategy for flood and coastal erosion risk management should achieve. This would be achieved by employing an integrated portfolio of approaches which reflect both national and local priorities, so as:

- to reduce the threat to people and their property;
- to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles; and
- to secure efficient and reliable funding mechanisms that deliver the levels of investment required to achieve the vision of this strategy.

National Planning Policy Framework (NPPF)

The National Planning Policy Framework (NPPF) was updated in July 2018, superseding previous planning guidance. The NPPF sets out the Government's planning policies for England and Wales. Within the framework it also sets out how they should be applied and provides a framework from which locally prepared plans can be produced. Key policies that relate to the River Crane are detailed in Table 4-1.

Table 4-1 – Specific objectives in the NPPF that relate to the Lower River Crane vision

Strategic Objective within the NPPF	Commentary related to the Lower River Crane
Open Space and recreation 96. Access to a network of high, quality open spaces and opportunities for sport and physical activity is important for the health and well-being of communities. Planning policies should be based on robust and up-to-date assessments of the need for open space, sport and recreation facilities (including quantitative or qualitative deficits or surpluses) and opportunities for new provision. Information gained from the assessments should be used to determine what open space, sport and recreational provision is needed, which plans should then seek to accommodate. 97. Existing open space, sports and recreational buildings and land, including playing fields, should not be built on unless: a) an assessment has been undertaken which has clearly shown the open space, buildings or land to be surplus to requirements; or b) the loss resulting from the proposed development would be replaced by equivalent or better provision in terms of quantity and quality in a suitable location; or c) the development is for alternative sports and recreational provision, the benefits of which clearly outweigh the loss of the current or former use. 98. Planning policies and decisions should protect and enhance public rights of way and access, including taking opportunities to provide better facilities for users, for example by adding links to existing rights of way networks including National Trails.	The NFFP recognises the importance of public open spaces and the value of well interconnected areas. Any changes to open space need to be assessed and if alternatives cannot be found the development would need to demonstrate that the alternative use clearly outweighs the loss of the former use.
Planning and flood risk 155. Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere. 156. Strategic policies should be informed by a strategic flood risk assessment and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting, local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards. 157. All plans should apply a sequential, risk-based approach to the location of development – taking into account the current and future impacts of climate change– so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk, by: a) applying the sequential test and then, if necessary, the exception test as set out below;	The NPPF recognises the need to avoid the risk of a development increasing flooding. Thus, any work undertaken as part of the Crane vision will need to demonstrate that the risk of flooding has not been increased.

b) safeguarding land from development that is required, or likely to be required, for current or future flood management; c) using opportunities provided by new development to reduce the causes and impacts of flooding (where appropriate through the use of natural flood management techniques); and d) where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations	
Conserving and enhancing the natural environment 170. Planning policies and decisions should contribute to and enhance the natural and local environment by: a) protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan); b) recognising the intrinsic character and beauty of the countryside, and the wider benefits from natural capital and ecosystem services – including the economic and other benefits of the best and most versatile agricultural land, and of trees and woodland; c) maintaining the character of the undeveloped coast, while improving public access to it where appropriate; d) minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures; e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate. **Habitats and biodiversity** 174. To protect and enhance biodiversity and geodiversity, plans should: a) Identify, map and safeguard components of local wildlife-rich habitats and wider ecological networks, including the hierarchy of international, national and locally designated sites of importance for biodiversity; wildlife corridors and stepping stones that connect them; and areas identified by national and local partnerships for habitat management, enhancement, restoration or creation; and b) promote the conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species; and identify and pursue opportunities for securing measurable net gains for biodiversity. 175. When determining planning applications, local planning authorities should apply the following principles: a) if significant harm to biodiversity resulting from a development cannot be avoided (through locating on an alternative site with	The NPPF recognises the need to conserve and enhance the local environment. In the updated NPPF there is also more of an emphasis on providing net gains for biodiversity from a development. There is also an emphasis on promoting the conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species. Of particular importance for the River Crane is where the NPPF states that where a development has a primary objective to conserve or enhance biodiversity it should be supported.

less harmful impacts), adequately mitigated, or, as a last resort, compensated for, then planning permission should be refused;

b) development on land within or outside a SSSI, and which is likely to have an adverse effect on it (either individually or in combination with other developments), should not normally be permitted. The only exception is where the benefits of the development in the location proposed clearly outweigh both its likely impact on the features of the site that make it of special scientific interest, and any broader impacts on the national network of SSSI;

c) development resulting in the loss or deterioration of irreplaceable habitats (such as ancient woodland and ancient or veteran trees) should be refused, unless there are wholly exceptional reasons and a suitable compensation strategy exists; and

d) development whose primary objective is to conserve or enhance biodiversity should be supported; while opportunities to incorporate biodiversity improvements in and around developments should be encouraged, especially where this can secure measurable net gains for biodiversity.

4.1.3. Local Planning Policy

The Lower River Crane is covered in both the London Borough of Richmond and the London Borough of Hounslow Local Plans since the boundary of the two boroughs is marked by the River Crane downstream of Chertsey Road. Upstream of this point both banks of the river are covered by the London Borough of Richmond and hence why the River Crane is mentioned in a greater extent in the Local Plan of the London Borough of Richmond rather than the Local Plan of the London Borough of Hounslow.

London Borough of Richmond – Local Plan

The Local Plan for the London Borough of Richmond was adopted in July 2018 (London Borough of Richmond, Online – 2019). The Plan sets out policies and guidance for the development of the borough over the next 15 years. Critically:

‘The Local Plan is prepared within a hierarchical framework of planning policy for England. At the top of the hierarchy are the various Planning Acts, the National Planning Policy Framework (NPPF) and the Planning Practice Guidance (PPG). Legislation requires that local authorities must take the NPPF into account when preparing their Local Plan. (London Borough of Richmond – Local Plan)’

Key strategic objectives within the local plan that are directly linked to the Lower River Crane are detailed in Table 4-2.

Table 4-2 – Strategic objectives within the Local Plan for the London Borough of Richmond that relate to the Lower River Crane vision

Strategic Objective within the Local Plan	Commentary related to the Lower River Crane
Strategic vision: protecting local character – Natural environment, open spaces and the borough's rivers The outstanding natural environment and green infrastructure network, including the borough's parks and open spaces, biodiversity and habitats as well as the unique environment of the borough's rivers and their corridors will have been protected and enhanced where possible. Residents will continue to highly value and cherish the borough's exceptional environmental quality.	There is a clear commitment to improving the habitat within the River Crane and the riparian corridor.
Strategic objectives: Protect and improve the borough's parks and open spaces to provide a high quality environment for local communities and provide a balance between areas for quiet enjoyment and wildlife and areas to be used for sports, games and recreation. Protect and enhance the borough's network of green infrastructure that performs a wide range of functions for residents, visitors, biodiversity and the economy. Protect and enhance the borough's biodiversity, including trees and landscape, both within open spaces but also within the built environment and along wildlife corridors Protect and improve the unique environment of the borough's rivers, especially the River Thames and its tributaries as wildlife corridors, as opportunities for recreation and river transport where possible, increasing access to and alongside the rivers where appropriate, and gain wider local community benefits when sites are redeveloped.	There is a commitment in the plan to improve open spaces and improve the environment, so people can enjoy these areas for both the wildlife and for recreation. Opportunities should also seek to improve access alongside the rivers for wider community benefits.
'A hierarchy of open spaces of different sizes and functions will be maintained, and improvements sought in areas of deficiency for open space or biodiversity. Many of the borough's parks and open spaces are of regional or metropolitan importance in providing opportunities for recreation, and many have historic significance, biodiversity value or can be regarded as areas of relative tranquillity. The open space network, including the Blue Ribbon network of the River Thames and River Crane corridors as well as other tributaries, and the links in between provide the natural infrastructure that performs a wide range of functions for residents, visitors, biodiversity and the economy. The borough's parks and open spaces provide not only recreational opportunities for those that live and work in this borough, but also for local communities and residents in neighbouring and other London boroughs, thus providing a green lung for south/west London.'	There is a recognition within the Local Plan of the value of the Blue Ribbon network of the River Thames and the River Crane corridors for a variety of functions.
'In order to achieve sustainable growth within the borough, future development is therefore expected to take place on brownfield sites. Improvements, such as enhancing the immediate environment, creating new pedestrian and cycling linkages, especially to and from as well as alongside the rivers, and other environmental enhancement will be sought.' 'Sites designated for their biodiversity and nature conservation value, including the connectivity between habitats will be protected and enhanced.'	Within the plan there is a commitment to improve both pedestrian and cycleways alongside the rivers within the Borough.

Specific Policy objectives within the Local Plan that relate to the Lower River Crane vision are detailed in Table 4-3:

Table 4-3 – Specific planning policy objectives in the Local Plan for the London Borough of Richmond that relate to the Lower River Crane vision

Specific Planning Policy Objective in the Local Plan	Commentary related to the Lower River Crane
Policy LP12 – Green Infrastructure Green infrastructure is a network of multi-functional green spaces and green features, which provides multiple benefits for people, nature and the economy. A. To ensure all development proposals protect, and where opportunities arise enhance, green infrastructure, the following will be taken into account when assessing development proposals: a. the need to protect the integrity of the green spaces and features that are part of the wider green infrastructure network; improvements and enhancements to the green infrastructure network are supported; b. its contribution to the wider green infrastructure network by delivering landscape enhancement, restoration or re-creation; and c. incorporating green infrastructure features, which make a positive contribution to the wider green infrastructure network.	There is a drive in the plan to enhance the wider green infrastructure network by delivering landscape enhancement, restoration or re-creation.
Policy LP 15 – Biodiversity A. The Council will protect and enhance the borough's biodiversity, in particular, but not exclusively, the sites designated for their biodiversity and nature conservation value, including the connectivity between habitats. Weighted priority in terms of their importance will be afforded to protected species and priority species and habitats including National Nature Reserves, SSSI and Other Sites of Nature Importance as set out in the Biodiversity Strategy for England, and the London and Richmond upon Thames Biodiversity Action Plans. This will be achieved by: 1. protecting biodiversity in, and adjacent to, the borough's designated sites for biodiversity and nature conservation importance (including buffer zones), as well as other existing habitats and features of biodiversity value; 2. supporting enhancements to biodiversity; 3. incorporating and creating new habitats or biodiversity features, including trees, into development sites and into the design of buildings themselves where appropriate; major developments are required to deliver net gain for biodiversity, through incorporation of ecological enhancements, wherever possible; 4. ensuring new biodiversity features or habitats connect to the wider ecological and green infrastructure networks and complement surrounding habitats; 5. enhancing wildlife corridors for the movement of species, including river corridors, where opportunities arise; and	There is a commitment in the plan to improve biodiversity particularly in creation of new habitats and their overall wider connectivity to surrounding habitats.

6. maximising the provision of soft landscaping, including trees, shrubs and other vegetation that support the borough-wide Biodiversity Action Plan.	
Policy LP 18 – River Corridors The River Crane is an important river corridor, which runs for 30 kilometres from Harrow through Twickenham and St Margarets to the Thames at Isleworth, and which has benefited from significant environmental improvements. Where appropriate, developments alongside and adjacent to the River Crane should contribute to the overarching aim of creating a new metropolitan park that provides a continuous, accessible link between Hounslow Heath and the River Thames, incorporating river restoration works along the lower Crane, including a long distance footpath, improved access for surrounding communities and an enhanced wildlife corridor. This applies in particular to the following development sites that are considered to be within the River Crane and the connecting Duke of Northumberland's River corridor: Richmond upon Thames College, Twickenham Station, Greggs bakery, The Stoop, Twickenham Stadium, the Depot and Mereway Day Centre.	There is a specific recognition of the value of the River Crane and its wider river corridor within the plan. It also highlights the need to take the opportunity to improve the river and the associated corridor when any adjacent properties are re-developed. The plan specifically recognises that there are opportunities at Richmond upon Thames College, Twickenham Station, Greggs bakery, The Stoop, Twickenham Stadium, the Depot and Mereway Day Centre.
Policy LP 21 Flood Risk and Sustainable Drainage **Flood risk** All developments should avoid, or minimise, contributing to all sources of flooding, including fluvial, tidal, surface water, groundwater and flooding from sewers, taking account of climate change and without increasing flood risk elsewhere. Development will be guided to areas of lower risk by applying the 'Sequential Test' as set out in national policy guidance, and where necessary, the 'Exception Test' will be applied. Unacceptable developments and land uses will be refused in line with national policy and guidance, the Council's Strategic Flood Risk Assessment (SFRA) and as outlined in the table below. In Flood Zones 2 and 3, all proposals on sites of 10 dwellings or more or 1000sqm of non-residential development or more, or on any other proposal where safe access/egress cannot be achieved, a Flood Emergency Plan must be submitted. Where a Flood Risk Assessment is required, on-site attenuation to alleviate fluvial and/or surface water flooding over and above the Environment Agency's floodplain compensation is required where feasible.	All restoration designs that are taken forward must make ensure that the works do not increase flood risk. Discussions would be had with the Environment Agency and a flood risk assessment be undertaken to provide the necessary evidence.
Sustainable drainage The Council will require the use of Sustainable Drainage Systems (SuDS) in all development proposals. Applicants will have to demonstrate that their proposal complies with the following: 1. A reduction in surface water discharge to greenfield run-off rates wherever feasible. 2. Where greenfield run-off rates are not feasible, this will need to be demonstrated by the applicant, and in such instances, the minimum requirement is to achieve at least a 50% attenuation of the site's surface water runoff at peak times based on the levels existing prior to the development	Opportunities for SuDs would be examined in more detail in the design phase of any projects taken forward.

Policy LP 31: Public Open Space, Play Space, Sport and Recreation A. Public Open Space, children's and young people's play facilities as well as formal and informal sports grounds and playing fields will be protected, and where possible enhanced. Improvements of existing facilities and spaces, including their openness and character and their accessibility and linkages, will be encouraged. New open spaces, play facilities and formal and informal land for sport and recreation should be linked to the wider Green Infrastructure network as they play an important role in creating social cohesion, encouraging and promoting healthier and more active lifestyles. National policy and guidance states that existing open spaces, sports and recreational buildings and land, including playing fields, should not be built on unless: an assessment has been undertaken which has clearly shown the open space, buildings or land to be surplus to requirements; or the loss resulting from the proposed development would be replaced by equivalent or better provision in terms of quantity and quality in a suitable location; or the development is for alternative sports and recreational provision, the needs for which clearly outweigh the loss.	There is an interesting balance to be had between retaining existing recreational space as it is currently used or through using part of this open space for a new restored river corridor. This change would by the very nature of it decrease the area available for certain activities (such as football) but has the potential to improve the Blue-Green Infrastructure network by offering a different form of recreational space and offering improved biodiversity benefits.

London Borough of Hounslow – Local Plan

The Local Plan for the London Borough of Harrow has specific policies on Green and Blue infrastructure. The only part of the London Borough of Hounslow which lies adjacent to the River Crane is in Cole Park Island where the London Borough of Hounslow boundary is along the old course of the River Crane. Key policies in relation to the River Crane are set out in Table 4-4

Table 4-4 – Specific planning policy objectives in the Local Plan for the London Borough of Hounslow that relate to the Lower River Crane vision

Strategic Objective within the Local Plan	Commentary related to the Lower River Crane
Strategic vision: protecting local character – Natural environment, open spaces and the borough's rivers The outstanding natural environment and green infrastructure network, including the borough's parks and open spaces, biodiversity and habitats as well as the unique environment of the borough's rivers and their corridors will have been protected and enhanced where possible. Residents will continue to highly value and cherish the borough's exceptional environmental quality.	There is a clear commitment to improving the habitat within the River Crane and the riparian corridor.
Policy GB5: Blue Ribbon Network Our approach: We will protect and enhance the borough's Blue Ribbon Network, recognising the multifunctional role that rivers and waterbodies play and their potential to contribute to the borough's regeneration. We will expect development proposals to: (h) Demonstrate that adverse impacts on aquatic and waterside environments are avoided where developments in, over or adjacent to waterbodies are proposed (for residential moorings, refer to Policy GB6);	There is an opportunity along Cole Park Island to both improve the water body of the River Crane in line with the WFD legislation.

(i) Have regard to the context and character of the Blue Ribbon Network, consistent with the Urban Context and Character Study and Thames Landscape Strategies, where development in the Thames Policy Area is proposed; (j) Restore waterbodies to their natural state in line with actions of the Thames River Basin Management Plan, and ensure developments are set back to provide a minimum 8m buffer strip to the main river, 16m to the Thames Tidal defence and 5m to ordinary watercourses. SuDS must be maximised on these sites to achieve an improvement in water quality in line with the aims of the Water Framework Directive; and (k) Provide an assessment of the impact of the proposal on the status of the waterbody, where it is likely that a proposal would have a significant adverse impact.	
Policy GB7 – Biodiversity Our approach: We will protect and enhance the London Borough of Hounslow's natural environment and seek to increase the quantity and quality of the borough's biodiversity. We will achieve this by: (a) Permitting development only where it can be shown that significant adverse impact on biodiversity is avoided, mitigated, or as a last resort, compensated; (b) Protecting designated international, national and local nature conservation areas, as set in supporting facts, and supporting new designations; (c) Promoting the qualitative enhancement of biodiversity sites, including improvements to access, connectivity and the creation of new habitat; (d) Working with partners, including the Hounslow Biodiversity Partnership, the Crane Valley Partnership, the Brent Catchment Partnership and the Thames Landscape Strategy to improve conditions for biodiversity; and (e) Encouraging the greening of the borough, through landscaping and tree planting, and protecting existing trees through Tree Preservation Orders (TPOs). We will expect development proposals to (f) Contribute to the greening of the borough, by incorporating green roofs and walls, landscaping, tree planting and other measures to promote biodiversity such as bat and bird boxes, through the preparation of ecological plans and strategies where major developments are proposed, thereby resulting in a gain for biodiversity in the borough; and (g) Contribute to the action plans set out in the Hounslow Biodiversity Action Plan.	There is a clear commitment in the Local Plan to enhancing the biodiversity in the Borough particularly including improvements to access, connectivity and creation of new habitat.
Policy EQ3 Flood risk and surface water management The SFRA sets out those parts of the borough that are at risk from flooding, and the extent to which flood events may impact the built environment. It should be used alongside the most recent flood risk mapping published by the Environment Agency to inform planning decisions. • The aim of the sequential and exceptions test is to steer new development to areas with the lowest probability of flooding. Flood zones established in the SFRA and Environmental Agency mapping are the basis for these tests, and their requirements are set out in the NPPF Technical Guidance. • Flood zones provide a guide for the probability of flooding. Zone 1 is considered low probability, Zone 2 is considered medium probability,	Any proposals taken forward would need to demonstrate that they did not create increased flood risk. Any proposal would need a flood risk assessment to demonstrate this.

Zone 3a is considered high probability and Zone 3b is considered part of the functional floodplain.

• Development proposals requiring a flood risk assessment include those located in Flood Zones 2 and 3 and those located in Flood Zone 1 of over 1ha. Flood Risk Standing Advice is available on the Environment Agency's website to inform these assessments.

Twickenham Area Action Plan

The Twickenham Area Action Plan was adopted in 2013. For the River Crane, this action plan specifically relates to the area from Twickenham Rough down to the centre of Twickenham but does not extend past the London Road crossing in the centre of town. This is termed the Northern Approach and the main aim for this area is 'the creation of an attractive entrance into the town centre with a new station, enhanced public realm and comprehensive mixed-use development of key opportunity sites and enhancing the environmental and community value of the River Crane corridor.' Reconnecting the town centre with the riversides along the Thames and Crane is a critical part of the broad spatial strategy. This is also true in relation to the extension of the River Crane walk/cycle way and the network of green spaces. From an environmental perspective, the action plan adopts a series of key principles for environmental Improvements. Specifically, for the River Crane these include:

- Protect and enhance the River Thames and River Crane corridors and reconnect them with wider links up and downstream;
- Enhance the open spaces of the Crane Corridor and manage them for environmental benefit as well as community use, including the creation of more natural riverbanks where feasible;
- Ensure that all new developments, environmental and transport improvements are designed to be sustainable;
- Ensure that new development positively enhances the town centre, and provide design briefs or guidance for key sites;
- Ensure that all new development, transport proposals and environmental improvements enhance accessibility for disabled people; and
- Upgrade the existing public open spaces and Civic Spaces and create new Civic Space within the town and improve links between these and to key parts of the centre and to take the opportunity to provide green infrastructure and soft landscaping throughout the town where possible.

Specifically, for the Northern Approach key environmental improvements are set out as:

- Upgrading of existing open space and provision of new open areas for public use in the Crane Valley, including the creation of more natural riverbanks where feasible. Creation of River Crane walk by station, allowing a link to Moormead Park to be provided;
- Improvements to street scene within Northern Approach and pedestrian links to town centre;
- New public piazza in front of upgraded station and former sorting office site; and
- Enhancements to setting and views of Heatham House

Thus, it is clear from a local planning perspective that any proposal that supports the re-naturalisation of the River Crane and improved access up and downstream is well supported by the local action plan for Twickenham.

4.1.4. London Rivers Action Plan (LRAP)

The London Rivers Action Plan (LRAP) was developed to integrate both the north and south London restoration plans that were developed by the Environment Agency and their partners. The main aims of the LRAP was to provide a forum for identifying where in London rivers could be restored and brought back to life using a variety of different techniques. It was produced in January 2009. The five key aspirations of the plan are:

- Improve flood management using more natural processes;
- Reduce the likely negative impacts of climate change;
- Reconnect people to the natural environment through urban regeneration;
- Gain better access for recreation and improved well-being; and
- Enhance habitats for wildlife.

4.2. Options Selection

An initial Landscape Vision for the Lower River Crane was developed by Astronaut Kawada Architecture (2018). The various, spatially specific, restoration visions identified in this document were used as a starting point for this project. A series of options have since been developed to enhance the Lower River Crane based on this vision. The options developed in this report are all deemed to be feasible at this stage of the overall strategy in line with the constraints that have been determined during the baseline assessment. The options complement the WFD objectives and fulfil many of the mitigation measures that are currently not in place for this water body (Table 3-2). They are also aligned to various strategies within the NPPF, the Local Plans for both the London Borough of Richmond and the London Borough of Hounslow (Table 4-1 to Table 4-4) and the Twickenham Local Plan. The measures also support in delivering LRAP (Section 4.1.4.).

The following three, distinct, options have been developed for consideration and have been discussed at an options workshop with interested parties on the 28th November 2018. Details were provided on the spatial arrangement of these options across the Lower River Crane and these are illustrated in Section 5. The workshop was held at the Council office in the London Borough of Richmond and representatives from councils, the Environment Agency, London Wildlife Trust, Friends of Groups, Astronaut Kawada and residents attended. The basic principles adopted for the spatial positioning of these distinct restoration options are outlined below:

1) Propose river restoration (Option 3) where identified in the Landscape Vision, or where further opportunities were identified in the early stages of this project, and where there are no constraints to prevent it from occurring;
2) Propose bank reprofiling (Option 2) where a lack of available space prevents a full-scale restoration project, but where there is sufficient room to remove the concrete bank and reprofiling the bank(s) within the same channel alignment; and,
3) Propose instream measures (Option 1) where there is not the potential to either restore the channel, or reprofile the bank(s), but there is the possibility to improve the habitat diversity of the instream environment through the addition of various measures.

The three principal options are outlined in more detail below. It is important to note that the most sustainable long-term scenario is with a fully restored channel (Option 3) followed by the bank reprofiling (Option 2). Any management option that includes keeping the concrete nature of the channel (including the instream measures in Option 1) will require a level of management as the concrete degrades over time which will necessitate intervention, often in quite confined locations. At some point in the future work is likely to be required to maintain the structural integrity of the concrete walling and as this arises opportunities to improve the channel should be sought using more sustainable solutions.

4.2.1. Option 1: Instream measures

This option retains the river in the same alignment and is undertaken when neither river restoration, or reprofiling of the banks, are possible due to constraints on space. As the watercourse in the Lower River Crane has been heavily modified and widened, instream features have the potential to make significant improvements to the habitat diversity within this localised water environment, improving the ecology and making the channel more resilient to fluctuating flow conditions. There is also the potential to improve access to/visibility of the riverside edge. Visually, this option can introduce a sinuous edge to the concrete channel which will in time encourage further deposition of sediments and marginal plant establishment in addition to the planted edge. In time, this will create a softened channel as well as improving the overall habitat biodiversity.

An example of such a project where this technique has been used is illustrated in Figure 4-1 (photographs provided by Salix and the Wild Trout Trust). The scheme was undertaken on Porters Brook, which was formally culverted under a car park, in the centre of Sheffield. The scheme not only de-culverted the channel but narrowed it within a very confined environment using a series of rock rolls, coir rolls, backfilling and coir pallets. This, award winning, project created a small meandering channel within its wider profile. Integrated into this scheme was a pocket park which not only provides additional flood storage but also a small recreational park in the centre of a very urbanised environment. The inclusion of rock rolls in the scheme as well as the addition of coir rolls and pallets helps to ensure stability of the instream environment during higher flows while enabling the instream vegetation to become quickly established. This was particularly relevant in this example as the Porters Brook flows off the Peak District and thus is quite a flashy river responding quickly to rainfall events. After only two years the vegetation was well established and monitoring revealed an increase in invertebrates and signs that brown trout were once again breeding in this area. A comparable approach is proposed for the Lower River Crane where rock rolls can be used to form the edge of the meandering low flow channel. Backfilling behind the rock rolls with the addition of coir rolls and pallets will help marginal vegetation to become quickly established further stabilising the instream environment. For this technique to be successful

on the Lower River Crane, localised thinning of existing riparian vegetation is required in places to ensure sufficient light can enter the channel to enable this instream vegetation to establish. As at least half of the Lower River Crane runs in a west to east direction it is likely that planting along the left bank could be more successful than the right bank as it would naturally receive more light.

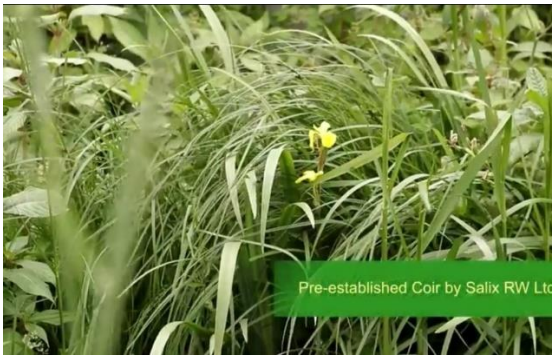
Porters Brook - Deculverting and establishment of new channel using rock rolls, coir rolls and pallets

Deculverting of channel from underneath the car park

Re-establishment of channel within wider confined area using rock rolls, coir rolls and pallets

Rock rolls being installed with coir rolls and pallets being planted behind

Rock rolls forming 'hard' edge of new channel



Marginal vegetation establishment after 2 years

Pocket park next to the new channel providing both recreation and flood storage benefits

Figure 4-1 – Option 1- Instream measures – Example showing Porters Brook pocket park in Sheffield (courtesy of Salix and Wild Trout Trust)

4.2.2. Option 2 – Reprofiling of banks

This option partly restores the river but keeps the general alignment of the river form. It would be undertaken where there is sufficient room to remove the concrete bank and then reprofile one, or both, banks. The extent of any reprofiling will need to be determined at detailed design stage. The improvements seek to achieve a better landscape integration of the watercourse within the neighbouring setting and would reduce the slope gradients of the watercourse wherever possible. This would improve the visibility of the channel and help

integrate the river into the local environment. The reprofiling would create more gradually sloping banks and is thus likely to develop more naturalised areas of improved habitat. Planting would help the habitat to develop at a more rapid rate. The battering of banks would also locally increase the channel capacity reducing the flood risk through locally making space for water. Schematics of option 2 are shown in Figure 4-2. Examples of where it has been undertaken successfully on the River Ravensbourne in the centre of Lewisham as part of a large-scale redevelopment is illustrated in Figure 4-3.

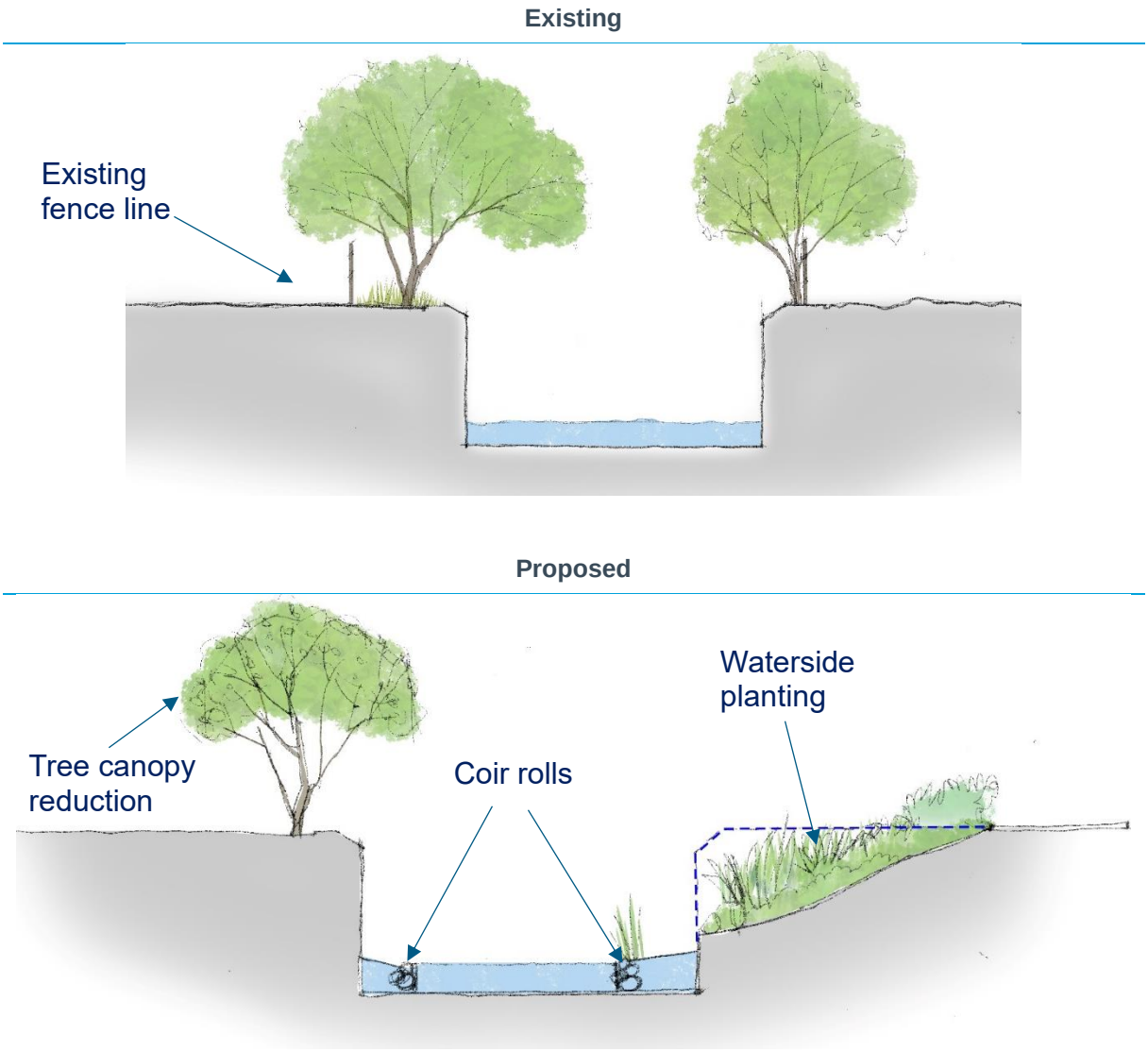


Figure 4-2 – Option 2- Reprofiling of banks

Restoration scheme	
River Ravensbourne, London Borough of Lewisham – prior to works (April 2005) (courtesy of the London Borough of Lewisham)	
River Ravensbourne, London Borough of Lewisham – following works (June 2007) (courtesy of the London Borough of Lewisham)	

Figure 4-3 – Option 2- Reprofiling of banks – Case study on the River Ravensbourne

4.2.3. Option 3 – River restoration

This option involves moving the river away from the current location and restoring the channel to a more naturalised form. This process would involve cutting the channel into the ground and profiling the banks to a more natural batter, maximising the biodiversity potential of the river. Marginal planting would also help improve the marginal fringes more rapidly. The restoration of the channel would achieve better landscape integration of the watercourse within any local park setting and re-establish a more natural channel form. Restoration would also locally increase channel capacity and the meandering nature of the new channel would slow water down providing Natural Flood Risk management benefits. The restoration would also provide a safer environment with respect to flood risk and public safety since flooding will be more predictable and access to the river is improved thus removing the safety risk associated with steep banks that is associated with concrete lined channels.

Generic objectives relating to each of the options include:

- To develop improvements to the river's physical form and functioning to improve the overall ecological value of the river and maximising biodiversity value within the park setting;
- To provide a riverine landscape that floods more frequently within a defined corridor in a managed way;
- To ensure the integration of the landscape with any river restoration work;
- To improve public safety through considerate design within the restored park landscape; and,
- To Identify potential constraints due to buried services, contaminated land, invasive species or existing infrastructure.

Option 3 is shown in Figure 4-4.

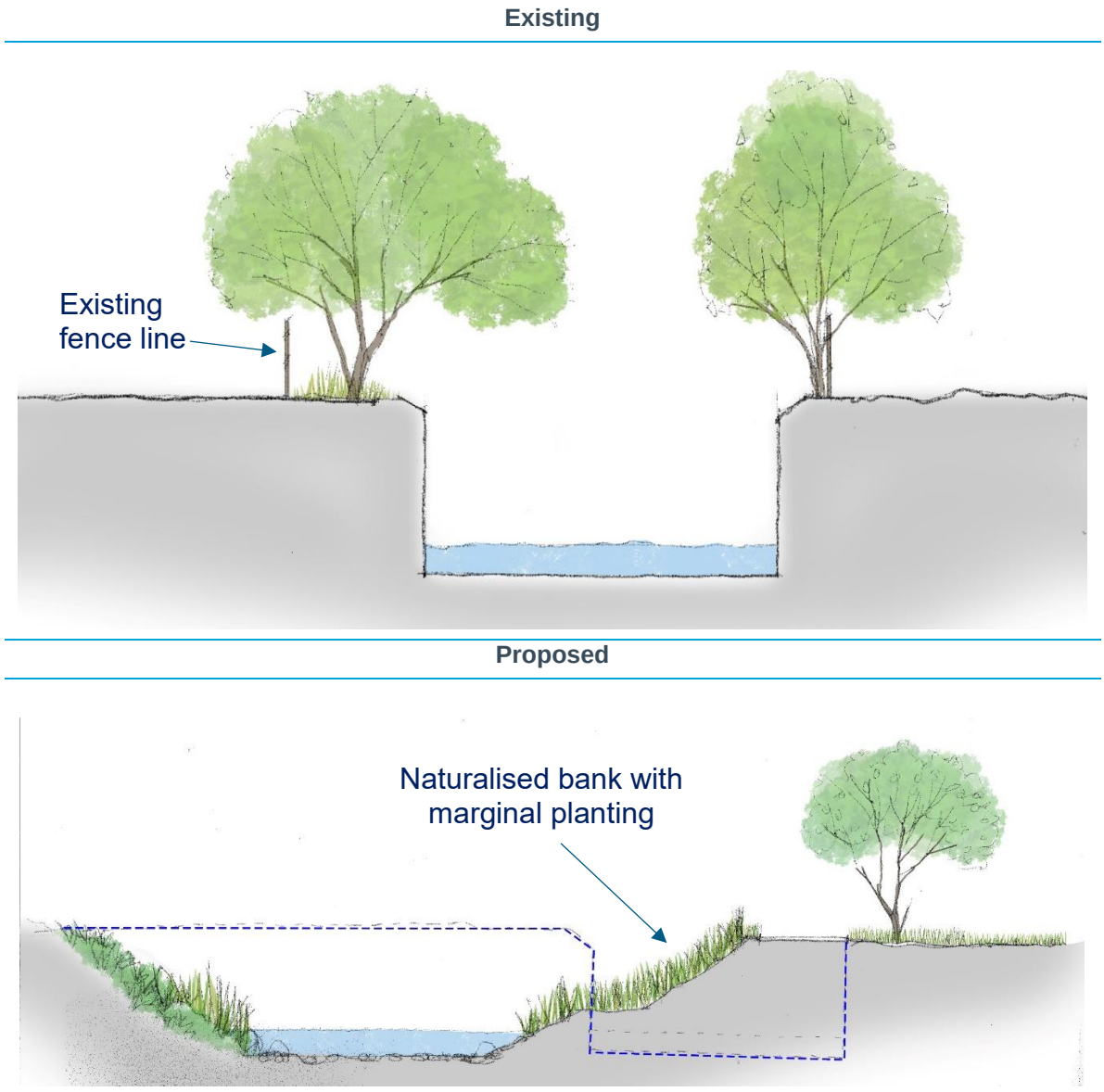


Figure 4-4 – Option 3 – Restoration of the channel

4.2.4. Option 3A

Option 3A is similar to option 3 but involves maintaining part of the old course as backwater habitat. The backwater habitat would be valuable fish refuge. This option can be undertaken when space allows. Option 3A is show in Figure 4-5.

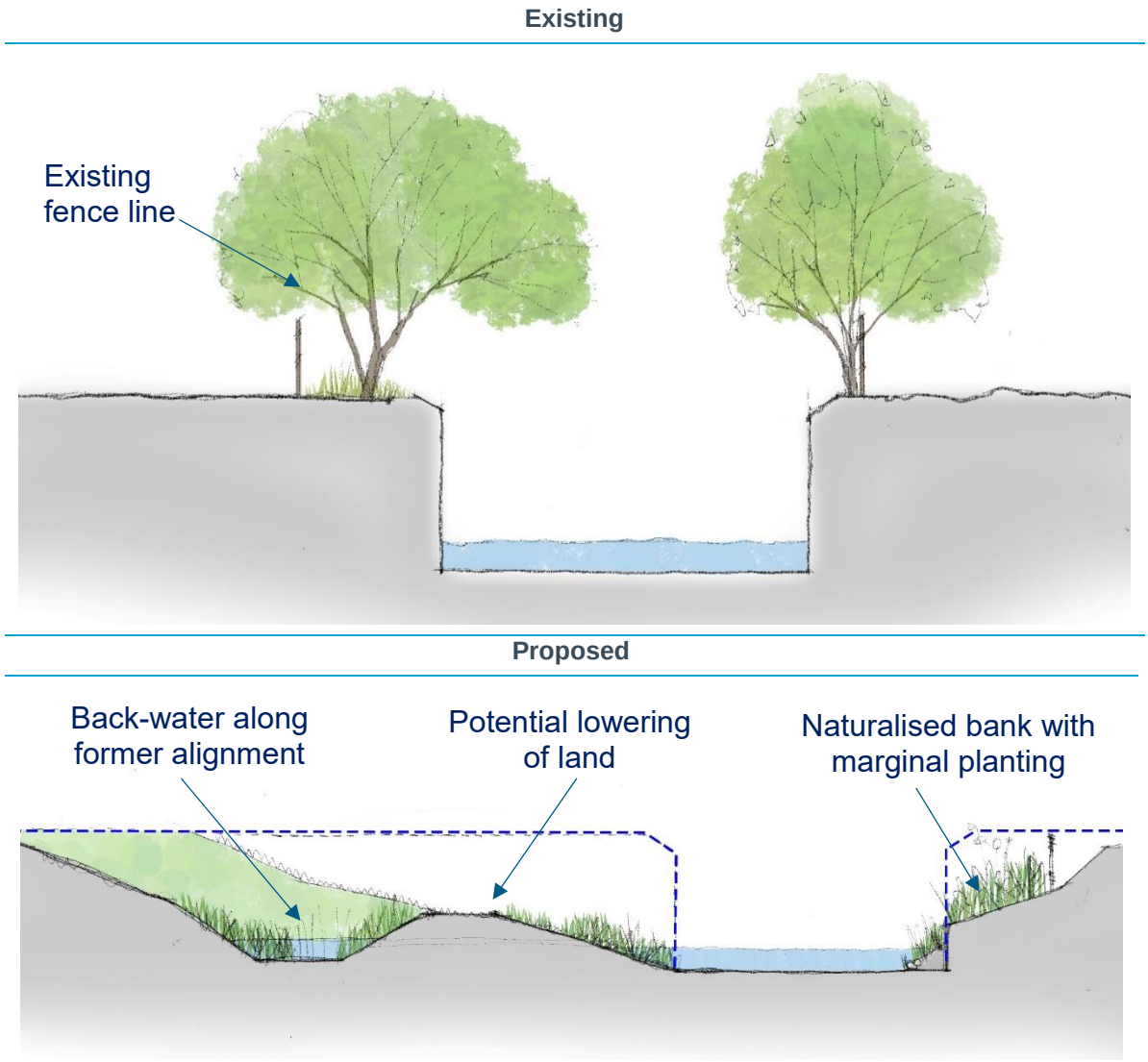


Figure 4-5 – Option 3A – Restoration of the channel with additional backwater

Numerous comparable projects have been undertaken across London. There are useful examples as they demonstrate where comparable techniques have been used to restore habitat through river restoration (see Figure 4-6). Further examples can be found on the River Restoration Centre website on their interactive project map (https://www.therrc.co.uk/uk-projects-map).

Restoration scheme	
Mayes Brook, London Borough of Barking	 
Stanmore Marsh, London Borough of Harrow	 
Newton Park, London Borough of Harrow	 

Figure 4-6 – Examples of river restoration schemes across London

4.2.5. Restoration opportunity plans

The results of the utilities search and geo-environmental desk study, were used to develop a series of opportunity maps through the overall study reach. These are illustrated on Figure 4-7 to Figure 4-10. The maps illustrate areas where there are no neighbouring constraints to the river that would prevent restoration occurring. This enables the river to be moved from the current location and restored within this area. The restoration plans developed in Section 5 reflect these opportunity mapping process.

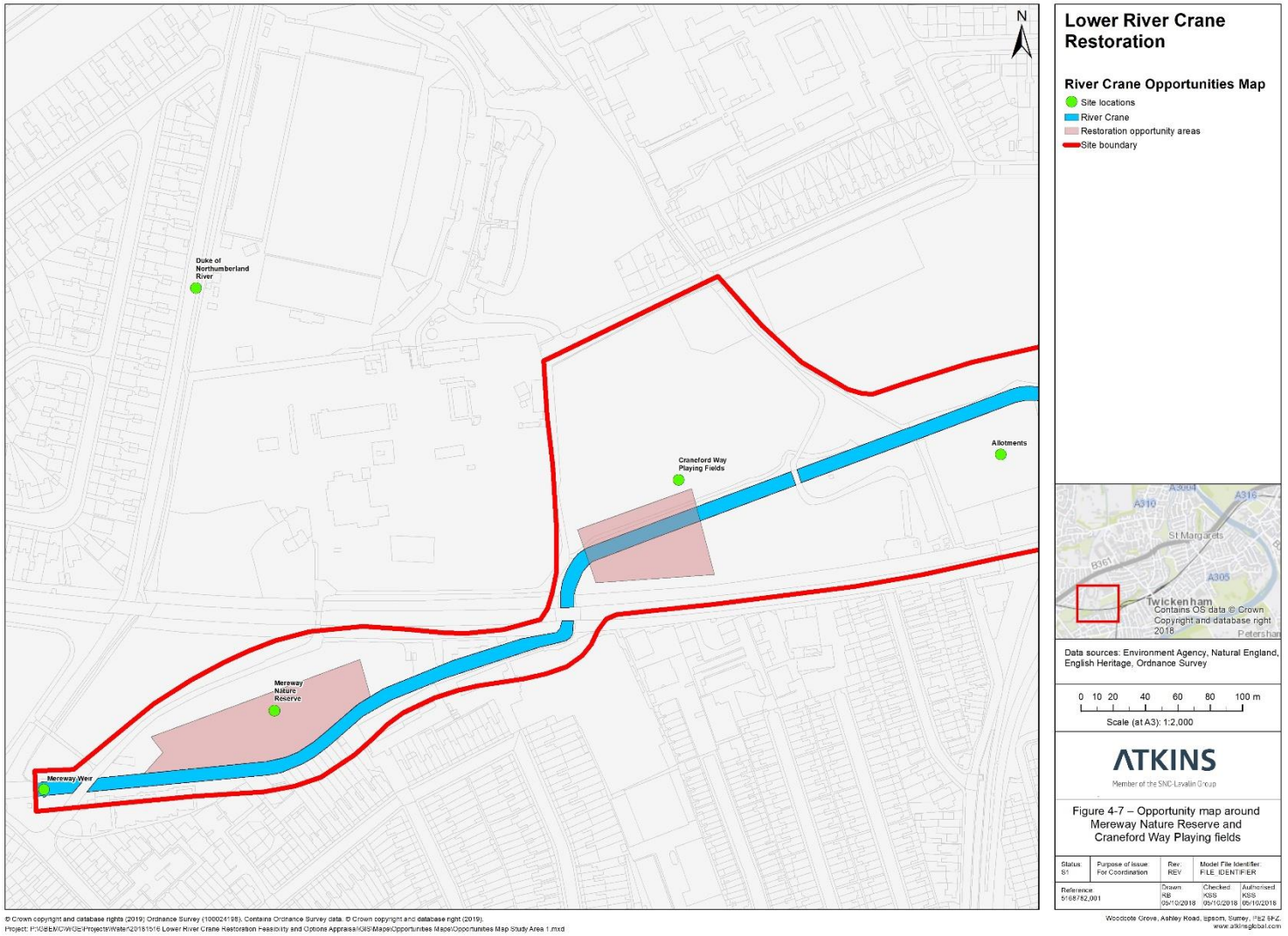


Figure 4-7 – Opportunity map around Mereway Nature Park and Craneford Way playing fields

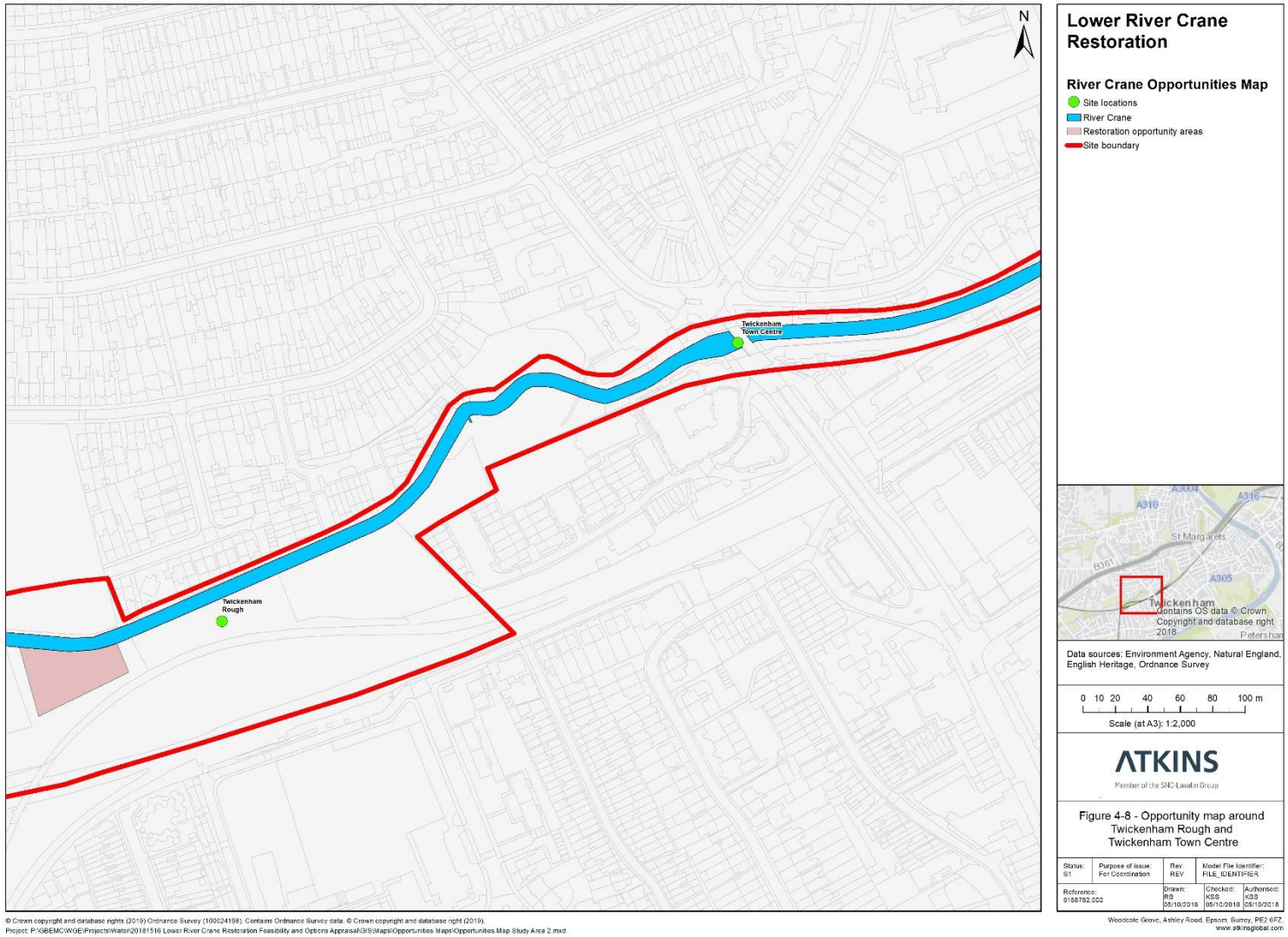


Figure 4-8 – Opportunity map around Twickenham Rough and Twickenham Town Centre

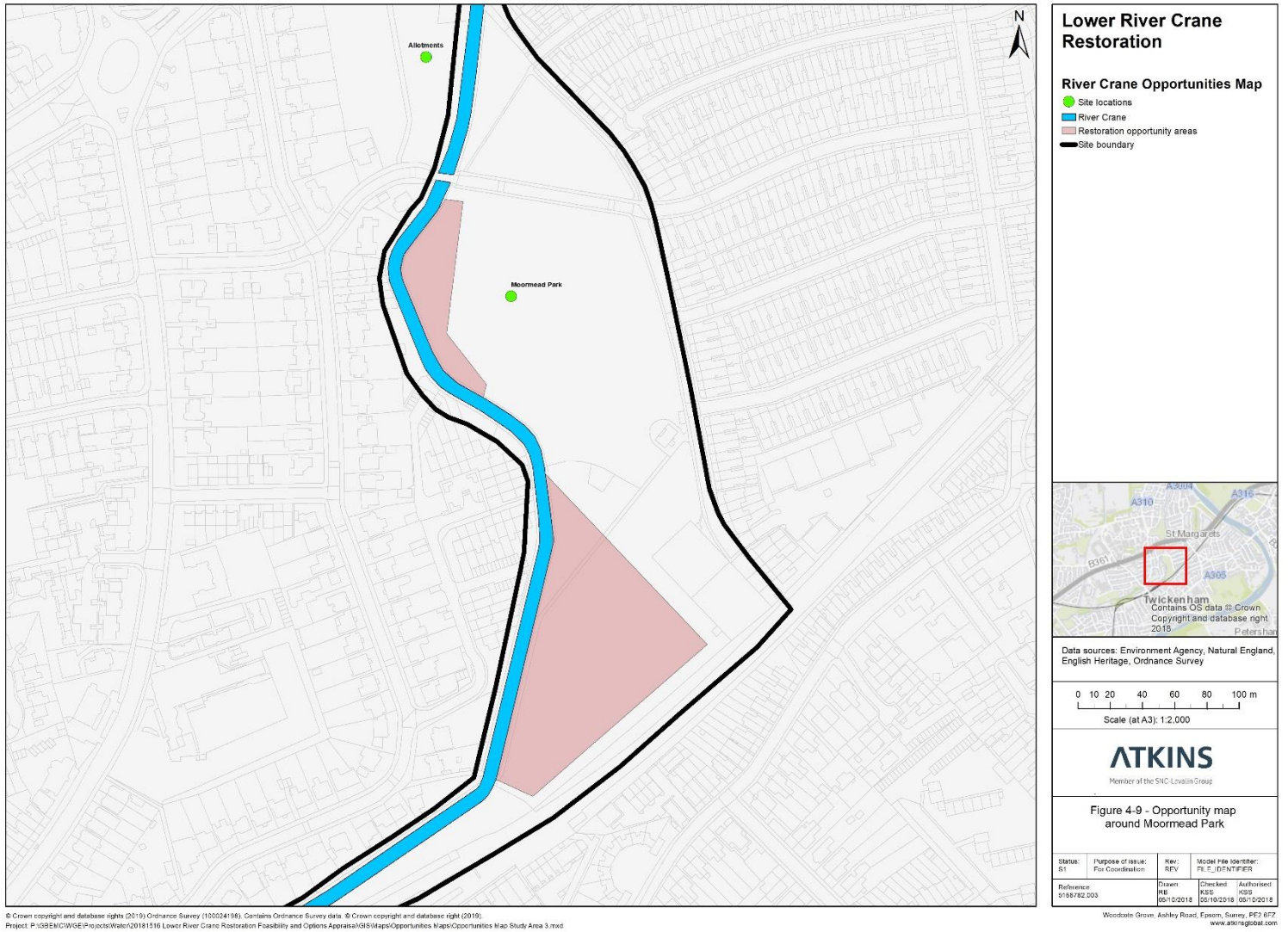


Figure 4-9 – Opportunity map around Moormead Park

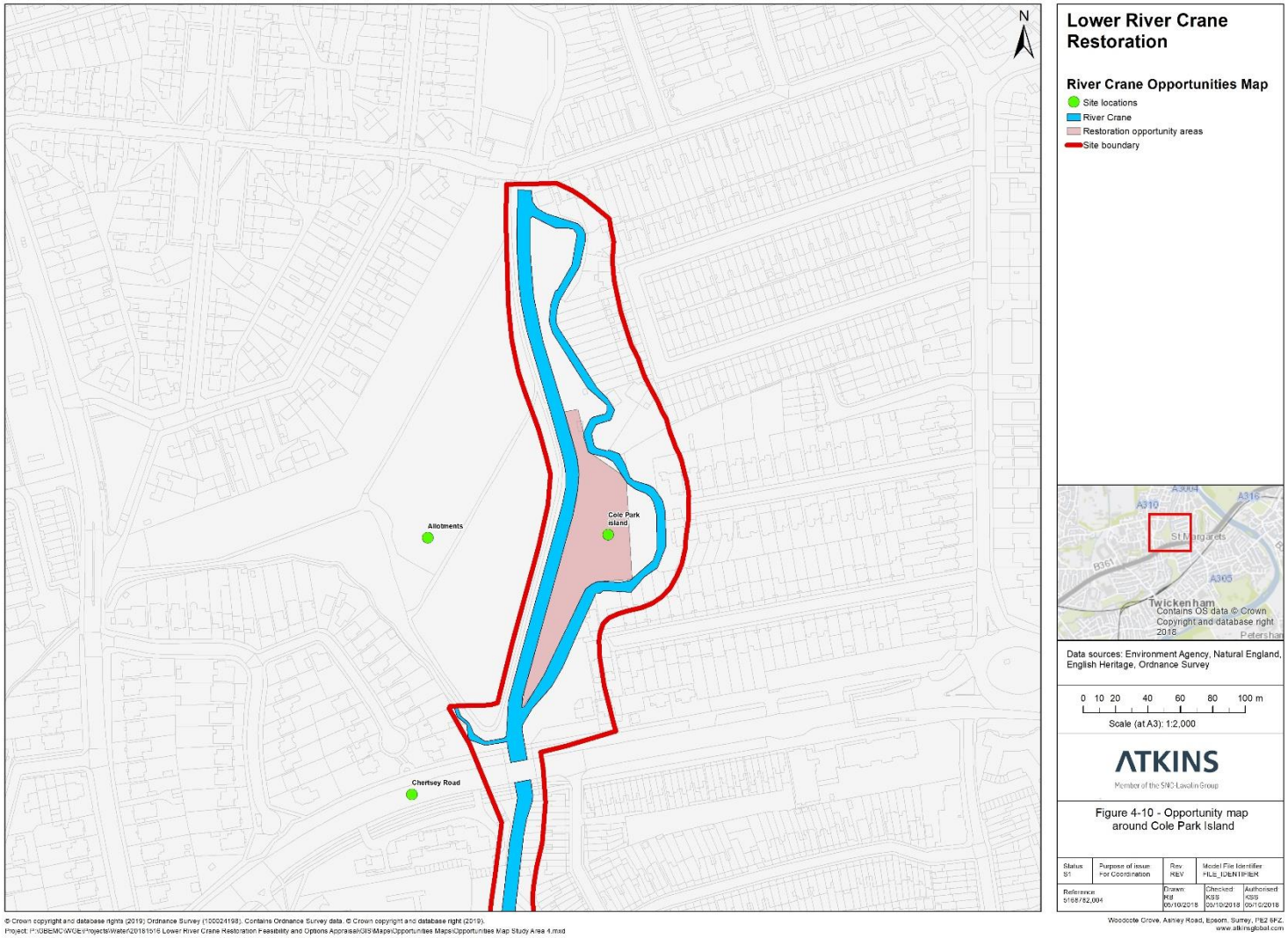


Figure 4-10 – Opportunity map around Cole Park Island

5. Restoration Plans

5.1. Introduction

Spatially specific restoration plans were developed throughout the Lower River Crane. The plans adopted the principles detailed in Section 4.2 using the three options, namely: Option 1-Instream measures; Option 2 – Reprofiling of bank(s); and finally, Option 3 – River Restoration. On each of the plans Option 3 is shown clearly where the channel is proposed to be taken away from the existing channel alignment whereas Options 1 and 2 are labelled on the plans accordingly. The location and extent of these plans are illustrated in Figure 5-1 and the concepts behind each of them detailed further in Sections 5.2 to 5.7. The areas that the plans were developed for include:

- Mereway Nature Park;
- Craneford Way playing fields;
- Twickenham Rough (two areas);
- Twickenham Town Centre;
- Moormead Park; and
- Cole Park Island.

The plans describing the various proposals developed were reviewed as part of the stakeholder workshops. In some areas several plans were developed where there were distinct variations on the options. Each of these plans have been designed to take on board comments and issues relating to access, maintenance and to ensure the adjoining land uses are considered. There will be a requirement for further discussions especially in locations that will require some reconfiguration of boundaries or where there would be new public access introduced. In areas where lighting is proposed on any new amenity areas/paths the Environment Agency has requested that low level lighting is used as a matter of principle. Issues of material re-use and disposal would need to be considered when any of the individual plans get taken forward. Currently, there is a presumption that all material could be used in the local vicinity and there would be no need to dispose of any material off-site. Maintenance of the various areas would need to be adapted to reflect any new environment. Maintenance plans would need to be developed as any project is implemented and could include the use of volunteers as appropriate. This model for management of park areas has proved effective in other London Boroughs. Additional plans would need to be developed to manage any invasive species if they are found in any of the restoration areas following any further surveys.

Additionally, the plans and text identify potential measures and the type of intervention that could be made to improve the contextual open spaces adjoining the riverside. These may not all be directly related to the river restoration but are intended to integrate the river restoration and extend benefits to the wider community by improving aspects such as:

- Improving the quality and offer of services within nearby parkland areas, play areas, informal uses, dog walking, cafes and community hubs;
- Connections to/from and along the river corridor that may improve commuting or recreational activities;
- Create biodiversity opportunities and nature conservancy opportunities for voluntary stewardship; and
- Create opportunities that allow riverside activity and access to the watercourse itself as part of a wider recreational area, addressing where dog access may be managed.

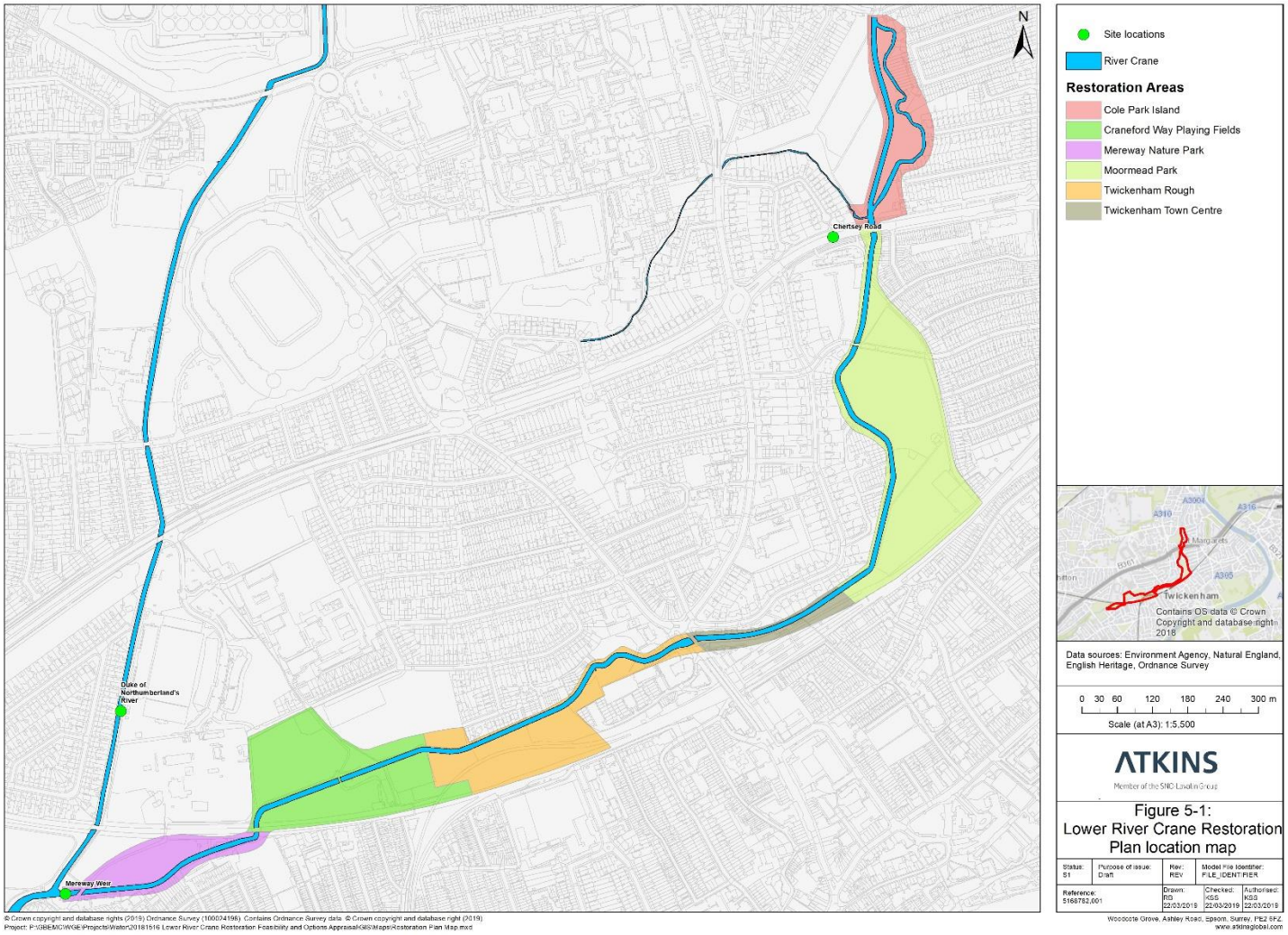


Figure 5-1 – Lower River Crane Restoration Plan location map

5.2. Mereway Nature Park

Two scenarios have been developed for Mereway Nature Park. These are detailed in Figure 5-2 and Figure 5-3. The first scenario (Figure 5-2) involves restoring the channel immediately downstream (Option 3A) of the bridge (downstream of Mereway Weir). The channel would be restored into the nature reserve itself with the concrete banks along the left bank being removed from the Environment Agency slip way down to the weir located further downstream. A part of the old watercourse would be kept as a backwater for fish refuge. The remainder of the channel would be filled in. As part of this scenario an additional path could be routed to the edge of the new channel. At the November 2018 workshop concerns were raised about access for maintenance around the old backwater. It was thus suggested that a second option should be developed which kept the channel in the existing location while incorporating a backwater into the nature reserve. This scenario is presented in Figure 5-3. This partial restoration scenario would involve re-naturalising all the left bank downstream from the Environment Agency slipway down to the weir. A backwater would be linked to the main River Crane upstream of the downstream weir. Each of these options would provide local benefits to flood risk as additional capacity would be provided in the channel making space for water. The nature park is currently not at risk from flooding according to the Environment Agency flood maps so a local benefit to flood risk could be readily achieved. Both options involve installing instream measures (Option 1) in the downstream section after the weir down to the railway crossing.

Both scenarios show the potential for a naturalised fish pass around Mereway Weir. It was suggested at the workshop that this should be shown on these drawings. This opportunity would be part of the refurbishment work that is planned by the Environment Agency on Mereway Weir. The original proposal was a Larinier fish pass immediately adjacent to the weir structure, but discussions have since evolved to consider a more natural by-pass channel. The location marked on both drawings is indicative only, but any project taken forward should be integrated with any restoration proposals and the various constraints considered. In addition to the proposals outlined there exists opportunities to improve the right bank alongside the old Mereway Day Centre and the former Greggs sites.

5.2.1. Integrated Landscape Opportunities

- Creation of an interpretative trail to the riverside edge, possibly with controlled access;
- Creation of a riverside dipping pontoon;
- Marginal planting habitats, to create a series of waterside transitional zones from water's edge, through scrub to woodland to diversify the local habitat; and,
- Extend the interpretative measures to other part of the Mereway Nature Park.

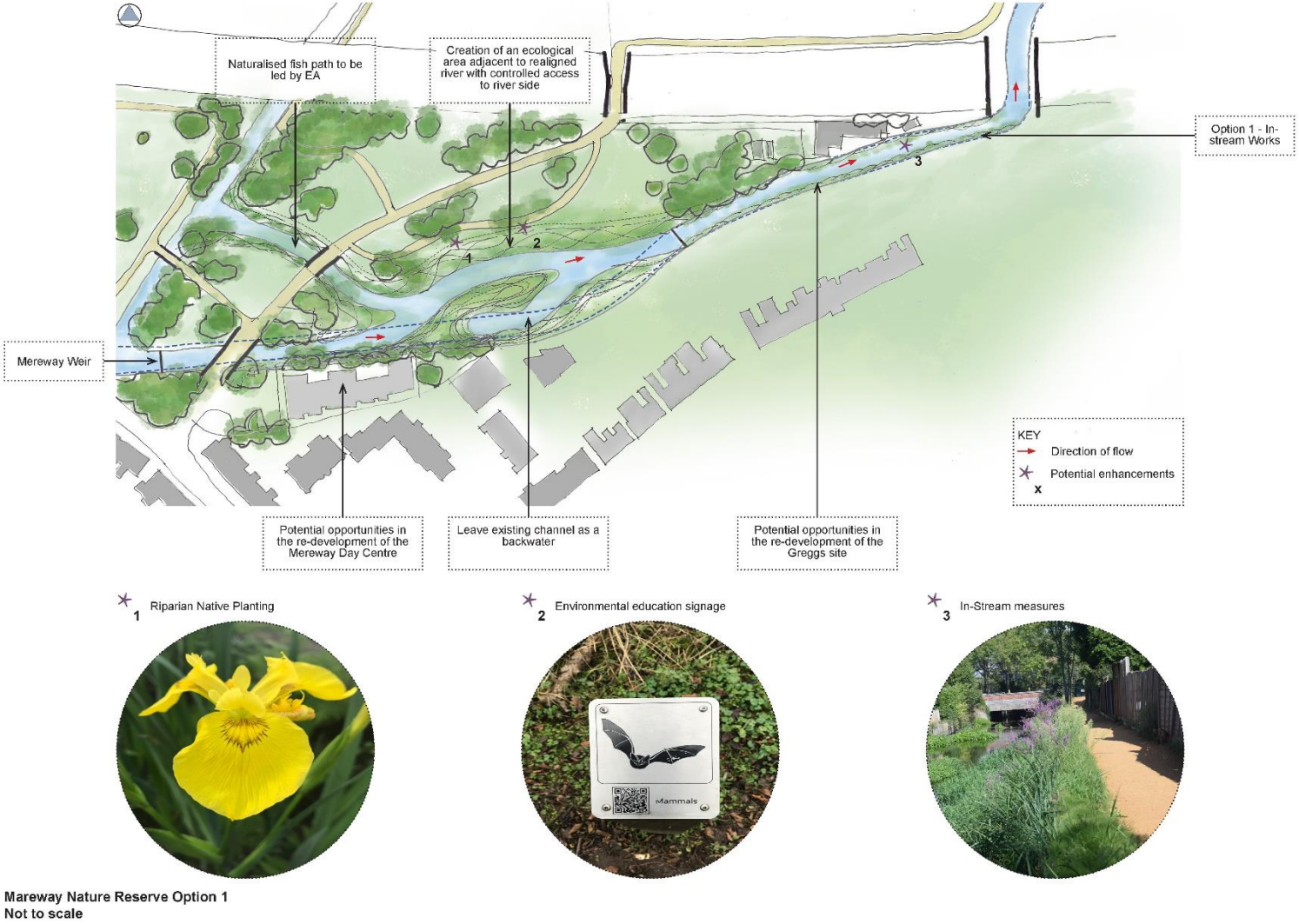


Figure 5-2 – Scenario 1 – Restoration of channel into Mereway Nature Park

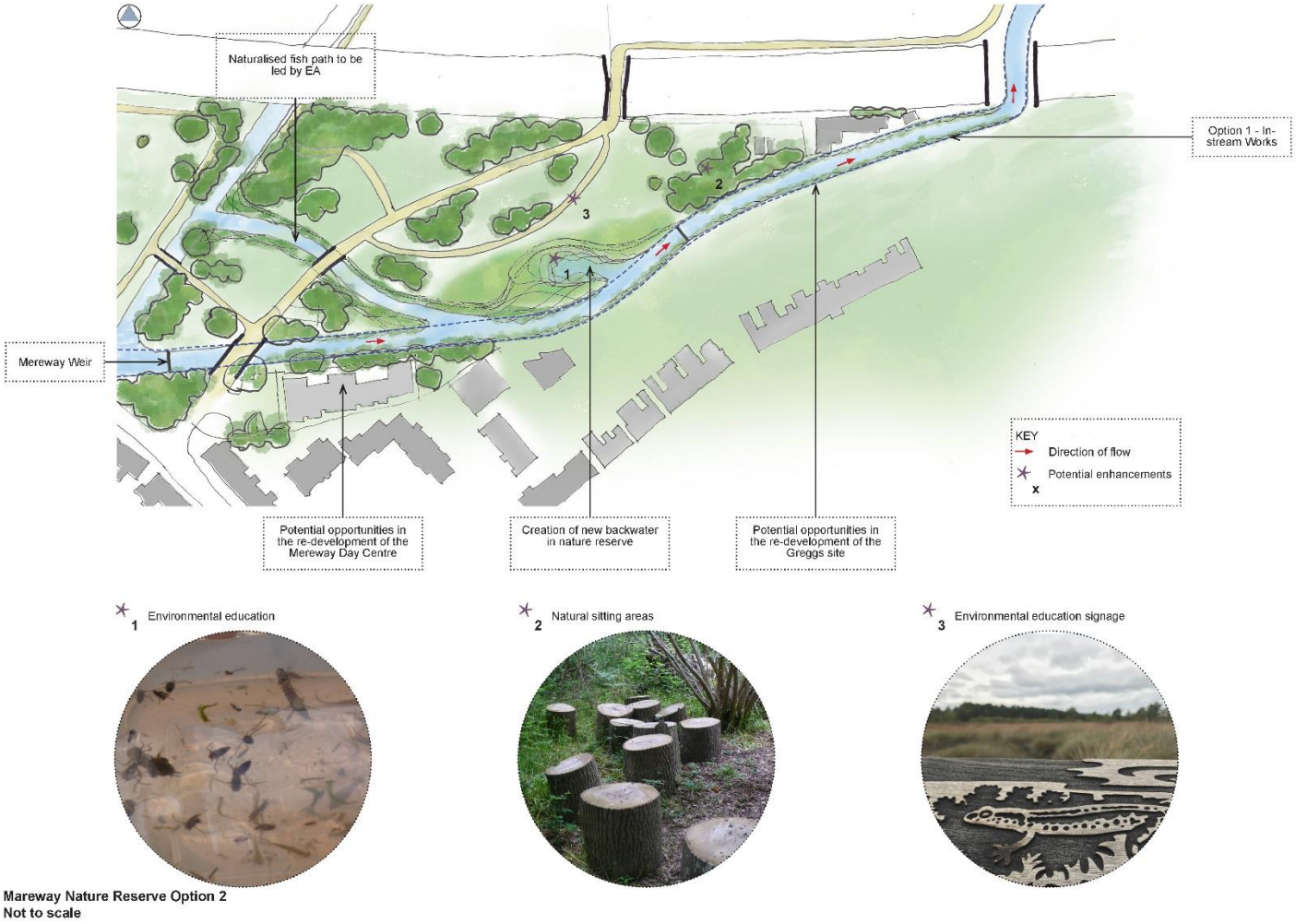


Figure 5-3 – Scenario 2 – Establishment of backwater into Mereway Nature Park

5.3. Craneford Way playing fields

In Craneford Way playing fields a scenario was presented at the workshop that showed a short length of restoration (Option 3A) immediately after the channel emerges under the railway line (see Figure 5-4). Opportunities were limited in this area as a result of multiple utilities and an Environment Agency gauging weir. The plan incorporates a small backwater into a currently underutilised area between the existing channel and the railway line and the rifle club further downstream along the right bank. A bridge has been incorporated into this area with potential benches to add an area for closer interaction with the river and an area for reflection. Limited changes have been proposed to the Craneford Way playing fields as it is recognised that this is an important amenity area. A more natural channel width would be required in the restored river and instream planting added. The restoration would locally increase channel capacity and the increased roughness (through vegetation) would slow the water down delivering natural flood risk management locally. Any design would need to ensure flood risk was not elevated elsewhere since much of Craneford Way playing fields are currently within flood zone 2 according to the Environment Agency flood maps (see Figure 3-1). Downstream of the proposed restoration scheme, there would be a section of channel that would be left unaltered as a result of the need for the functioning of the Environment Agency gauging weir to be maintained. However, downstream of this structure, instream measures (Option 1) are proposed that will enhance the instream environment when no physical alteration to the banks of the channel are possible. In this location, the establishment of the instream vegetation is likely to be more successful along the northern bank as this area is likely to get more natural light.

5.3.1. Integrated Landscape Opportunities

- Creation of a platform to give an increased sense of interaction with the river corridor;
- Explore potential to extend the open space provision to the other side of the river, utilising part of the Rifle Club site to create new riverside areas, possibly with controlled access; and
- Extend the improvements to the wider Craneford Park to create a holistic masterplan with:
  - New footpath connections across the park;
  - Access to the riverside with an appropriate beach style edge to the river side with consideration of waterside safety;
  - Improved play facilities, perhaps including natural play options integrated with the areas of woodland;
  - Creation of mounded area or a raised area as part of the balance of cut and fill that might arise from river restoration works; and
  - Diversify the mown grassland to include areas of meadow grassland.

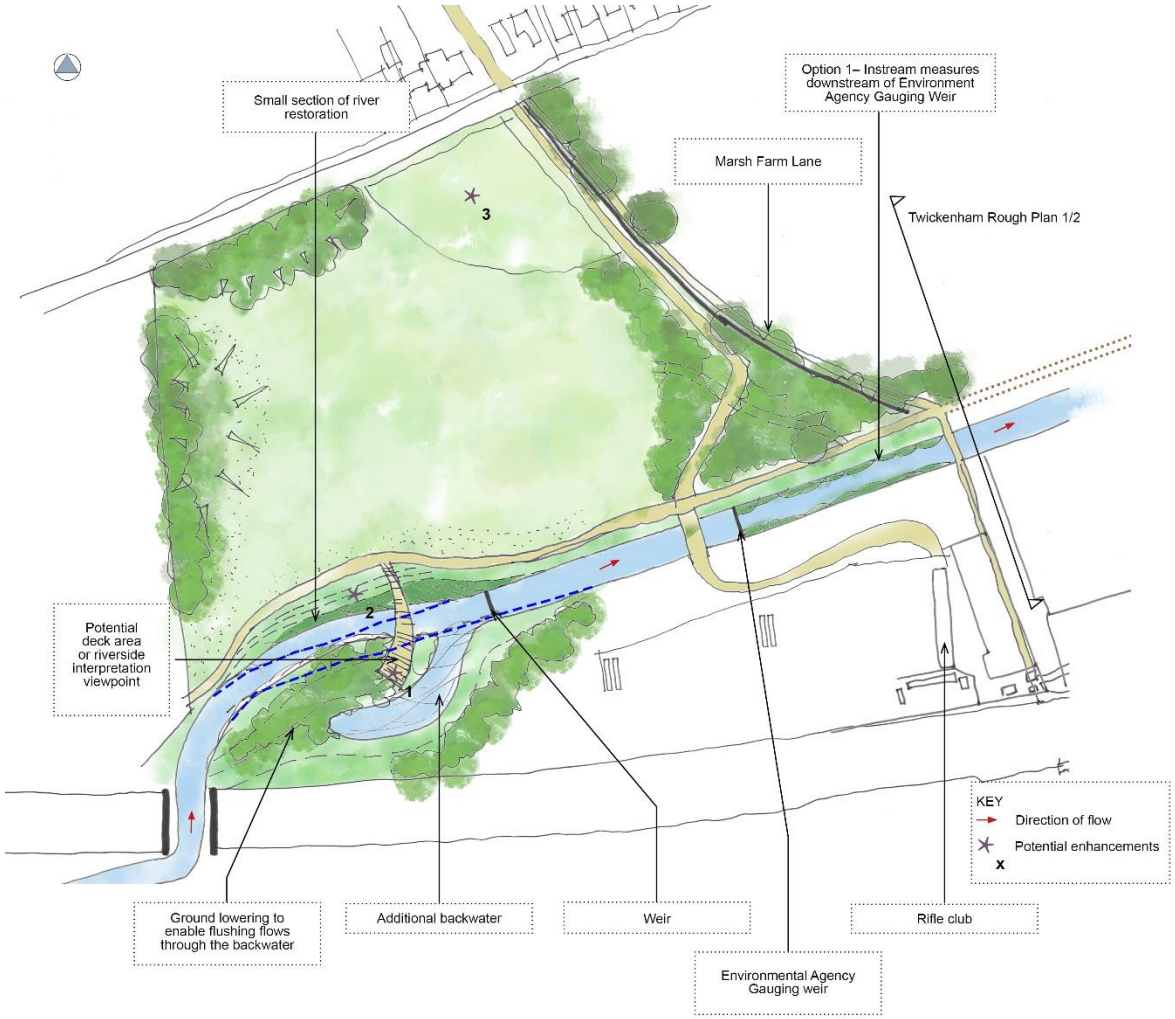


Figure 5-4 – Restoration within Craneford Way playing fields

5.4. Twickenham Rough

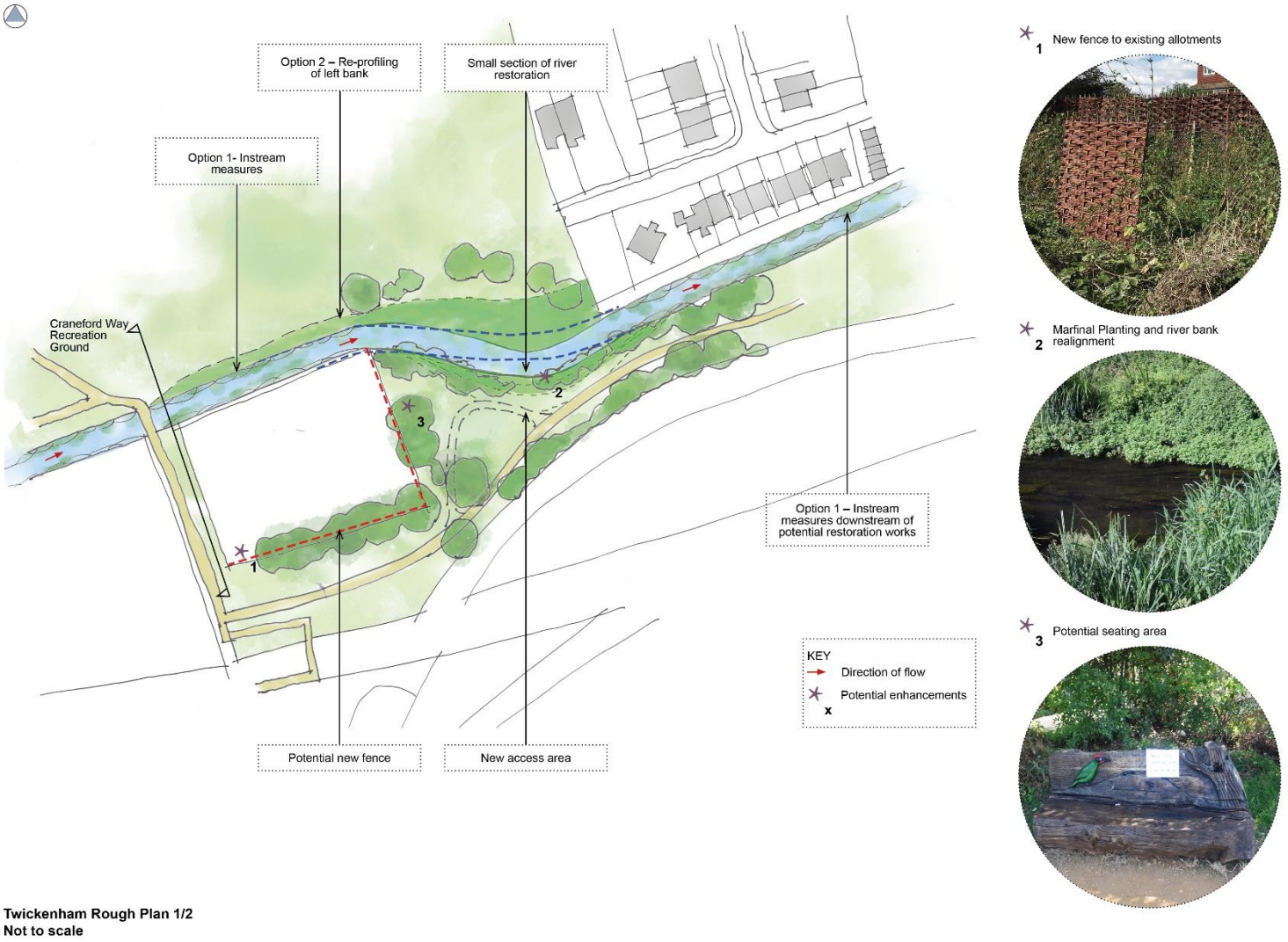
As with the area upstream in the Craneford Way playing fields, opportunities in Twickenham Rough are limited due to utilities, space and the proximity of the channel to numerous houses as the channel flows towards the centre of Twickenham. One scenario that has been identified is a small length of restoration (relocation of channel – Option 3) immediately downstream of the allotments along the existing right bank (see Figure 5-5). Restoration would involve moving the channel southwards and re-naturalising both banks. The channel would be tied back into the existing alignment upstream of the houses on the left bank. The short length of restoration would locally increase channel capacity and reduce flood risk through making space for water. The area to the right bank is currently not within Environment Agency flood map zones so localised benefits to flood risk could be readily achieved. Downstream of this point to the centre of Twickenham enhancement would focus on instream measures (Option 1) (see Figure 5-6). Instream measures (Option 1) are also proposed alongside the allotments upstream of the proposed restoration works. The localised narrowing and associated planting associated with the instream measures will help support in improving the instream environment. Alongside narrowing, it is likely that in some locations this would need to be accompanied by localised tree thinning to enable more light to get into the channel to support the development of localised riverine planting. Without tree thinning the success of any instream measures will be impacted. Any measures that are implemented would need to not increase flood risk.

While this restoration opportunity is limited it also has the potential to add significant recreational benefits as a new pathway could link to the footpath which was installed between Twickenham Rough and the centre of Twickenham in the summer of 2018. This offers the potential for a seating area linked with the newly restored channel within 5-10 minutes' walk from the town centre. At the workshop, broadly everyone was content to see something go forward at this location but there was recognition that there would need to be extensive public consultation to get everyone on side as there have been previous proposals in this location which have not been well received by all parties. It has also been noted that previous contamination has been identified in this area with remediation works undertaken. Thus, the risks of disturbance would need to be fully assessed in relation to known and potential contamination with any proposed restoration option. An additional security fence may be necessary for the allotment as this area is currently fenced off.

There are currently plans to redevelop the area to the north of the River Crane for a playing field for Richmond and Thames College which includes the installation of a 3G pitch. The Local Plan however dictates that any proposal in this location 'is required to protect and, where possible, enhance, the River Crane corridor' (London Borough of Richmond Local Plan, 2018). Thus, there is support for this proposal through the Local Plan. Re-naturalisation of the left bank (Option 2) could also be undertaken in this area via bank reprofiling. Bank reprofiling will help improve the edge of the river taking out the steep concrete bank side and replacing it with a more naturalised form which would involve a more gentle bank slope. Localised planting on the bank face is also likely to be required with this option.

5.4.1. Integrated Landscape Opportunities

- Creation of a seating area with possible views along the river corridor and new instream measures – this would be connected to the recently implemented footpath;
- Provide habitat measures, log piles, bird and bat boxes;
- Improve the boundary to the allotment gardens; and
- Achieve riverside connections to nearby housing areas as part of future improvements to the land which is presently used by Richmond College.



Twickenham Rough Plan 1/2
Not to scale

Figure 5-5 – Restoration plan within Twickenham Rough Part 1

Figure 5-6 – Restoration plan within Twickenham Rough Part 2

5.5. Twickenham Town Centre

The area around the centre of Twickenham is the most constrained section of the Lower River Crane. Along the whole length of this reach the channel is constrained along the left bank by gardens of houses and on the right bank by Twickenham Railway Station. Thus, restoration opportunities are limited and confined to instream measures (Option 1). Figure 5-7 illustrates the proposals in this area. In addition to the constrained space, the channel is also heavily shaded from both banks. Alongside the instream measures, localised tree thinning would therefore be essential to enable more light to get into the channel to support the development of localised riverine planting. This would increase visibility of the river in the locations where there are existing riverside paths or potential to create new footway riverside links. The instream measures may also be effective on the north (left) bank as a result of more natural light reaching this area. Without tree thinning the success of any instream measures will be impacted. Any measures that are implemented would need to not increase flood risk. Integrated in the redevelopment of the station there is the potential to increase the length of an access path downstream to Moormead Park and also to undertake localised tree thinning to provide more light into the channel.

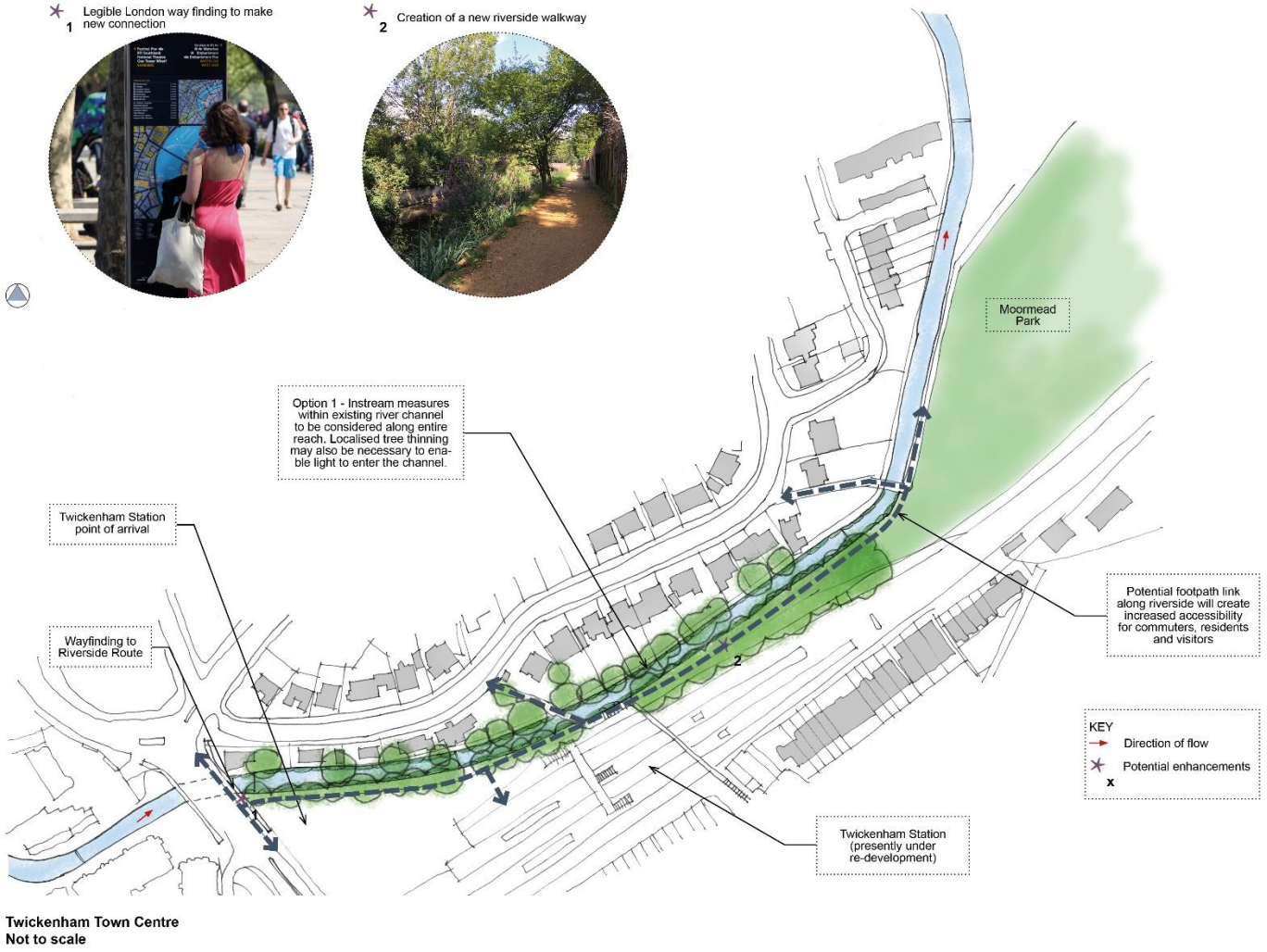


Figure 5-7 – Restoration plan within Twickenham Town Centre

5.6. Moormead Park

There is perhaps the greatest potential for restoration of the River Crane in Moormead Park within the overall project. Two scenarios were presented and illustrated at the workshop that showed restoration of the channel in two locations within the park, namely:

- restoration of the channel between the upstream entrance of the park and the existing play area; and
- restoration of the channel in the lower end of the park immediately upstream of Hillview Road.

Both scenarios showed these commonalities. In the upstream restoration, the moving of the channel would necessitate the relocation of the existing pathway and associated lighting. The restoration of the channel in this area will act as a central feature within the park and would also be tied to the new pathway that is currently being constructed between the railway station and Moormead Park, which in itself would mean greater footfall. The channel would be directly moved into the park and be designed to have a naturalised form with associated planting. The newly meandering course would reduce flood risk locally through slowing water down and allowing flood water to move into a larger area. The restoration will actually create a safer environment than exists at present providing a more predictable flood regime and safer access to the channel. This meandering channel would achieve benefits of natural flood risk management through making space for water. A new footpath would be created alongside the new planform. The restoration of the channel in this location would necessitate the moving of the play area. However, this presents an opportunity to develop a new play area which could directly be linked to any planned redevelopment of the pavilion into a cafe to truly provide an integrated solution within the park. Part of the old course would be left as a backwater for a fish refuge. Access to the area between the existing channel alignment and the new one would be restricted to access for maintenance only to ensure there are no security issues associated with the river restoration.

In the downstream restoration area, a small amount of restoration is proposed to be undertaken within both scenarios upstream of Hillview Road crossing. The channel would be moved into the park and designed to have a naturalised form with associated planting. The scenario to make any larger area for the restoration is constrained by utilities. The channel would form a natural wet edge between the park and the park boundary and thus there would be no additional security concerns with this proposal. This would be additionally enhanced by leaving part of the existing course as a backwater for fish refuge. To maximise the potential biodiversity benefits in this area it would be beneficial to remove the weir which is located downstream of the Hillview Road crossing as it currently creates a backwater upstream. This has been identified as being a good opportunity within the engineering review. As with the other area, increasing the local channel capacity and the creation of a meandering watercourse would help slow water down and provide local flood risk benefits. Downstream of the weir, instream measures (Option 1) are proposed all the way down to Chertsey Road in both the scenarios detailed above.

It was recognised that the area within the park is used heavily for football during the weekend. Any restoration in the upstream part of the park would necessitate losing this facility from an 11-a-side perspective, although both scenarios show a retention of a 5-a-side pitch. In the main park downstream, an area has been allocated for two 11-a-side pitches for Youth U15/U16 with each measuring 96.92 m by 60.35 m after incorporation of the runoff/safety area around the pitch. This has been successfully integrated alongside the restoration proposals. Discussions around the potential gain of a new integrated river park landscape against the loss of recreational space will need to be discussed further as any project gets taken forward. Both of these points have been noted as important in the Local Plan.

The variation between the scenarios presented centred around whether to retain the existing bridge at the upstream limit of the park (Figure 5-8) or to move it slightly further downstream along the new restored course (Figure 5-9). The scenario of moving the bridge as presented in Figure 5-9 allows the existing channel to align at an improved angle as it enters the park maximising restoration potential. Any option taken forward in this area would need to demonstrate that it was not creating an increase in flood risk as the whole of Moormead Park is within Flood Zone 2 as illustrated by the Environment Agency flood maps (see Figure 3-1).

Following further discussions with the Steering Group a further scenario was developed that did not involve restoration but focussed on instream measures (Option 1) along the whole length of the channel and then reprofiling (Option 2) along the right bank in the areas where there are no constraints. This option is illustrated in Figure 5-10. The advantages of this option are that it retains the existing green space and provides habitat benefits, but it will not integrate the river into the park and therefore not maximise biodiversity improvements. It will also not deliver natural flood risk management to any significant degree as it will not enable the general river alignment to be changed. Localised narrowing and associated planting will help support in improving the instream environment. Any instream work would need to be accompanied by localised tree thinning to enable more light to get into the channel to support the development of localised riverine planting. Without tree thinning the success of any instream measures will be impacted. Any measures that are implemented would need to not increase flood risk. As the existing channel is retained in the current location any works to the

channel which opens up the view to the channel will need to be mindful of the housing from which the gardens back onto the left bank of the channel particularly when it comes to provision of screening for privacy.

5.6.1. Integrated Landscape Opportunities

Restoration scenarios offer the potential to integrate the river restoration to create a significant change in the character and experience within this local park. It is essential that the position and alignment are fully considered to strike a balance between loss of parkland or pitch playing space and the amenity of residents. The scale of the park allows the continued provision of playing pitches as well as meeting other green infrastructure objectives that could be tailored to meet local stakeholder aspirations in the next stages of design:

- Consider the overall design of the park to reflect a contemporary well designed new urban park facility as a new attraction for Twickenham;
- New entrances or bridges and other structures could be designed within the park to reflect an overall design language and hierarchy, to improve the sense of arrival and direction around the park;
- Interpretation and wayfinding proposals should relate to Twickenham Station and the wider town centre and provide an opportunity to highlight the River Crane, any new local attractions and make the new connections;
- Enhance connections between Twickenham Station via a new riverside walk and the park to the wider residential areas;
- Review the location of play facilities, potentially co-locating the play area with the proposals for refurbishment of the disused pavilion;
- Redevelop the pavilion as a community café/hub;
- Create waterside recreation beach areas, allowing a designated area for dog access;
- Provide a riverside walkway for Options 1 & 2 only, to allow views of the river corridor, noting Option 3 would not be possible as this would bring activity closer proximity to nearby dwellings which may be unwelcome;
- Create habitat areas with limited access on the island areas which are not publicly accessible with ecological measures such as log piles, bird and bat boxes; and
- Provide additional tree planting along main routes to give additional structure to the park and increased tree cover.

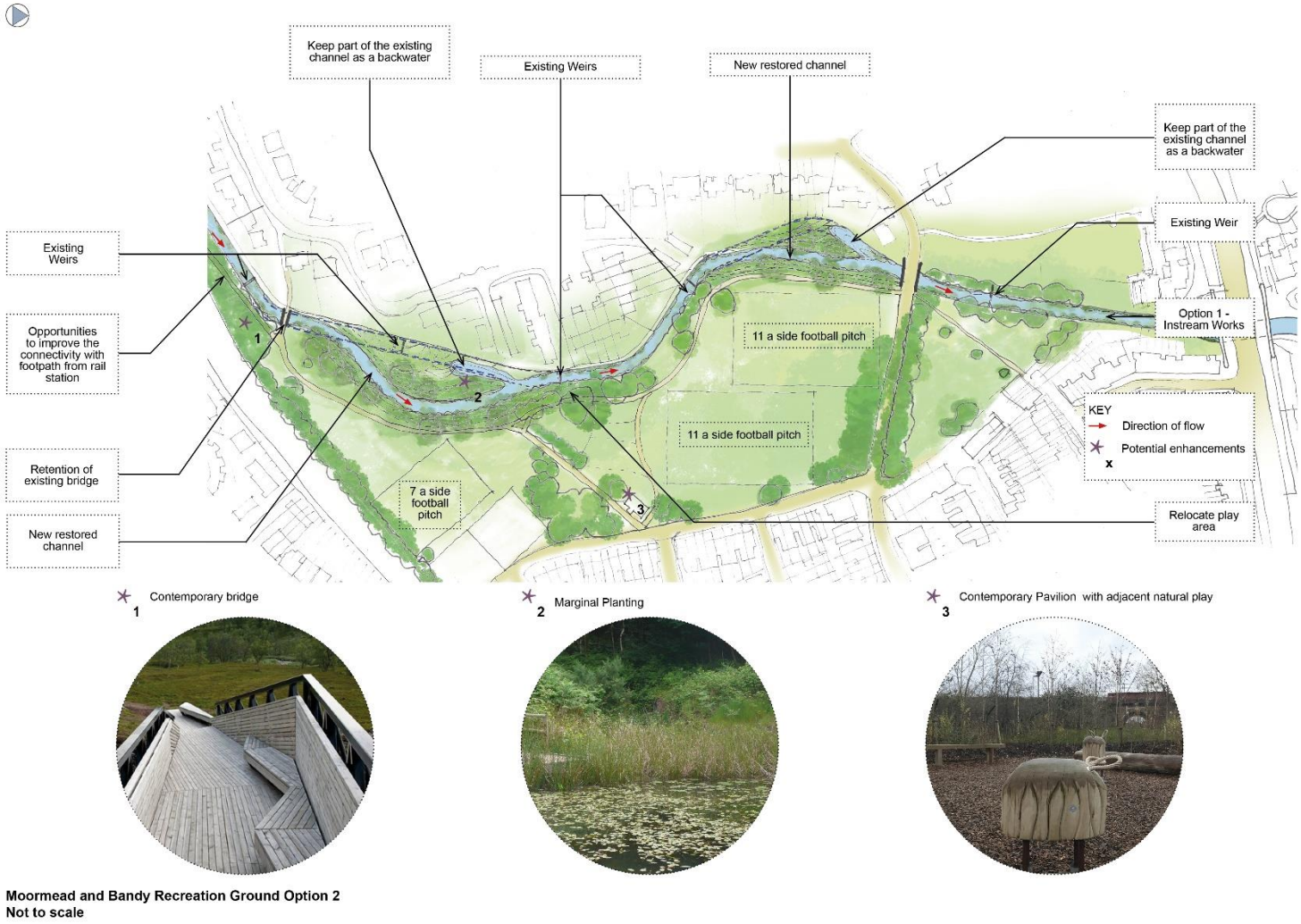


Figure 5-8 – Restoration scenarios in Moormead Park retaining the existing upstream bridge

Figure 5-9 – Restoration scenarios in Moormead Park which involve the moving of the upstream bridge

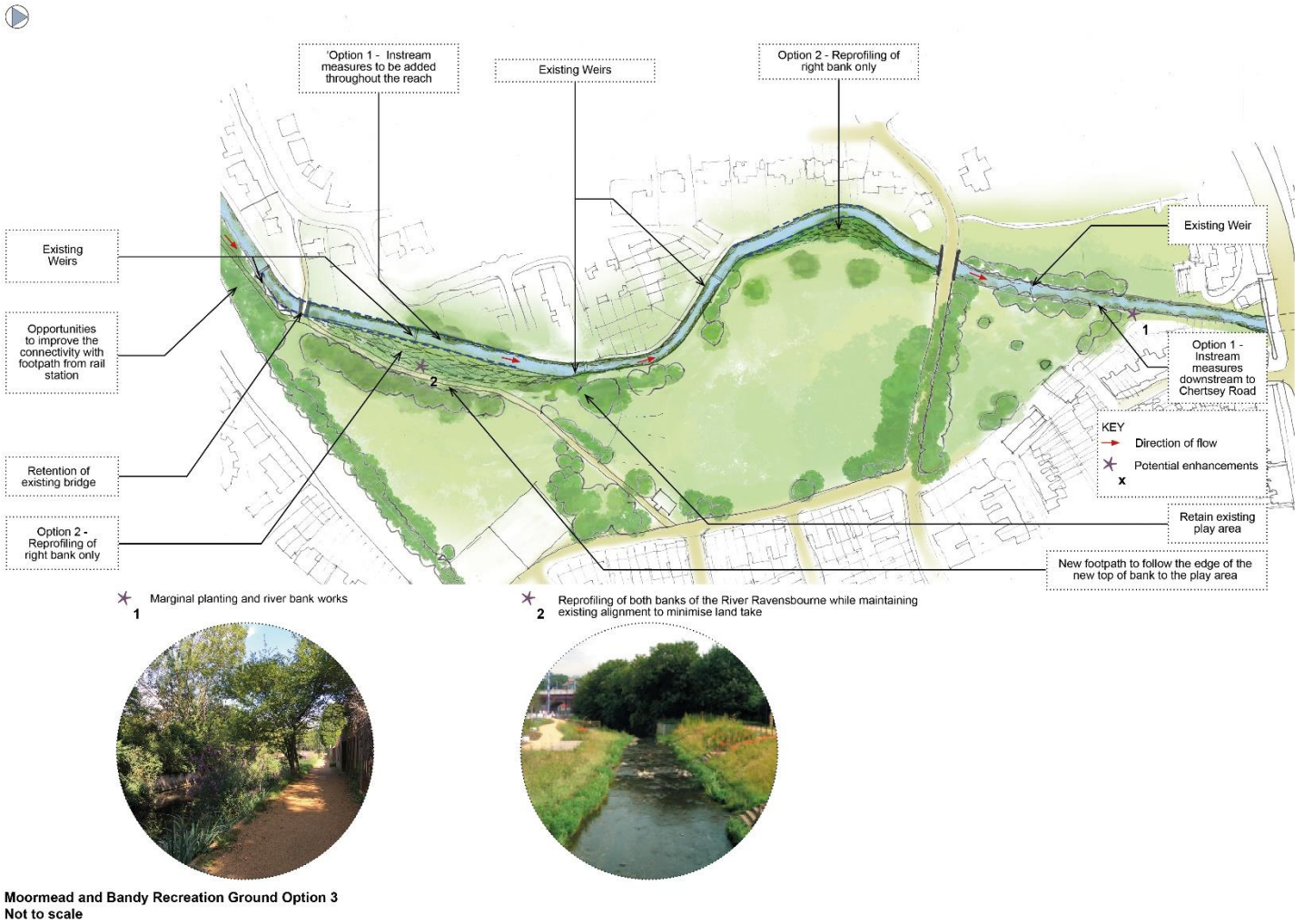


Figure 5-10 – Instream and bank re-profiling options in Moormead Park

5.7. Cole Park Island

In the workshop two scenarios were presented that showed a short length of river restoration immediately downstream of the first weir after the channel goes under Chertsey Road (Figure 5-11 and Figure 5-12). This would involve cutting a new section of channel but would be designed to have a naturalised form with associated planting. This was consistent for both scenarios. Opportunities for a greater amount of restoration were restricted by both space and utilities. However, undertaking restoration would locally increase channel capacity and thus locally reduce flood risk by making space for water. A short section of bank reprofiling (Option 2) is proposed on the right bank at the downstream section of the island. Bank reprofiling will help improve the edge of the river taking out the steep concrete bank sides and replacing them with a more naturalised form which would involve a more, gentle bank slope. Localised planting on the bank face is also likely to be required with this option. Instream measures were also proposed in each of the scenarios (Option 1). Any option taken forward would need to demonstrate that it was not creating an increase in flood risk as the whole of Cole Park Island is within Flood Zone 2 as illustrated by the Environment Agency flood maps (see Figure 3-1).

A principal objective of any work within Cole Park Island was to develop a new public access path and cycleway between Chertsey Road and Northcote Road. The major differences between the two scenarios reflected how this access has been incorporated within the proposals. It was recognised that any plans would need to be thoroughly consulted on since achieving any access in this area would require compromises. The differences between the two scenarios produced thus focused on the development of this access path. The first scenario (Figure 5-11) had the access path running along the left bank of the new channel and then crossing to the island at the existing bridge. The footpath would then run along the right bank before cutting back to the left bank on a new lower bridge. The entrance to the allotments may also need to be moved to ensure privacy to the allotments. As the footpath/cycleway runs alongside the allotments and the island, fencing would be required to ensure that security for both the allotments and the residents adjacent to Cole Park Island is maintained.

The second scenario (Figure 5-12) had a bridge further upstream which crossed the channel along the new realignment downstream of the existing weir. The access route would then run within the island earlier and stay along the right bank of the channel for longer and then cross back to the left bank at the downstream limit of the island at a new bridge in the same location as the other bridge. As with the other scenario, fencing would be required to ensure that security for both the allotments and the residents adjacent to Cole Park Island is maintained.

Discussion at the workshop centred around the need to balance any proposals with security concerns for local residents and allotment holders. Wider consultation would be required to determine the best scenario to be taken forward. Access between the two roads was largely welcomed, but the challenge is in how this can be achieved while addressing these various concerns. It was also suggested that a third scenario should be developed that keeps the access track along the left bank to avoid the island altogether. This scenario is presented in Figure 5-13. This would require more changes within the allotments but alleviates any concern of the residents whose properties are adjacent to Cole Park Island as this scenario would not involve having an access route within the island itself. The restoration measures (Option 3), bank reprofiling (Option 2) and instream measures (Option 1) remain the same in this option as with the other two detailed previously. At the workshop, it was also noted that Japanese Knotweed was present on the island and any restoration plans should support the eradication of this invasive. There were also discussions around the recent clearance of the old course of the Crane and it was pointed out that there was local support for some water to continue down this old course. Thus, any restoration proposals would need to ensure that this was still possible moving forward. Any maintenance plans for the river in the future would need to incorporate some form of clearance at defined intervals to ensure open flow of water along the old course can be fully achieved.

5.7.1. Integrated Landscape Opportunities

All three scenarios offer the potential to integrate the river restoration to the wider area and create a significant change in the character and an accessible experience along the River Crane in this location. While the proposals will not facilitate access across the A316 Chertsey Road which remains a barrier, the route would provide an alternative linear recreational and commuter road away from traffic and open up the river corridor visually. Landscape measures could include:

- Access to/from the allotments for allotment users and to allow views to the attractive allotments whilst ensuring a secure boundary;
- Terraced riverside garden concept which could relate to the allotments and local character;
- Creation of a true 'island form' for Cole Island as part of the river restoration proposals, retaining the use for residents to formally manage the island and its habitat on a voluntary basis;
- Minor works to improve the sinuous back- water flow and habitat; and
- Opportunity to create new visually distinct bridge crossing.

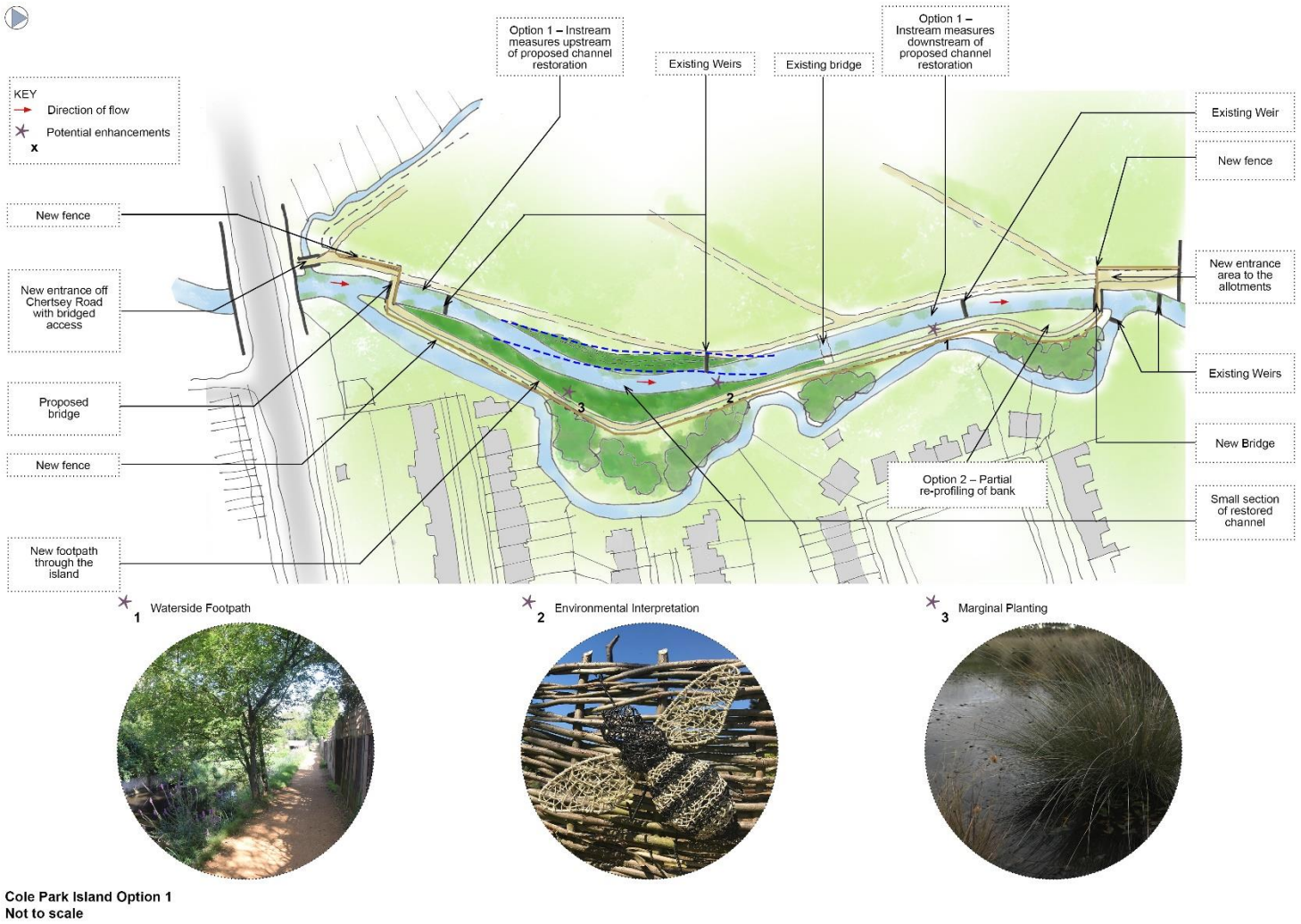


Figure 5-11 – Restoration scenario 1) in Cole Park Island

Keeps the access route along the left bank in the upper section before crossing to the right bank

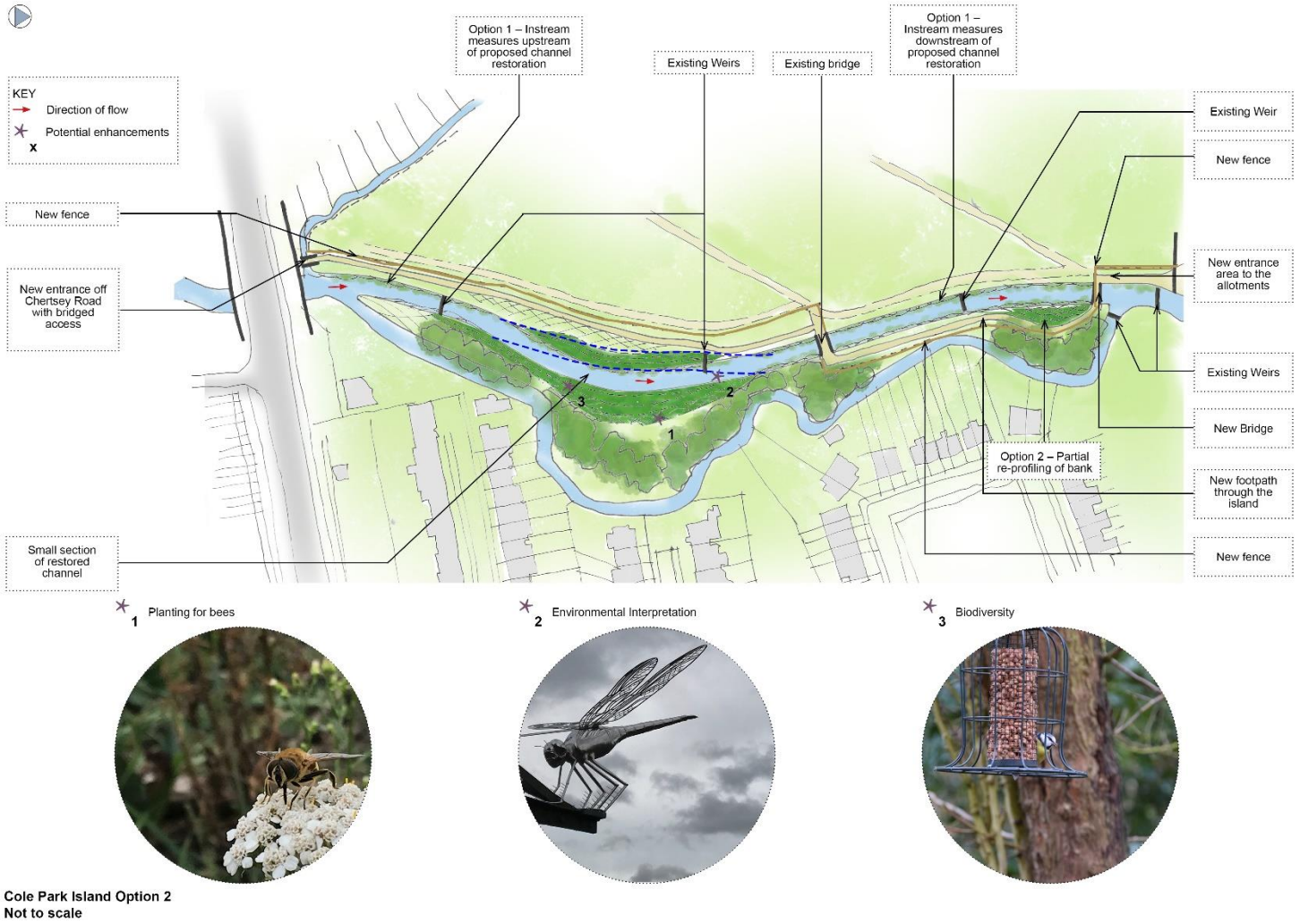


Figure 5-12 – Restoration scenario 2) in Cole Park Island

Keeps the access route along the right bank in the upper section continuing downstream before crossing back over at the downstream limit

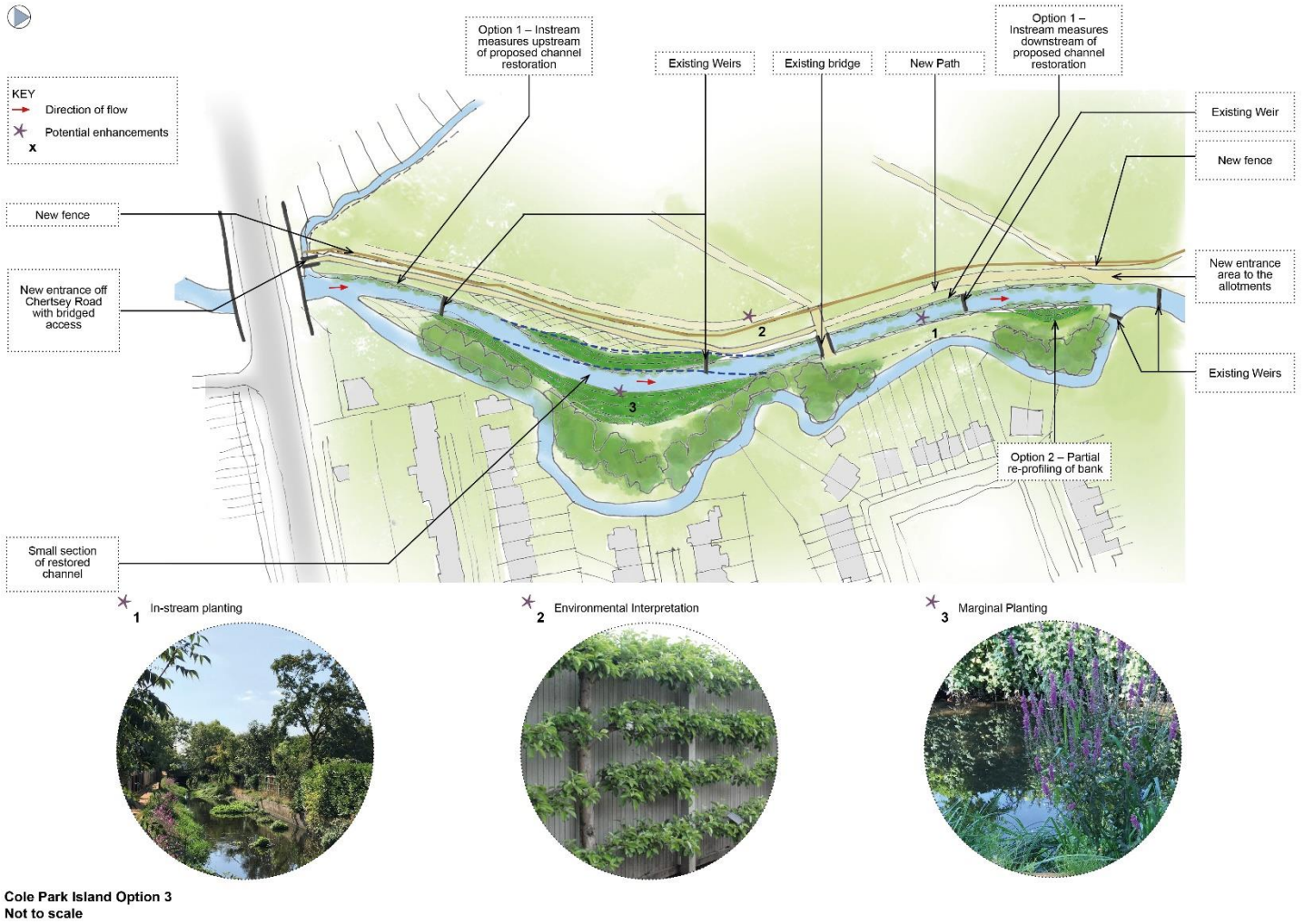


Figure 5-13 – Restoration scenario 3) in Cole Park Island

Keeps the access route along the left bank all the way down to the downstream limit

6. Costings

6.1. Background

Provisional costings have been developed for the various scenarios at each study reach, as described in Section 5. The approach taken is appropriate for the current feasibility phase of the project, using the information currently available and concentrating on the main items and activities that are proposed.

The cost estimates consist of the following:

Construction cost of the proposed works – This is the cost to construct the scheme design as presented, based on estimated quantities and rates, for example X metres of river channel realignment, at a rate of £Y per linear metre. The cost estimates are based on feasibility design proposals that have been prepared and are presented in Section 5. The design sketches have enabled key quantities to be estimated for the purposes of costing. Rates have then been applied to these quantities. Rates have typically been derived from a mix of industry sources and experience of similar projects. For some specific features, such as the instream measures that are proposed to provide in-channel improvements, budget costs were requested from the suppliers.

Preliminaries and overheads – In addition to constructing the proposed scheme, the construction phase will include these costs which take account of the cost of establishing and running the site. These costs are typically proportional to the duration of the works. For the purposes of estimating these costs and assuming possible funding and delivery routes, each reach has been considered as a separate standalone project. If in reality there were opportunities to combine schemes and deliver a larger project, it is likely economies of scale would help achieve cost savings (e.g. reduced site mobilisation and demobilisation, and potentially a shorter programme by undertaking different work simultaneously).

Design and management – An allowance has been made to cover the professional fees required to take the project from its current phase through to construction. This will include design work, preparation of planning application, flood risk assessment, stakeholder engagement, tender appraisal, CDM services and overall project management. Consideration has been given to project scale, complexity and risk to inform this estimate. For the purposes of estimating these costs and assuming possible funding and delivery routes, each reach has been considered as a separate standalone project. If in reality there were opportunities to combine schemes and deliver a larger project, it is likely economies of scale would help achieve cost savings.

A **contingency allowance** has been applied to the cost estimates, as is common practice with civil engineering infrastructure projects. This allowance is to cover risk, uncertainty and optimism bias. With reference to the HM Treasury Green Book, a 60% allowance is added at feasibility stage. As the project progresses and more detail is available (e.g. from further design, survey data, stakeholder feedback) the allowance is reduced to reflect the lower level of uncertainty and better understanding of risk.

Typical risks and uncertainties at feasibility stage that could potentially need to be addressed (i.e. typically resulting in cost increases) include:

- Buried services that need to be diverted or mean the design needs modifying.
- Contaminated land being discovered in Geotechnical Investigations.
- Stakeholder objections causing programme delays.
- Environmental or archaeological constraint that requires additional surveys to be undertaken, delays the construction window or necessitates a less efficient way of working.

In the following sections, a cost estimate summary table is provided for each scenario, reach by reach.

Assumptions

- Unless stated otherwise, excavated soil from works such as creation of new passages, backwaters and bank regrading will be reused on site for general landscaping and costs of earthworks disposal have not been included;
- Broken out concrete from Options 2 and 3 are disposed offsite with disposal costs included in unit rates of works;
- Although existing buried services have been identified, it is assumed that these will not be diverted during construction works, with the exception of the relocated footpath lighting in Moormead Park;
- Normal construction methods can be adopted and no restrictions that affect efficiency;
- Indicative costs are based on industry guidance and similar project experience;
- No contaminated land or invasive species constraints that affect working methods or costs.

6.1.1. Mereway Nature Park

Table 6-1 – Costings for Mereway Nature Park Scenario 1

Details	Costs	
Prelims and overheads	£	38,000
Estimated cost of works	£	623,950
Construction sub-total	£	661,950
Design and management	£	70,000
Risk and contingency	£	439,170
TOTAL	£	1,171,120

In this instance, landscaping works cover 8991 square metres with a unit rate of £69.40

Table 6-2 – Costings for Mereway Nature Park Scenario 2

Details	Costs	
Prelims and overheads	£	38,000
Estimated cost of works	£	506,700
Construction sub-total	£	544,700
Design and management	£	70,000
Risk and contingency	£	368,820
TOTAL	£	983,520

In this instance, landscaping works cover 7170 square metres with a unit rate of £70.67

6.1.2. Craneford Way playing fields

Table 6-3 – Costings for Craneford Way playing fields

Details	Costs	
Prelims and overheads	£	56,000
Estimated cost of works	£	681,065
Construction sub-total	£	737,065
Design and management	£	80,000
Risk and contingency	£	490,239
TOTAL	£	1,307,304

In this instance, landscaping works cover 15192 square metres with a unit rate of £44.83

6.1.3. Twickenham Rough

Table 6-4 – Costings for Twickenham Rough

Details	Costs	
Prelims and overheads	£	45,000
Estimated cost of works	£	337,865
Construction sub-total	£	382,865
Design and management	£	50,000
Risk and contingency	£	259,719
TOTAL	£	692,584

In this instance, landscaping works cover 7658 square metres with a unit rate of £44.12

6.1.4. Twickenham Town Centre

Table 6-5 – Costings for Twickenham Town Centre

Details	Costs	
Prelims and overheads	£	16,500
Estimated cost of works	£	146,250
Construction sub-total	£	162,750
Design and management	£	25,000
Risk and contingency	£	112,650
TOTAL	£	300,400

In this instance, landscaping works cover 5992 square metres with a unit rate of £24.41

6.1.5. Moormead Park and Bandy Recreation Ground

Table 6-6 – Costings for Moormead and Bandy Recreation Ground Scenario 1

Details	Costs	
Prelims and overheads	£	77,500
Estimated cost of works	£	1,077,120
Construction sub-total	£	1,154,620
Design and management	£	90,000
Risk and contingency	£	746,772
TOTAL	£	1,991,392

In this instance, landscaping works cover 34987 square metres with a unit rate of £30.79

Table 6-7 – Costings for Moormead and Bandy Recreation Ground Scenario 2

Details	Costs	
Prelims and overheads	£	77,500
Estimated cost of works	£	1,259,495
Construction sub-total	£	1,336,995
Design and management	£	90,000
Risk and contingency	£	856,197
TOTAL	£	2,283,192

In this instance, landscaping works cover 33059 square metres with a unit rate of £38.10

Table 6-8 – Costings for Moormead and Bandy Recreation Ground Scenario 3

Details	Costs	
Prelims and overheads	£	77,500
Estimated cost of works	£	536,950
Construction sub-total	£	614,450
Design and management	£	90,000
Risk and contingency	£	422,670
TOTAL	£	1,127,120

6.1.6. Cole Park Island

Table 6-9 – Costings for Cole Park Island Scenario 1

Details	Costs	
Prelims and overheads	£	75,500
Estimated cost of works	£	573,205
Construction sub-total	£	648,705
Design and management	£	90,000

Risk and contingency	£	443,223
TOTAL	£	1,181,928

In this instance, landscaping works cover 7044 square metres with a unit rate of £84.25

Table 6-10 – Costings for Cole Park Island Scenario 2

Details	Costs	
Prelims and overheads	£	75,500
Estimated cost of works	£	666,290
Construction sub-total	£	741,790
Design and management	£	90,000
Risk and contingency	£	499,074
TOTAL	£	1,330,864

In this instance, landscaping works cover 8235 square metres with a unit rate of £83.37

Table 6-11 – Costings for Cole Park Island Scenario 3

Details	Costs	
Prelims and overheads	£	75,500
Estimated cost of works	£	546,305
Construction sub-total	£	621,805
Design and management	£	90,000
Risk and contingency	£	427,083
TOTAL	£	1,138,888

In this instance, landscaping works cover 7044 square metres with a unit rate of £80.43

7. Natural Capital Assessment

7.1. Background

Natural capital can be defined as:

> *"the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soil and minerals) that combine to yield a flow of benefits to people" (Natural Capital Coalition, 2015).*

These flows of benefits to people from ecosystems have often been termed 'ecosystem services'. The term has gained acceptance in policy because it conveys an important idea: that ecosystems are valuable in many ways and that our wellbeing is dependent upon them. Intrinsically linked to the ecosystem services concept is the ecosystems approach, which stems from the notion that ecosystems need to be considered as a whole, as changes to or impacts on one part of an ecosystem can have consequences for the whole system (Defra, 2007). This framework therefore requires a much wider range of impacts to be systematically considered as part of the appraisal process, leading to better decision making (Defra, 2007).

Within this study we therefore attempt to estimate, in monetary terms, the impact of the restoration plan on ecosystem services provision at the sites, to contribute to the economic assessment of the scheme.

7.2. Approach

A series of four key steps were followed to determine the impact of each option on ecosystem services terms (Figure 7-1).

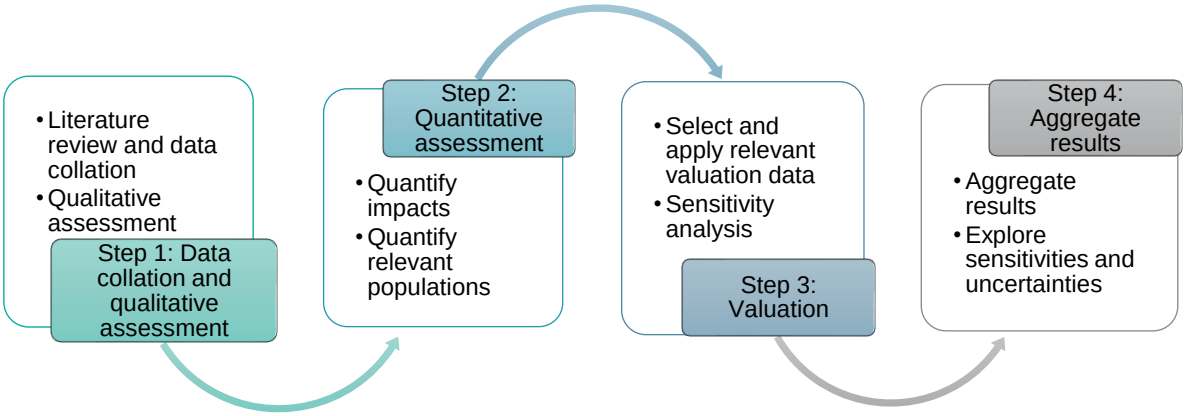


Figure 7-1 – Summary of approach and valuation steps

7.2.1. Step 1: Data collation and qualitative assessment

Data were collated from a variety of sources (see Section 7.3 below) to understand the scheme baseline (i.e. prior to construction) and features of the areas.

Following this, a qualitative assessment was made of the ecosystem service impacts of the scheme based on the ecosystem services included in the Millennium Ecosystem Assessment framework (UN, 2003). The impacts of the scheme were assessed against a 'do nothing' baseline, whereby nothing is done to restore or enhance the areas.

7.2.2. Step 2: Quantitative assessment

Where impacts were considered to be significant, the impacts were estimated in quantitative terms. Site-specific data were used as far as possible within the assessment.

7.2.3. Step 3: Valuation

The majority of desk-based studies such as this use an approach called 'value transfer' to incorporate monetary values into the assessment. This can be defined as follows (Eftec, 2010):

> *"Value transfer (which is also known as 'benefits transfer') allows existing economic valuation evidence to be applied in a new context, such as estimating the monetary value of environmental benefits associated with a proposed policy. It is typically a quicker and lower cost approach to generating economic valuation evidence, compared to commissioning a specifically designed primary valuation study."*

This study used a value transfer approach, with key uncertainties and limitations highlighted. Sensitivity analysis was undertaken to explore the impact of using different assumptions, valuation approaches and value transfer studies.

7.2.4. Step 4: Aggregate results

Where relevant, the values across each ecosystem service category are then aggregated to provide an estimate of the overall impact on ecosystem services of the scheme.

7.3. Qualitative Assessment

The first step was to collate the available information from expert judgement and desk studies and undertake a qualitative review of the potential ecosystem services impacts of the scheme. Qualitative approaches to investigate ecosystem services are not able to attribute monetary values, nor do they aim to. However, the assessment determines the baseline provision of services and the anticipated change to this under the scheme being assessed. The assessment also captures those changes in service provision which are not fully captured by a quantitative assessment. The framework used for the qualitative assessment is originally based on the Millennium Ecosystem Assessment framework (UN, 2003).

The assessment (outlined in Table 7-1) shows that the main benefits of the scheme are considered to relate to the aesthetic and recreational value of the enhanced greenspace areas and amenities, and biodiversity along the river as expressed through existence value as well as its role in underpinning other ecosystem services. Further explanation is provided in the following sections.

Table 7-1 – Qualitative assessment overview of the effect of the scheme on ecosystem services provision

Ecosystem Service Type	Significance of impact
Provisioning Services	
Food	o
Water	o
Raw materials	o
Genetic resources	✓
Medicinal resources	o
Ornamental resources	o
Regulating Services	
Air quality regulation	✓
Noise regulation	✓
Waste treatment (water purification)	o
Regulation of water flows	✓
Erosion prevention	o
Climate regulation	o
Pollination	✓
Biological control	✓
Cultural Services	
Spiritual experience	o
Aesthetic information	✓✓
Inspiration for culture, art and design	o

Recreation and tourism	✓✓
Information for cognitive development	✓
Existence value	✓✓
Supporting Services	
Maintenance of life cycles of migratory species	o
Maintenance of genetic diversity	✓
Maintenance of soil fertility	✓

Key	
xx	Potentially significant adverse impact
x	Potential minor to moderate adverse impact
o	No material impact expected
✓	Potential minor to moderate positive impact
✓✓	Potentially significant positive impact

7.3.1. Existence value

Existence value reflects 'the willingness to pay that people have towards improvements in or protection of the ecological quality of a resource where there is no intention of using or consuming that resource' (Environment Agency, 2003).

Habitats within the area include amenity grassland, rough grassland, scattered trees and riparian vegetation. Trees offer habitat for foraging and nesting/roosting habitat for insects, birds and bats. The amenity grassland is considered to provide limited foraging opportunities for species such as birds and invertebrates. Rough grassland provide habitat for various species of birds, small mammals and insects and the riparian vegetation does not provide primary habitat for terrestrial species, but it is likely to act as an important foraging corridor.

Overall the scheme aims to improve biodiversity by introducing new in-channel, marginal and riparian habitats to the river and enhance five areas of greenspace along the river. The scheme is considered to be beneficial for biodiversity and therefore the existence value. Non-use/existence values for in-river improvements are captured by National Water Environment Benefit Survey (NWEBS), but we have not found any suitable studies that reflect the biodiversity improvements to the areas of greenspace.

7.3.2. Amenity value

The Lower River Crane currently has a range of facilities for recreation including sports fields and footpaths. Data from Strava (Figure 7-2 below) indicate that the area is used for running and cycling. However, visitor numbers to the area may be affected by a few aspects including the lack of features of visual interest, poorly maintained or limited accessibility of footpaths and facilities and the modified, unnatural appearance of the river.

Figure 7-2 – Strava running and cycling heatmap of Lower River Crane area ©Strava 2017 ©Mapbox ©OpenStreetMap ©DigitalGlobe

It is considered likely that restoration of the river and enhancement to the surrounding greenspaces will provide a more interesting and enjoyable natural environment and encourage greater use of the areas. The WHO's (2016) review of evidence on urban green spaces highlights several mechanisms through which access and use of green space may produce health benefits, including:

- Improved relaxation and restoration – contact with green space has been shown to reduce stress levels and improve mental health;
- Improved social capital – green space can foster social interactions, leading to improved social cohesion;
- Improved immune system functioning – studies have shown that contact with nature can benefit immune responses;
- Enhanced physical activity, improved fitness and reduced obesity – access to green space has been found to be associated with increased physical activity;
- Improved exposure to sunlight and better sleep – there is evidence that greater engagement in outdoor activities can improve vitamin D levels and natural light exposure, which can help to maintain circadian rhythms;
- Enhanced 'pro-environmental behaviour' – research has shown that exposure to nature can increase cooperation and 'sustainable intentions and behaviour'; and
- Anthropogenic noise buffering, reduced exposure to air pollution and reduction of the urban heat island effect.

Greater use of Mereway Nature Park, Craneford Way Playing Fields, Twickenham Rough, Moormead Park and Cole Park Island by the local community is therefore likely to provide several health and wellbeing benefits, which we attempt to value in monetary terms in Section 7.4 below.

7.4. Quantification and monetisation

7.4.1. Amenity benefits

7.4.1.1. Method

There are a number of ways to capture the 'local community' or amenity benefits of urban parks and greenspace. Measuring and valuing the direct use of a site in terms of the number of visits for each activity type and value per visit can miss the indirect benefits provided, as outlined in Section 7.3, which can be challenging to value on an individual basis (Eftec, 2015). Therefore, we follow the approach used by Eftec (2015) and other studies we have taken previously whereby we attempt to capture the broader amenity benefits of living close to 'enhanced' parks or greenspace. This 'hedonic pricing' approach uses the uplift in property prices, found through a range of empirical studies, associated with proximity to green spaces as a proxy for these amenity benefits. This attempts to measure the value people place on having access to a higher quality urban greenspace, for a variety of reasons.

Estimation of this 'price premium' has been investigated by a range of studies. Here we use two alternative studies for comparison and to represent a lower and upper bound. Both approaches use 2018 average property prices in Twickenham from the Land Registry, taking an average of terraced, flats, detached and semi-detached properties weighted based on property type national averages from the English Housing Survey (2016-2017).

Property numbers were gathered using 2011 census from the Office for National Statistics and postcode data from Ordnance Survey Code Point open data (updated quarterly) and applying a buffer around the boundary of the five Restoration Plan areas. Both approach 1 and 2 considered the preferred options for the benefit valuation, considering Mereway Nature Park option 2, Moormead Park ground option 2 and Cole Park Island option 2.

It is important to note that the values represent a 'one-off' rather than annual value, since they represent an enhancement in the capital value of property in the area. Furthermore, when considering the total value for all areas a separate valuation was completed to avoid double counting resulting from postcode overlap for the five Restoration Plan areas.

7.4.1.2. Results

Approach 1: Upper Bound

The first approach assumed a 3% property price uplift due to the presence of a park, with a 1.5% increase resulting from park enhancement. Properties were considered within 300 m of the area, representing the Access to Natural Green Space Standard 1 (at least two hectares of greenspace within 300 m). This approach follows the assumptions from Eftec's (2015) Beam Parklands study and only considers residential properties for consistency.

The results for each of the five areas are shown in Table 7-2. Based on this approach the total amenity benefits are estimated to be £92m.

Table 7-2 – Approach 1: valuation using Eftec (2015) Beam Parklands assumptions

Restoration Plan	Number of properties – 300 m buffer	% value uplift	Average property price (£2018)	Estimated amenity value of proposed works (one-off)
Mereway Nature Park (option 2)	1383	1.50%	£967,704	£20,075,019
Craneford Way Playing fields	1693	1.50%	£967,704	£24,574,843
Twickenham Rough	1683	1.50%	£967,704	£24,429,687
Moormead Park (option 2)	2410	1.50%	£967,704	£34,982,499
Cole Park Island (option 2)	1717	1.50%	£967,704	£24,923,216
All areas*	6344	1.50%	£967,704	£92,086,712

*Note the total value for all areas is not a sum of the individual options to avoid double counting resulting from postcode overlap

Approach 2: Lower Bound

An alternative set of assumptions is provided by a 2010 study by the Greater London Authority (GLA). This found a 0.08% increase in house prices for each hectare of park space within 1 km of housing in London. Applying the same 50% uplift approach due to an enhancement from Eftec (2015) the percentage increase in prices were calculated taking the area of the enhanced parks in ha, outlined in Table 7-3.

Table 7-3 – Percentage increase in prices for properties within 1 km

Restoration Plan	Area (ha)	Percentage increase in prices within 1 km (%)
Mereway Nature Park (option 2)	0.72	0.0288
Craneford Way Playing fields	1.5	0.06
Twickenham Rough	0.8	0.032
Moormead Park (option 2)	3.3	0.132
Cole Park Island (option 2)	0.8	0.032

Using these assumptions, the benefits of the park enhancement are estimated to be in the order of £58m (Table 7-4). This is close to the value for approach 1, and we therefore take £58-£92m as representing a reasonable range for the amenity benefits of the proposed works at the five sites.

Table 7-4 – Approach 2: valuation using GLA (2010) assumptions

Restoration Plan	Number of properties – 1km buffer	% value uplift	Average property price (£2018)	Estimated amenity value of proposed works (one-off)
Mereway Nature Park (option 2)	10,201	0.0288%	£967,704	£2,843,006
Craneford Way Playing fields	10,761	0.0600%	£967,704	£6,248,078
Twickenham Rough	9,887	0.0320%	£967,704	£3,061,661
Moormead Park (option 2)	11,589	0.1320%	£967,704	£14,803,433
Cole Park Island (option 2)	10,279	0.0320%	£967,704	£3,183,049
All areas*	19,782	0.3048%	£967,704	£58,348,231

*Note the total value for all areas is not a sum of the individual options to avoid double counting resulting from postcode overlap

7.4.1.3. Caveats

The approach used within this study to estimate the potential amenity benefits of the proposed greenspace enhancement provides an indicative value only, based on a number of assumptions as described above, and the use of value transfer. This approach attempts to estimate the value people place on having access to a higher quality urban greenspace, and the associated benefits to health and wellbeing. It does not represent the actual increase in house prices that would be expected to be generated by the proposed works.

It is also important to note that changes in the preferred options for Mereway Nature Park, Moormead Park or Cole Park Island would not significantly alter the resulting estimated value because it is not sufficiently sensitive to the exact changes.

7.4.2. In-river recreation, amenity and non-use approach

7.4.2.1. Method

The calculation of potential benefits for the Restoration Plan option 1: Instream measures, and option 2: Bank reprofiling was undertaken using the Environment Agency's National Water Environment Benefits Survey (NWEBS) benefits values. The NWEBS method accounts for in-river improvements that the 'price premium' approach does not specifically include. Due to the nature of these options the NWEBS method therefore provides a more realistic estimate of the potential benefit value.

The NWEBS were developed by the Environment Agency for river basin management planning. The values represent the benefits per kilometre of water body for improvements between WFD status bands and are available at both catchment and river basin district level. They do not capture all benefits relating to improvements in a water body; instead they represent willingness-to-pay for six specific benefit components:

- Fish;
- Invertebrates and other animals;
- Plants;
- Clarity of water;
- Channel condition/flow; and
- Safety for recreation.

Therefore, the focus is constrained to benefits relating to recreation, amenity and non-use (Figure 7-3). Application of the NWEBS values requires an assessment of the likely extent of improvement in WFD status across each ecosystem service arising from the different options being assessed.

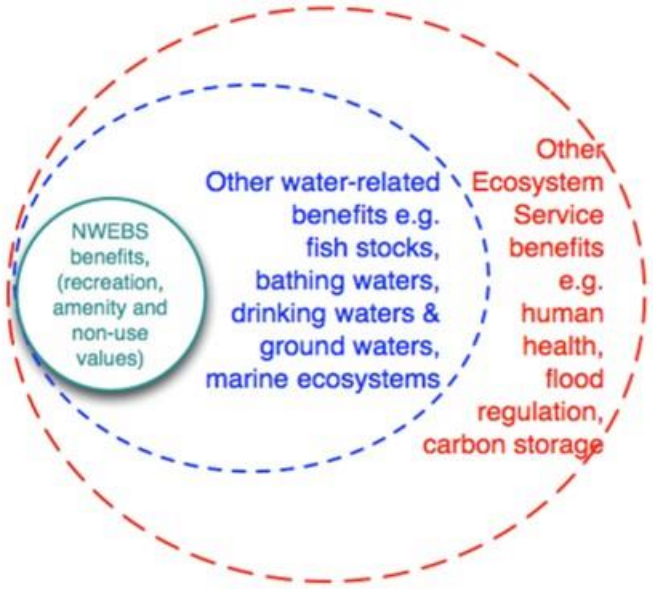


Figure 7-3 – Scope of NWEBS benefits assessment

The valuation of the change in river ecological condition was estimated using transfer values for WFD band step changes and the length of improved river. NWEBS values were uplifted to 2018 prices using the Gross Domestic Product deflator. A discount rate was then applied (at the social time preference rate) over a 40-year time horizon to document the present value benefits accruing for each option. The transfer values were taken from the London catchment in which the Lower Crane sits and are based on the Cycle 2 2016 WFD water body status. Low, central and high values are provided for the varying step changes in conditions (e.g. Poor-Moderate).

The value in monetary terms arising from each assessed option was determined based on the magnitude and length of improvement to the river. This assessment was based on expert judgement and qualitative

information from the desk studies described in Section 3 (geo-environmental desk study, ecological baseline assessment, engineering review, geomorphological assessment and land scape assessment survey). This was used to infer the potential step-change in status according to WFD banding (e.g. an improvement from Poor to Moderate) that may arise because of the restoration measure. The length improved, and significance of improvement assumed for each option, are outlined in Table 7-5 below.

Table 7-5 – Predicted changes to river WFD status from the assessed options

Option Name	Length Improved (km)	Fish	Other animals (e.g. inverts)	Plants	Water clarity	Condition of river channel and flow	Safety of the water for recreation
Instream measures	1.8	Moderate to Good	Moderate to Good	Poor to Moderate	Moderate to Good	Poor to Moderate	Already Good
Bank reprofiling	0.15	Moderate to Good	Moderate to Good	Poor to Moderate	Moderate to Good	Poor to Moderate	Already Good

7.4.2.2. Results

The results of the NWEBS benefit assessment are shown in Table 7-6. The annual benefits for the assessed options are estimated to be £125k per annum with a Present Value total of the benefits over a 40-year time horizon (selected for consistency with the Environment Agency's Water Appraisal Guidance) estimated at £2.71m. It should be noted that the NWEBS values were designed to be used to estimate the benefits of catchment scale programmes of improvements, and Metcalfe (2012) suggests considerable care should be taken if using the values for one-off improvements.

Table 7-6 – NWEBS assessment results

Restoration Plan	Total length of river impacted (km)	Assumed Year Benefits start	Assumed Benefit time horizon (years)	Benefits per annum (£2018)	PV benefits over 40 years (£2018)*
Option 1: Instream measures	1.8	1	40	£118,254	£2,621,232
Option 2: Bank reprofiling	0.15	1	40	£9,588	£212,532
			Total for all options	£127,842	£2,833,765

*To calculate present value benefits, the social rate of return (3.5%) was used for years 0-30 and declining thereafter, as recommended in the Green Book (HM Treasury, 2018).

7.5. Limitations

While the results of the benefit assessment provide an important assessment of the potential change to ecosystem services provision, there are a number of limitations which should be taken into account:

- Measuring the aggregate area affected by natural capital enhancement is an area of uncertainty and there are few empirical rules for estimating the aggregate population. Furthermore, the most recent census data is from 2011 and therefore not current.
- The NWEBS transfer values are designed to represent changes in WFD status, but these are generally more suitable for assessing benefits at a catchment or river basin scale for improving WFD status, rather than individual options. The approach is therefore likely to over-estimate the scale of benefits accrued given the relatively small spatial scale of this study.
- There is some uncertainty associated with the scenarios of WFD status change used to generate the overall NWEBS benefits. There is additional uncertainty concerning the likelihood of significant ecosystem service benefits being realised.

7.6. Cost Benefit Analysis

In order to assess how cost beneficial each of the options are, a cost benefit assessment (CBA) has been used to compare the costs to the benefits. The resulting benefit:cost ratios are summarised in Table 7-7.

The benefit value used in the cost benefit assessment is from the NWEBS assessment for instream measures and bank reprofiling and from Approach 1 of the uplift method for Mereway Nature Park, Craneford Way playing fields, Twickenham Rough, Moormead Park and Cole Park Island. As discussed above, there is some uncertainty associated with the economic valuation of the benefits of each option. Furthermore, the analysis was carried out using the following assumptions:

- The cost values used, as described in Section 6, include costs for construction, preliminaries and overheads, design and management and a contingency allowance. However, opex costs were not included due to the assumption that maintenance work in the areas will not increase/ change from current practices and therefore will be negligible.
- The time horizon for the scheme is assumed to be 40 years following the Environment Agency's Water Appraisal Guidance general standard (2017) and the lack of structures being implemented and therefore reduced degradation risks.
- The analysis provides a simplified scenario as options have not been programmed and the results are based on full upfront delivery. Therefore, the costs and the amenity benefits for Mereway Nature Park, Craneford Way playing fields, Twickenham Rough, Moormead Park and Cole Park Island are assumed to occur in 'year 1' with no discount rate applied. The annual benefits for instream measures and bank reprofiling calculated using the NWEBS approach were also assumed to occur in year 1 and summed over 40 years with a discount rate applied.

Overall it is estimated that the scheme has the potential to deliver a benefit in the order of £9 to £14 for every £1 spent over an assumed 40-year life time.

Table 7-7 – Summary cost benefit analysis (2018 price levels)

Restoration Plan	Cost	Lower Benefit	Upper Benefit	Lower Benefit:cost ratio	Upper Benefit:cost ratio
Option 1: Instream measures	£810,450	£2,621,232	£2,621,232	3.2	3.2
Option 2: Bank reprofiling	£19,710	£212,532	£212,532	10.8	10.8
Mereway Nature Park	£983,520	£2,843,006	£20,075,019	2.9	20.4
Craneford Way Playing fields	£1,307,304	£6,248,078	£24,574,843	4.8	18.8
Twickenham Rough	£692,584	£3,061,661	£24,429,687	4.4	35.3
Moormead Park	£2,283,192	£14,803,433	£34,982,499	6.5	15.3
Cole Park Island	£1,363,264	£3,183,049	£24,923,216	2.3	18.3
All areas*	£6,629,864	£61,126,354	£94,864,835	9.2	14.3

*Note the total value for all areas is not a sum of the individual options to avoid double counting resulting from postcode overlap. The total also includes the benefits from instream measures and bank reprofiling, which do not have separate costings but are included within the other area costs.

7.7. Restoration planning

The results in Table 7-7 demonstrate that while the instream measures (Option 1) are cheaper to deliver they do not provide as high a benefit to cost ratio as the proposed restoration areas. The bank reprofiling shows a high benefit to cost ratio where it can be delivered but similarly it is not as high as the upper bound for each of the restoration areas. Decisions to undertake proposed restoration work can therefore not be determined by the cheapest approaches alone (Option 1 – Instream measures) as while this option is cheaper than the other options, it does not deliver the same increase in natural capital value as the more expensive measures as measured by the benefit to cost ratio. Thus, in areas where multiple different options could be undertaken decisions as to which options to take forward will need to be determined by a more complex assessment. A consensus will need to be achieved on the preferred options to take forward in each of the restoration areas as detailed and strategic planning undertaken to secure funds to maximise the gain that can be delivered across the Lower River Crane from a natural capital perspective.

8. Key findings and recommendations for further studies

8.1. Key findings

The feasibility and options appraisal report reviewed the whole area within the Lower River Crane to investigate restoration opportunities. Following a review of potential options and constraints the main focus of the river restoration opportunities were in Mereway Nature Park, Craneford Way playing fields, Twickenham Rough, Moormead Park and Cole Park Island. Reprofiling the bank and instream measures were also proposed elsewhere within the river where land constraints prevented any wider restoration opportunities, including Twickenham Town Centre. Key findings of the various baseline studies are detailed below:

1. The geo-environmental assessment included a review of historical maps from the area along the study area and 2 km upstream. The review has not identified significant industrial legacy that could represent a major source of contamination and a risk to river water quality. However, the land immediately surrounding the current river channel includes current commercial activities and has historically been used for railway activities and landfilling.

   Potential constraints associated with the scheme are predominantly associated with potential contamination in shallow soils and sediments due to previous phases of development and landfilling. The site in its current layout is unlikely to represent an unacceptable risk to site users and nearby residents. However, construction groundworks required for the regeneration of the River Crane site have the potential to mobilise dusts to air, generate waste soils, mobilise sediment to surface water and create preferential pathways to shallow groundwater. Appropriate construction and materials management will therefore be required during the construction phase to reduce exposure and releases of contaminated soil, sediment and dusts. Imported soils will also need to be validated as chemically suitable for landscaping in public open spaces.

2. The ecological baseline assessment identified four sites with European or National statutory designations within 2 km of survey area. These are Richmond Park SAC, SSSI and NNR; Syon Park SSSI; Ham Lands LNR; and Isleworth Ait LNR. No statutory designated sites are located within the proposed River Crane restoration area itself or associated with the River Crane further up or downstream. There are thirty non-statutory SINC within 2km of the survey area and four within the boundaries. These are located at Twickenham Junction Rough, Moormead recreation ground, The River Crane at St Margarets's and The River Crane at St Margarets's Richmond side. The first two areas would need to be considered during any restoration planning.

   From a WFD perspective, the study area is within the Crane surface water body catchment (water body ID GB106039023030). The Crane is not designated as an A/HMWB under the WFD because despite being obviously modified and significantly straightened, the watercourse does not require this planform to be maintained for the provision of alternative uses e.g. flood protection or navigation purposes. The Crane water body currently has an overall status of Poor, with an ecological status of Poor (including biological quality elements) and chemical status of Good. There are therefore many opportunities for improving the channel.

3. An engineering review demonstrated that the Lower River Crane is channelised throughout. Buried services have revealed a variety of utility cables around the site which will need to be assessed further as the project develops. Critically, any restoration that is undertaken in the upper section of Moormead Park would involve the relocation of an electricity cable that feeds a row of footpath lighting within the park.

4. A geomorphology survey revealed that the channel is heavily modified and lacking in instream diversity as it has a uniform cross-section within a trapezoidal channel. The channel was channelised at various stages throughout the twentieth century.

5. A landscape assessment demonstrated that the corridor of the Lower River Crane is a hidden asset, which is not easily accessible from either the wider urban area of central Twickenham or from within the adjoining spaces. The rapid development surrounding the river corridors has left the Lower River Crane with a lack of cohesiveness. Along many sections the channel is entirely isolated in a fenced

corridor, a utilitarian concrete lined flood channel accompanied by parallel runs of utilities, flood defence controls such that the river itself is completely contained in an urbanised element. The channel is overshadowed by unmanaged tree growth and in places it has become a barrier to movement and is no longer easily recognised a river.

The Lower River Crane can be described as a series of reaches with their relationship to the adjacent urban areas/parkland:

- Mereway Nature Park.
- Craneford Recreation Ground.
- Twickenham Rough.
- Twickenham Town Centre.
- Moormead and Bandy Recreation Ground.
- Cole Park Island.

6. A Structural Condition Survey was undertaken to assess each of the weirs located within the Lower River Crane with the focus on weir removal. Each of the 15 barriers, or weirs, were assessed for their structural condition, ease of removal, ease of access to site and assessment of any increased risk to bank or bed stability as a result of removing the weir. Each weir was assigned a Red Amber Green (RAG) rating based on the perceived ease of removal as accessed both from the site visit findings and an assessed way of removing or modifying the weir structure in the future.

7. Provisional costings have been developed for the various scenarios at each study reach, as described in Section 5. The approach taken is appropriate for the current feasibility phase of the project, using the information currently available and concentrating on the main items and activities that are proposed. This follows standard guidance for a project at this stage of development.

8. A Natural Capital Assessment was undertaken to attempt to estimate in monetary terms the impact of the restoration plan on ecosystem services provision at the sites, to contribute to the economic assessment of the scheme. Natural capital can be defined as 'the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soil and minerals) that combine to yield a flow of benefits to people' (Natural Capital Coalition, 2015). The benefits of restoration schemes can now be valued in monetary terms and thus this information can be extremely helpful in seeking funding to deliver the schemes.

There are numerous further studies that may need to be undertaken, to various degrees, as the project progresses. Potential studies are detailed below.

8.2. Future work

8.2.1. Ordnance assessment

An ordnance survey would be necessary within the main areas where any restoration is planned as it is known locally that ordnance landed in this area in the Second World War.

8.2.2. Topographic survey

There was no available topographic survey information for the Lower River Crane. Topographic survey information would be required along the course of the river to inform the detailed design stage. This could be combined with LiDAR information.

8.2.3. Archaeological investigations

It is recommended that a desk based archaeological assessment is required in the next phase of the project to determine any potential archaeology as the project progresses. All the documentary, database and map evidence can be used to identify areas of high and of low/no archaeological potential. This information will then be used to establish any next steps that may be required as the project progresses. It has been pointed out that the Mereway Nature Park is potentially a site of archaeological interest and thus would need to be examined further as any options are taken forward in this area.

8.2.4. Treatment of Invasive Species

Invasive species were not noted in the ecological baseline survey. However, locally it has been suggested that Japanese Knotweed is present within Cole Park Island. It is recommended that a full invasive species assessment is made before any of the restoration proposals are taken forward. Any necessary mitigation measures would need to be employed during any restoration works, in relation to removal and disposal of waste and control of spread.

8.2.5. Geotechnical Investigations

To establish the nature of the ground conditions at the site a series of trial pits would need to be dug and tested for contamination. The scope of this work would need to be developed once a preferred option in each of the area has been determined. This would need to be undertaken as part of the detailed design phase in an area that is progressed into the next stage of the design process.

8.2.6. Barrier/weir removal project

A separate project is recommended to be undertaken to focus on the most efficient way of addressing fish passage issues and opportunities for enhancement at each of the 15 structures identified along the Lower River Crane. This will need to involve a more detailed structural reviewed integrated within information already available on fish passage to determine the most cost-effective ways of delivering fish passage while maximising other habitat benefits.

8.2.7. Restoration trial

A separate project is recommended to be undertaken to trial some of the instream measures and bank reprofiling. A good location to trial any works would be a 140 m section of river between the Environment Agency gauging weir in Craneford Way playing fields (see Figure 5-4) and the area around the allotments in Twickenham Rough (see Figure 5-5). This could be supplemented by the 96 m of bank reprofiling proposed on the left bank in Twickenham Rough (see Figure 5-5). Costs are detailed in Table 8-1 but savings could be made by amalgamating works (to save preliminary and overhead costs) and discussions with a contractor as part of an Early Contractor Involvement exercise to lower the risk and contingency budget.

Table 8-1 – Restoration trial costs

Trial	Instream Measures Cost	Bank reprofiling cost
Prelims and overheads	£23,000	£23,000
Estimated cost of works	£31,500	£12,960
Construction sub-total	£54,500	£35,960
Design and management	£5,000	£5,000
Risk and contingency (60%)	£35,700	£24,576
Total	£95,200	£65,536

Should further trials be required another suitable location would be within Twickenham Rough from the proposed restoration area down to Twickenham town centre (Figure 5-6). Any work in this area would require vegetation management to allow more light into the channel.

8.2.8. Detailed design

Further work would be required to develop the initial concepts into detailed designs for the variety of features and structures required in each of the specified areas. This would include more specific details on any design elements for the channel including the planform, cross-sections and material used. In addition, details on all the main scheme elements (such as structures) and landscaping would need to be further developed. Land ownership boundaries will need to be considered at this stage. The Health and Safety aspects of the scheme would need to be reviewed through the undertaking of a designers risk assessment and the addition of appropriate Safety Health and Environment (SHE) boxes on all design drawings. All projects taken forward

would need to comply with CDM regulations (2015). Costs would be revised as it the project moves forward with an aim to reduce the associated risk budget.

8.2.9. Flood risk assessment

Once the detailed design of any scheme has been undertaken a flood risk assessment would be required to demonstrate that the project did not increase flood risk and, where possible, demonstrate where some flood risk benefits could be achieved. It is recommended that discussions are held between the strategy steering group and the EA flood risk team to determine the EA views on the restoration proposals and any potential requirements there may be in relation to floodplain compensation.

8.2.10. Ecology surveys

It is recommended that the following surveys are carried out prior to any works beginning:

- Extended Phase 1 survey to determine habitat types, botanical species lists, and protected species potential.

This will highlight any immediate issues prior to any work being undertaken. A review of any updated conservation status would also be made before any design gets taken forward as well as a review of what this may mean for any design. Given that one of the main drivers for the project is to deliver WFD improvements it may also be worth undertaking a baseline of the key biological elements before construction and then one-year post-construction to try and establish any improvements that have been made.

8.2.11. Water Framework Directive assessments

A WFD compliance assessment may be requested by the Environment Agency as part of the planning permission for the scheme. This would need to assess biological/ hydromorphological / water quality elements to ensure the scheme is compliant with the WFD legislation. It is recommended that consultation with various individuals within the Environment Agency is undertaken to establish what the likely nature of this work would be.

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