Heathrow Airport Limited

Heathrow's North-West Runway

Water Quality and Hydro-ecology Assessment

16 June 2014

AMEC Environment & Infrastructure UK Limited

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Non-Technical Summary

This Water Quality and Hydro-ecology Report has been prepared by AMEC Environment & Infrastructure on behalf of Heathrow Airport Limited (HAL). The report provides technical information and assessments to support Part 5.5 (Enhancing the Natural Environment) of Volume 1 of the Technical Submission to the Airports Commission[1]. The assessment relates to water quality and hydro-ecology, with particular consideration being given to the requirements of the Water Framework Directive (WFD)[2]. The WFD aims to protect the 'ecological statu's of water bodies, whilst taking account of their necessary use. Article 4.7 of the WFD allows changes to water bodies as a result of new activities if:

- All practicable steps are taken to mitigate the adverse impact on the status of the body of water;
- The reasons for those modifications or alterations are of overriding public interest and/ or the benefits to the environment and to society of achieving the objectives are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development; and
- The beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

The proposed development crosses the routes of the Colne Brook, Wraysbury River, River Colne, Longford River and the Duke of Northumberland's River. Without mitigation, the proposed development would have had the potential to cut off the flow in all of those rivers, creating considerable hydrological disruption, potentially preventing flow in the downstream reaches of all rivers, as well as resulting in the direct loss of all aquatic and riparian habitat within the site boundary. These changes would not satisfy Article 4.7 of the WFD. Furthermore, construction and operational effects would have the potential to cause pollution to surface and groundwaters.

The inclusion of mitigation and enhancements to the masterplan clearly demonstrates compliance with Article 4.7, preventing impacts to water quality, and maximising the aquatic habitat opportunities of the local water bodies within the constraints of the overall physical modifications. The overall strategy with regards to the water environment is integrally linked with flood risk, biodiversity and landscape considerations and was described in Part 5.5 of Volume 1 of the Technical Submission. Key aspects relating to water quality, hydro-ecology and the WFD include:

- ***Maintaining river flow regimes, as the fundamental basis for maintaining water quality and ecology.*** The strategy avoids changes to flows in the Colne Brook, as well as in the downstream reaches of all rivers. The Colne Brook Spur, while providing an extensive new area of aquatic and riparian habitat, will be designed to only take an equivalent amount of flow as the reduction in flow in

[1] Heathrow Airport Limited (2014) Taking Britain further – Heathrow's plan for connection the UK to growth
[2] European Parliament & Council (2000) Water Framework Directive (Directive 2000/60/EC)

the Poyle Channel, which avoids net changes to flows downstream. The only net change to flow downstream is the potential to help support low flows in the Duke of Northumberland's River and River Crane through the release of highly treated surface water runoff;

- ***Ensuring that the development has no impact on water quality***, considered through all phases of development and operation, including:

  - *Channel design*. The new channels will pass over areas of contaminated land. Where those areas cannot be remediated during construction, the bed of the new channel will be lined with impermeable material wherever necessary;

  - *Construction activities*. Best practice will be adhered to at all times. Historic contamination will be considered during construction and particularly during dewatering, when measures will be taken to avoid mobilising contaminants or discharging them to surface waters. More detailed consideration of potential groundwater-related impacts has been presented in an appendix (**Appendix B**);

  - *Operational activities*. A robust drainage strategy will effectively treat runoff, with specific consideration of hydrocarbons and de-icants. All discharges will be to surface water, to prevent mobilisation of contaminants in groundwater;

  - Water quality will be regularly monitored, both during construction and operation.

- ***Protecting the overall hydro-ecology of the Colne valley***. Beyond the protection of downstream flow regimes, this will be achieved through sensitive channel design, use of a minimum number of flow management structures, and the creation of extensive new areas of aquatic and riparian habitat in the Enhanced Colne Valley. A high priority has been given to maintaining fish passage through the Colne Valley, which will be achieved by:

  - Designing the culverts beneath the runway environmentally sensitively (an assessment has been included of the feasibility of culverts of the length proposed being successful in allowing fish passage);

  - Removing existing barriers to migration on the Colne Brook, thereby enhancing potential for mitigation by that route, which also allows the main River Colne to be reached further upstream.

- ***Ensuring that there are no impacts on other water users***. Maintaining the flow regime and water quality downstream will avoid impacts on both downstream licensed abstractors and amenity and biodiversity features. There will be no impacts on the public water supply reservoirs in the vicinity of Heathrow, or on the supply to those reservoirs. Any impacted local licensed abstractors or consented discharges will be consulted with individually and mitigation put in place where necessary.

During development of the masterplan, alternative strategies were considered, including the avoidance of culverting. This would have involved the diversion of all channels around the runway, which was found not to be possible due to the length of channel that would be required and resulting channel gradients. As a result, restoring flow to all downstream channels would only have been possible by pumping. The strategy therefore provides an optimal solution for the natural environment overall, in the context of which any impacts on the water environment have been mitigated as far as possible. The local conditions of both the surface water and groundwater environment have been accounted for. Particularly relevant to meeting the requirements of the WFD and the satisfaction of Article 4.7 is ensuring that impacts to habitat availability and associated ecology are localised. The strategy has been designed with the primary aims of ensuring that the existing flow regime is maintained in the downstream reaches of all water bodies (to avoid any impacts on the downstream rivers or water users), and avoiding any effects further upstream in the Colne Valley (through careful consideration of fish passage through the inter-connected channels of the Colne Valley).

Abbreviations

AWB	Artificial Water Body
EA	Environment Agency
HAL	Heathrow Airport Limited
HMWB	Heavily Modified Water Bodies
PAH	Poly-aromatic hydrocarbon
PPG	Pollution Prevention Guidance
RBMP	River Basin Management Plan
SAF	Sustainability Appraisal Framework
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
WFD	Water Framework Directive

Contents

1. Introduction

1.1 Background

This report has been prepared by AMEC Environment & Infrastructure on behalf of Heathrow Airport Limited (HAL). To meet the growing need for additional air capacity, HAL has proposed an extension to the existing Airport[3]. The proposed development would include:

- A 3,500 m runway to the north-west of the existing Airport;
- Two new terminal buildings;
- Aircraft movement areas and taxiways;
- Various aircraft stands (pier serviced stands and remote stands);
- Car parking; and
- Ancillary uses.

Further details of the development can be found in HAL's submission to the Airports Commission.

This report provides technical assessment and details underlying Part 5.5 of the Enhancing the Natural Environment Strategy presented in of Volume 1 of HAL's submission to the Airports Commission[3]. The assessment of potential effects with and without mitigation was undertaken in accordance with the Commission's Sustainability Appraisal Framework (SAF) as described below[4].

The technical content of the report relates to water quality and hydro-ecology, in order to address the Commission's requirements as well as more specific questions raised by the Environment Agency (EA) during consultation. Specifically this technical report relates to the water strategies for:

- Maintaining river flows for ecology;
- Maintaining water quality;
- Preserving hydro-ecology; and
- Managing the impacts on other water users.

Particular consideration is given to the requirements of the Water Framework Directive (WFD)[5].

[3] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth
[4] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf
[5] European Parliament & Council (2000) Water Framework Directive (Directive 2000/60/EC)

Section 2 of the report describes the legislative and policy context relevant to the assessment. **Section 3** describes the current baseline around Heathrow Airport. Potential effects resulting from the proposed development are assessed without and with mitigation in **Sections 4 and 5**. Conclusions are given in **Section 6**.

1.2 Airports Commission Requirements

The overall requirements of the Airports Commission for Water and Flood Risk (Annex 9) are "to protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk". The Commission makes specific references to a number of issues including the potential for hazards to water quality from de-icing of aircraft and runways, and the need to develop in line with the WFD[5].

1.3 Heathrow's Objectives

At the earliest stage of the development of Heathrow's mitigation strategies it was identified that there was an opportunity to provide a 'legacy' for the local area. To ensure that Heathrow met its flood risk and wider water, biodiversity and landscape requirements, specific technical strategies were produced where the overarching focus was to ensure that together they would meet Heathrow's overall objectives for the natural environment.

This Water Quality and Hydroecology Assessment, upon which the Water Strategy has been developed, also sits alongside the Flood Risk Strategy which has also been submitted to the Airports Commission[3]. The primary objective is to develop a sustainable and effective strategy that will ensure flood risk is not increased, and protects river flows, water quality and aquatic ecology during and beyond the lifetime of the development that takes into account the potential impacts of climate change.

The water strategy will achieve our objectives through:

- Realigning watercourses within the enhanced Colne Valley Park to move water sustainably around the airport, and in so doing form part of an enhanced landscape, limiting the amount of culverting required;
- Providing compensatory flood storage to replace the floodplain storage lost through the development. This means flood risk to people and property will not increase and where possible will decrease;
- Ensuring the downstream flow regimes are maintained so there is no adverse impact on water quality, ecology or on other water users. If appropriate the strategy will seek to supplement flows in the River Crane with treated water from the engineered wetland;
- Maintaining connectivity of the aquatic habitat through the Colne catchment, utilising the River Colne and its distributaries across the Colne Valley; and
- Avoiding any effects on water quality across all water bodies, both surface water and groundwater, through channel design, best practice construction practices and monitoring during operation.

In implementing this strategy will meet the Airports Commission's requirements, particularly "to protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk". It will also mean the requirements of local, national and European guidance, policies and legislation including the WFD[5], Foods Directive, UK Floods and Water Management Act and the National Planning Policy Framework (NPPF)[6] are met.

[6] Communities and Local Government (2012) National Planning Policy Framework.

2. Legislative and Policy Context

2.1 Water Framework Directive

Water quality and hydro-ecology are considered in international and domestic legislation, as well as in local policies. The majority of requirements are driven by the WFD[5]. The WFD drives the EA's approach to protection of the water environment in England. The Directive came in to force in 2000, and requires all member states of the European Union to manage the water environment to consistent standards, with an emphasis on the overall ecological health of a water body. The overall standard is based on the achievement of Good Ecological Status, and aims to improve the physical and biochemical habitat of rivers in order to ensure that the biology and chemistry can reach Good Status[7]. The WFD considers impacts from a range of pressures on ecology including water quality, morphology (e.g. channel shape or connection of river to floodplain), water use and invasive species. The status of all water bodies is reported in River Basin Management Plans (RBMPs).

In some cases, water bodies that have been extensively modified from their natural form for a specific purpose have been designated as Heavily Modified Water Bodies (HMWBs), and there are also water bodies such as some reservoirs and canals that would not exist in any form naturally, and so are known as Artificial Water Bodies (AWBs). HMWBs and AWBs are required to meet Good Ecological 'Potential' rather than 'Status'. This latter classification applies to many of the watercourses around Heathrow, which have been modified for a variety of purposes. The Ecological Potential of a water body represents the degree to which the quality of the water body's aquatic ecosystem approaches the maximum it could achieve, given the heavily modified characteristics of the water body that are necessary for the use or for the protection of the wider environment. The assessment of Good Ecological Potential considers flow, mitigation measures and quality elements (chemical and biological) as a three stage process.

The WFD can, under specific circumstances, allow for deterioration of status. This is set out in Article 4(7) of the Directive, by which deterioration may be allowed as a result of new activities if (amongst other requirements):

- All practicable steps are taken to mitigate the adverse impact on the status of the body of water;
- The reasons for those modifications or alterations are of overriding public interest and/ or the benefits to the environment and to society of achieving the objectives are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development; and
- The beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

[7] There are five different status options based on the overall quality of the water body: High, Good, Moderate, Poor and Bad. High status applies to pristine water bodies; Good status is the desired minimum to be achieved for all waterbodies across the EU. Moderate, Poor and Bad can all be described as varying degrees of a 'failure to meet Good status'. The requirement to prevent deterioration of status applies to all levels.

Where the provisions set out in Article 4(7) of the Directive are used, the EA notify the European Commission and report this in subsequent RBMPs.

2.2 Other Legislation, Regulations and Policies

In addition to the WFD, there are a number of other European directives that influence the protection and management of the water environment, as outlined in **Table D.1** (in **Appendix D**). Those European directives have been, or are being, implemented in English law through a range of legislation and regulations, with the main ones also being identified in **Table D.1** along with other relevant national regulations.

3. Baseline

3.1 Water Environment

3.1.1 Rivers

Heathrow Airport is located across the River Colne and River Crane catchments, both of which are tributaries of the River Thames. The western part of the Airport, along with the entirety of the masterplan area, is within the lower Colne catchment.

The Colne Valley lies to the west of the Airport. The direction of river flow is in general from north to south, towards the River Thames. The Colne Valley in the vicinity of the Airport contains a number of water courses, including the River Colne and a number of other channels that split off from the Colne further upstream. The main watercourses, from west to east, are the Horton Brook, Colne Brook, Wraysbury River (connected to the Colne Brook by the Poyle Channel), River Colne, Longford River and Duke of Northumberland's River, as shown on **Figure 3.1**.

From west to east, further details of the watercourses include:

- Horton Brook is located approximately 3.5 km to the west of the Airport, and flows south between the Queen Mother Reservoir and Wraysbury Reservoir, parallel to the Colne Brook, joining Colne Brook near Hythe End before it flows into the River Thames;
- Colne watercourses:
  - Colne Brook flows in a southerly direction, flowing between the Queen Mother Reservoir and Wraysbury Reservoir, to join the River Thames at Egham. Upstream of the Airport (at Uxbridge), Colne Brook is connected to the River Colne. This watercourse is approximately 2.5 km to the west of the Airport;
  - The River Colne flows in a southerly direction, parallel to the Colne Brook and Horton Brook, approximately 0.5 km to the west of Heathrow Airport. Just to the north of the M4, the River Colne splits in to two channels. The western channel is then known as the Wraysbury River, while the eastern channel is still known as the River Colne. The two channels flow approximately parallel to each other, with the Wraysbury River up to 1 km east of the River Colne, southwards in between the Wraysbury Reservoir and King George VI Reservoir, before re-joining in Staines. The combined watercourse joins the River Thames at Staines-Upon- Thames;
  - South of the M4 the River Colne splits, and an additional channel, the Duke of Northumberland River, flows parallel to the River Colne, and flows along the existing western boundary of the Heathrow Airport, before flowing east along the southern boundary of the airport. The Duke of Northumberland River flows East to join the River Crane near Feltham;
  - At Longford, west of the north western corner of the Airport, the River Colne splits again to include the Longford River. This watercourse runs adjacent to the Duke of Northumberland River,

and follows around the eastern boundary of the Airport, and continues to flow in an eastern direction;

- Connectivity is maintained between Wraysbury River and the Colne Brook through the Poyle Channel, flows from west to east to the north of Wraysbury Reservoir; and

- **Figure 3.1** shows the approximate proportion of flow in each of the channels of the Colne Valley. The percentages represent approximate flow splits, and have been presented in order to illustrate the relative size of the channels and the interconnectivity between channels.

- The River Crane flows in a southerly direction, to the East of the Airport. It takes flow from the Duke of Northumberland River, and flows in to the River Thames at Isleworth.

The network of channels in the Colne Valley has been extensively modified over time, and results in inter-connections between channels and even between catchments. Those of most relevance are the connection of the Wraysbury River and Colne Brook by the Poyle Channel, and connection of the Colne and Crane catchments by the Duke of Northumberland's river. Much of the length of the Horton Brook, Colne Brook, Wraysbury River and River Colne is relatively natural, in terms of the bed and bank materials, although all have some flow control structures (e.g. weirs or sluices) and re-aligned or straightened reaches. There is a programme of planned work to address some of these historic modifications through the River Basin Planning process (as discussed in **Section 2.2**).

In contrast, the Duke of Northumberland's River and the Longford River flow in highly managed and modified channels around the current western and southern boundaries of the Airport. The Duke of Northumberland's River was 'daylighted' from its former culverted route during the development of Terminal 5, which led to the 'Twin Rivers Scheme', but which the Longford River and Duke of Northumberland's River flow in parallel but separate channels from Longford until they diverge to the south of Terminal 4.

3.1.2 Lakes

Within the vicinity of the Airport, there are lakes and reservoirs that form part of the South West London SPA, designated for the habitat they provide for birds. The reservoirs provide storage for water supply, with water pumped from the River Thames. Those in closest proximity to the site are Wraysbury Reservoir to the southwest (west of the M25), and King George VI and Staines Reservoirs to the south (east of the M25). The Queen Mother Reservoir is located to the west of Colnbrook. To the west of Wraysbury Reservoir and south of Queen Mother Reservoir is a network of surface waterbodies formed as a result of old gravel workings. The Horton Brook and Colne Brook both run through this area, with the Horton Brook running directly in to and through some of the lakes (while others are fed by groundwater). There are also some smaller lakes (again, from gravel workings) in the vicinity of the M4-M25 junction.

3.1.3 Geology and Hydrogeology

Heathrow Airport and the surrounding area are underlain by shallow deposits known as the Taplow Gravels. These gravels are of Quaternary age, and form part of a wide expanse of terraced river sands and gravels across the Thames floodplain. The gravels overlie the Tertiary London Clay, which in turn overlies the regionally important Chalk aquifer. Consisting predominantly of sand and gravel, but with local with lenses of silt, clay or peat, the Taplow Gravels are generally permeable and range from 3 to 6 m thick (the thickness varying across the site both to natural variation and to past gravel extraction). The groundwater levels in the gravels are usually shallow and within 2m of the ground surface[8]. The London Clay is more than 50 m thick and prevents direct groundwater interaction between the gravel and chalk aquifers.

Further detail of the geology and hydrogeology is provided in **Appendix B**.

3.2 Water Framework Directive Classifications

The baseline water quality and hydro-ecology of the site has been considered with respect to the waterbody classifications in the Thames RBMP. The watercourses within and around the proposed site are located across the London, Colne and Maidenhead to Sunbury catchments of the Thames RBMP[9] . The rivers, larger lakes/ reservoirs and the groundwater bodies are all defined as water bodies under the WFD[5.] The water bodies can be seen in **Figure 3.2** and a list of them can be seen in **Table 3.1**.

The statuses of all the water bodies, seen in **Table 3.1**, are taken from the Thames RBMP[9] and updated status information (as received from the EA in April 2014). All the water bodies with the exception of Horton Brook are designated as HMWBs or AWBs. The HMWB designations of the rivers are for ‘urbanisation’ and/or ‘flood protection’[10]. The AWB designations of the lakes are for water supply (reservoirs) and ‘wider environment’ (former gravel pits).

Figure 3.2 shows the current WFD status of all surface water bodies in the vicinity of the Airport. Heron Lake, to the southwest of the Airport, is the only water body that currently achieves Good Ecological Potential. There is no singular reason driving the classification of the waterbodies in this area, but the most common factors are:

- Mitigation measures ‘not in place’ in river waterbodies. Mitigation measures are required to enable the waterbody to reach its greatest potential allowing for the accepted uses of the waterbody. Improvements that are expected to be feasible for the river HMWBs in this area (i.e. are listed in the RBMP) include removal or adjustment of structures causing barriers to fish migration (e.g. weirs without fish passes), lack of connectivity of the river to the floodplain, and the need to ensure appropriate sediment and vegetation management;

- Fish being in lower numbers and not necessarily the range of species expected in these rivers; and

- Phosphorus concentrations, which cause failures in the majority of the river and lakes. This is common with a widespread extent of phosphorus failures around the country, and represents a

[8] Terminal 5 Project, Twin Rivers Diversion, Design Note 3 T5-ES-LF-34-00-WP-00003.rtf
[9] Environment Agency (2009) Thames River Basin Management Plan
[10] The designation for navigation for the River Colne relates to the Grand Union Canal rather than the river itself

significant concern for the EA and potential investment requirement for those responsible for sources of phosphorus to the environment. The phosphorus concentrations are also seen in water bodies further upstream in the Colne and Crane catchments, and represent contributions from a range of sources upstream.

Further information about the water quality and fish populations of the rivers is included in **Appendix A**.

The shallow gravel aquifer is designated as a groundwater body under the WFD and is also failing to achieve Good Status, as a result of poor water quality. This is due to contamination from past land use activities (including a fuel farm, sludge disposal from sewage treatment works, a number of landfills in former gravel quarries, and other industrial sites). Some formerly contaminated areas have been remediated, including during the construction of Terminal 5, but further contamination is very likely to remain. Further details regarding ground contamination can be found in the Geo-Environmental Assessment submitted to the Airports Commission[11]. More details of the groundwater quality are provided in **Appendix B**.

[11] AMEC (2014) Heathrow's North-West Runway – Geo-Environmental Assessment

Table 3.1 Classification Information for Water Bodies in the Thames RBMP that could potentially be affected by Development at Heathrow

Water Body ID	Water body name	Overall Status/ Potential	Ecol. Status	Chem. Status	Overall Objective	Water Body Type*	Status of Individual Elements	Mitigation Measures (MMs)
GB 106039023090	Colne and GUC[1]	Poor	Poor	Fail	Good Potential by 2027	HMWB (flood protection, navigation)	High status- invertebrates, ammonia, dissolved oxygen, pH, temperature. Moderate status- fish, hydrology, mitigation measures, PAHs Poor status- Phosphate	MMs not in place relate primarily to structures impeding fish migration, hard engineered banks, and presence of culverts MMs already in place primarily relate to bank reprofiling, setting back embankments, appropriate dredging, sediment management and vegetation control
GB 106039023010	Colne Brook	Moderate	Moderate	-	Good Potential by 2027	HMWB (flood protection)	High status- ammonia, dissolved oxygen, pH, temperature Moderate status- mitigation measures Poor status- fish, phosphate Not high status- hydrology	MMs not in place relate primarily to structures impeding fish migration and lack of floodplain connectivity MMs already in place primarily relate to appropriate vegetation control
GB 106039023040	Horton Brook	Moderate	Moderate	-	Good Status by 2027	n/a	High status- ammonia, pH, temperature, hydrology Good status- dissolved oxygen, phosphate Moderate status- invertebrates	n/a
GB 106039023450	Port Lane Brook[2]	Moderate	Moderate	Good	Good Potential by 2027	HMWB (urbanisation)	High status- ammonia, dissolved oxygen, pH, temperature Moderate status- mitigation measures Poor status- invertebrates, phosphate Not high status- hydrology	MMs not in place relate to preservation/restoration of historic habitats, and sediment management strategy MMs already in place relate to appropriate channel maintenance
GB806100108	Unknown[3]	Moderate	Moderate	-	Good Potential by 2015	AWB (surface water transfer)	Based on expert judgement	Not identified

Table 3.1 (Continued) Classification Information for Water Bodies in the Thames RBMP that could potentially be affected by Development at Heathrow

Water Body ID	Water body name	Overall Status/ Potential	Ecol. Status	Chem. Status	Overall Objective	Water Body Type*	Status of Individual Elements	Mitigation Measures (MMs)
GB 106039023030	Crane (including part of the Yeading Brook)	Poor	Poor	Good	Good Potential by 2027	HMWB (urbanisation)	High status- pH Good status- ammonia, dissolved oxygen Moderate status- fish, macrophytes, hydrology, mitigation measures Poor status- invertebrates, phytobenthos, phosphate	MMs not in place primarily relate to structures impeding fish migration, hard engineered banks, presence of culverts MMs already in place primarily relate to appropriate vegetation control
GB30642334	The Queen Mother Reservoir	Poor	Poor	-	Good Potential by 2027	AWB (drinking water, wider environment, water storage)	Good status – phytoplankton, mitigation measures Bad status – total phosphorus	None identified
GB30642490	Staines Reservoir (North)	Moderate	Moderate	-	Good Potential by 2027	AWB (drinking water, wider environment, water storage)	Good status –mitigation measures Moderate status – phytoplankton Bad status – total phosphorus	None identified
GB30642525	Staines Reservoir (South)	Poor	Poor	-	Good Potential by 2027	AWB (drinking water, wider environment, water storage)	Good status – mitigation measures Poor status – Phytoplankton Bad status – total phosphorus	None identified
GB30642417	Wraysbury Reservoir	Poor	Poor	-	Good Potential by 2027	AWB (drinking water, wider environment, water storage)	Good status- phytoplankton, mitigation measures Bad status- total phosphorus	None identified
GB30642488	King George VI Reservoir	Moderate	Moderate	Good	Good Potential by 2027	AWB (drinking water, wider environment, water storage)	Good status- mitigation measures Moderate status- phytoplankton Bad status- total phosphorus	None identified
GB30642538	Heron Lake	Good	Good	-	Good Potential by 2015	AWB (drinking water, recreation)	Good status- mitigation measures	None identified

Table 3.1 (Continued) Classification Information for Water Bodies in the Thames RBMP that could potentially be affected by Development at Heathrow

Water Body ID	Water body name	Overall Status/ Potential	Ecol. Status	Chem. Status	Overall Objective	Water Body Type*	Status of Individual Elements	Mitigation Measures (MMs)
GB30642430	Wraysbury No1 Gravel Pit	Moderate	Moderate	-	Good Potential by 2027	AWB (wider environment)	High status- hydrology Good status- total phosphorus Moderate status- phytoplankton, total phosphorus	None identified
GB30642489	Wraysbury II Gravel Pit/ Wellapool Lake	Poor	Poor	-	Good Potential by 2027	AWB (wider environment)	High status- hydrology Good status- mitigation measures Poor status- phytoplankton, total phosphorus	None identified

* AWB= Artificial Water Body; HMWB = Heavily Modified Water Body
1 Includes both the River Colne and Wraysbury River
2 Includes the Longford River
3 This waterbody name will change to ‘Duke of Northumberland's River at Heathrow’ in the next RBMP (Personal comms. With EA, 2014)

3.3 Water Users

3.3.1 Abstractions

Figure 3.3 displays the locations of currently licensed abstractions from rivers or groundwater in the area, according to information received from the EA, more details are provided in **Table 3.2**.

Table 3.2 Abstractions within or in the Vicinity of the Site

Abstraction	Type	Use	Location
28/39/36/0058	Groundwater	Process Water	Northrop Road (within site boundary) Gravel aquifer
TH/039/0028/007	Groundwater	Evaporative Cooling, toilet flushing and irrigation	Heathrow Airport (within site boundary) Chalk aquifer
28/39/36/0023	Groundwater	Spray Irrigation, General Farming & Domestic	Home Farm (within site boundary). Gravel aquifer
28/39/31/0144	Groundwater	Spray Irrigation	Mayfield Farm. Within site boundary. Gravel aquifer
28/39/28/0586	Surface water	Supply To A Leat For Throughflow	Stanwell Moor
28/39/28/0301	Surface water	Spray Irrigation	Multiple points: Colne Brook downstream of development, and west of Horton Brook
28/39/28/0520	Surface water	Make-Up Or Top Up Water	Colne Brook downstream of development
28/39/28/0576	Groundwater	Iver South Sewage Treatment	Northwest of site. Chalk aquifer
TH/39/0031/001	Groundwater	(Heathrow Airport)	South of Airport. Gravel aquifer
28/39/31/0185	Groundwater	(Heathrow Airport)	South of Airport. Gravel aquifer

As seen in **Table 3.2** and **Figure 3.3**[12] there are four groundwater abstraction licences that exist within the red line boundary, and one surface water abstraction on the south western development site boundary. The uses of these abstraction licences are listed in **Table 3.2**. The south western most groundwater abstraction is for Heathrow Airport for a range of uses from Evaporative cooling to toilet flushing and irrigation. In addition there are a number of further groundwater or surface water abstractions within 2 km of the new development site boundary.

3.3.2 Discharges

Details of consented discharges have been received from the EA.

[12] Although this table indicates only seven key licences within the red line boundary or downstream, **Figure 3.3** indicates more abstraction locations. This is because some of the licences have multiple abstraction points.

There are no identified discharges within the existing site boundary of Heathrow Airport. However, there are a large number of discharges in the surrounding area and the EA has confirmed that these are all permitted, either to land or water, but may not necessarily be continuous discharges. From the data received, it is not possible to confirm the status of all discharges with certainty, but some key uses that are assumed to have regular or continuous discharges are highlighted in **Figure 3.3** (including those from water treatment works, Wastewater Treatment Works (WwTWs) and arable farming).

Based on the data provided the mapping indicates there is a cluster of six discharge points located within the north western most area of the proposed development site. These are all related to local commercial/ industrial activities such as construction work, and industrial waste. There is also one discharge (associated with the existing sewerage network) located in Longford.

There are numerous potential discharge points outside the proposed site boundary, as shown in **Figure 3.3**. Of particular note are the water treatment works and sewerage treatment discharge points both located on the Colne Brook north of the M4 motorway. The Iver South Sewage Treatment Works, which is located adjacent to the Colne Brook to the south of the M4, no longer has a consented discharge to the brook as it is now a sludge works, with liquid waste transferred to Mogden treatment works. There are also a number of discharges to the River Colne north of the proposed development site. To the south of the development site there are further discharges located on the Colne Brook and River Colne, to the east of Wraysbury Reservoir, and to the Poyle Channel.

3.3.3 Conservation Sites

Due to the hydrological connectivity of different channels within the River Colne catchment there are a number of designated sites located close to the Airport, or on downstream river reaches. For the purpose of this assessment only water-dependent sites, located in close proximity or downstream of the Airport are considered. Those highlighted in **Table 3.3** have been included as 'water users' since they have some reliance on, or at least connectivity with, river channels that may be affected by the development. All water-dependent designated sites within close proximity to Heathrow Airport are shown in **Table 3.3** and **Figure 3.4**.

Table 3.3 Water Dependent Designated Sites

Designated Site	Designations	Potential Connectivity/ relevance?	Distance from Site (direction)
Staines Moor	SSSI	Yes- downstream on River Colne and Wraysbury River	3km (S)
Bedfont Lakes	Local Nature Reserve	No- no connectivity	4km (S)
Cranebank	Local Nature Reserve	No- River Crane upstream of Duke of Northumberland's River confluence so no connectivity	2.5km (E)
Arthur Jacob Nature Reserve	Local Nature Reserve	Yes- downstream on Colne Brook	2km (W)
Pevensey Road	Local Nature Reserve	Yes- downstream on River Crane	6km (SE)
Crane Park Island	Local Nature Reserve	Yes- downstream on River Crane	7km (SE)
Kempton Park Reservoirs	SSSI, RAMSAR & SPA	No- no connectivity	8km (SE)
Wraysbury Reservoir	SSSI, RAMSAR & SPA	No- no connectivity or direct impact	3km (SW)
King George VI Reservoir	SSSI, RAMSAR & SPA	No- no connectivity or direct impact	3km (S)
Staines Reservoirs	SSSI, RAMSAR & SPA	No- no connectivity or direct impact	3km (S)
Wraysbury No.1 Gravel Pit	SSSI, RAMSAR & SPA	Yes- downstream on Horton Brook	4.5km (SW)
Wraysbury and Hythe end Gravel Pits	SSSI, RAMSAR & SPA	Yes- downstream on Horton Brook	4km (SW)

4. Assessment of Effects

4.1 Summary of Receptors to be Considered

On the basis of the baseline presented above, **Table 4.1** identifies potential receptors, i.e. water features or water users that could potentially be impacted by the development of a third runway to the north-west of the Airport. All potential receptors are included, but some are screened out from further consideration in the right hand column. For those remaining in the assessment, the potential for impact is assessed in the following chapters.

Table 4.1 Potential Receptors: Water Environment and Downstream Users

Potential Receptor	Description	Potential for Impact? (to be considered in subsequent sections)
Rivers and lakes		
Horton Brook	Flows from north to south along the Colne Valley. West of Colne Brook	Yes
Colne Brook	Flows from north to south along the Colne Valley. East of Horton Brook and west of Wraysbury River.	Yes
Wraysbury River	Flows from north to south along the Colne Valley. East of Colne Brook and west of River Colne.	Yes
River Colne	Flows from north to south along the Colne Valley. East of Wraysbury River and west of Longford River.	Yes
Longford River	Offtake from River Colne at Longford. Flows south along current Heathrow western boundary, and then east along current southern boundary as the western 'twin river'.	Yes
Duke of Northumberland's River	Offtake from River Colne at Harmondsworth Moor. Flows south along current Heathrow western boundary, and then east along current southern boundary as the eastern 'twin river'.	Yes
River Crane	Flows from north to south to the east of Heathrow. Takes flows from the Duke of Northumberland's River.	Yes
Gravel groundwater body	Shallow gravel aquifer directly underlying the site and surrounding area. Contains areas of historic contamination as a result of previous land uses.	Yes
Chalk groundwater body	Chalk aquifer confined beneath at least 50m of London Clay. Potential connectivity via abstraction boreholes through to the Chalk	Yes
River Thames	Takes water from the Colne Brook, River Colne, River Crane	Yes
Water supply reservoirs	Pumped water supply reservoirs, taking water from the Thames. Raised above surrounding ground level.	No (no interaction with development or potential for impact)
Designated sites		
Other water features of the South West London SPA (Wraysbury No. 1 Gravel Pit SSSI and Wraysbury and Hythe End Gravel Pits SSSI)	Former gravel workings now refilled with groundwater and/or river flow. The Horton Brook flows directly through some of the water bodies.	Yes
Staines Moor SSSI	Alluvial meadows, located between Wraysbury River and River Colne to the north of Staines	Yes
Arthur Jacob Local Nature Reserve	Constructed wetlands adjacent to Colne Brook, downstream of Poyle Channel	Yes
Pevensey Road and Crane Park Island Local Nature Reserves	Meadow, wetlands and woodland adjacent to River Crane, downstream of Duke of Northumberland's River	Yes
Bushy Park (Royal Park)	Water features in the park are fed by the Longford River	Yes

Table 4.1 (Continued) Potential Receptors: Water Environment and Downstream Users

Potential Receptor	Description	Potential for Impact? (to be considered in subsequent sections)
Water users		
Agricultural abstraction at Harmondsworth	Boreholes at Harmondsworth (Home Farm, licence 28/39/36/0023)	Yes
Other abstractions located within the red line boundary	Abstractions under licence TH/039/0028/007 operated by Heathrow.	No (only Heathrow's own licences)
	Licence 28/39/36/0058 and 28/39/31/0144 located to the south and east of the site, away from development area.	No (away from development area)
Agricultural abstractions from Colne Brook	A number of abstraction points from the river, downstream of the Poyle Channel (28/39/28/0301 and 28/39/28/0520)	Yes
Transfer abstraction from River Colne	Transfer from River Colne to flood alleviation scheme at Stanwell Moor (28/39/28/0586)	Yes
Consented discharges	Small industrial/commercial discharges located in the north between Colne Brook and Wraysbury River, and on the River Colne and Poyle Channel	Yes

4.2 North-west Runway Overview

The extension of Heathrow would involve the construction of a new runway to the northwest of the current Airport along with a new terminal and satellite terminal. The new runway would be constructed to the north of the current A4 and to the south of the junction of the M25 and M4. The runway will cover part of Harmondsworth village, the southern half of Harmondsworth Moor (including the BA Waterside development) cross the M25 (which will be reconfigured in to a tunnel) and continue to the west of the Lakeside Road industrial area north of Colnbrook village. The village of Longford, Longford Moor and the Bedfont Court Estate to the east of the M25 also falls within the masterplan boundary.

4.3 Assessment of Effects without Mitigation

4.3.1 Runway Location

The proposed runway location crosses over the majority of the Colne Valley, since the runway orientation is west-east while the rivers in general run from north to south. The runway would cross the routes of the Colne Brook, Wraysbury River, River Colne, Longford River and the Duke of Northumberland's River. **Table 4.2** shows the length of water bodies identified in the RBMP within the site boundary that would be lost as a result of the masterplan, resulting in the direct loss of aquatic and riparian habitat along these lengths.

Table 4.2 Length of Water Bodies Lost within the Site Boundary (km)

Water Body	Length Lost (km)
Duke of Northumberland's River	3.6
Longford River	2.4
River Colne	3.4
Wraysbury River	1.8
Colne Brook	1.1

In addition to the direct loss of aquatic and riparian habitat within the site boundary, the masterplan has the potential to cut off the flow in all of these rivers, creating considerable hydrological disruption and potentially preventing flow in the downstream reaches of all rivers. This would affect flows to the River Thames, as well as affecting both the quality and quantity of water supply to both people and habitats downstream using the water in the rivers.

4.3.2 Construction Effects

Considering the proposed location of the third runway, construction will take place within, or in the vicinity of, watercourses (as identified in **Section 3.2.1**). Without mitigation, construction activities have the potential to cause pollution to groundwater and surface watercourses, through mobilisation of sediment or fuel spills.

Construction will also require excavation in to the gravel aquifer, and piling for foundations through in to the underlying London Clay. As there are areas of contaminated land in the vicinity (both known and unknown), these could become disturbed during construction and result in contamination to surface waters or groundwaters, and with the potential to contaminate the water supplies of local abstractors (potential effects of construction on groundwater have been considered in further detail in **Appendix B**).

4.3.3 Operation Effects

If diversions are put in place to allow the flow of water in the rivers that would otherwise be cut off by the runway, potential impacts without this mitigation strategy could occur including:

- If new channel diversions were to be constructed over areas of contaminated ground, this could result in a long-term source of contamination to the surface water in the new channel, hence impacting on water quality and potentially the aquatic ecology downstream;
- Transfer of pollutants or species between rivers;
- Introduction of new structures causing a barrier to movement of fauna along the river; and

- Changes to the flow regime in downstream reaches of rivers, with changes in water depth or velocity reducing habitat availability, and potentially reducing dissolved oxygen content and impacting on water quality.

Airport operations involve considerable use of fuels and de-icers. Without mitigation, runoff containing spills or residues of those fuels and de-icers could enter surface or groundwaters. This could result in contamination of downstream surface or groundwaters with hydrocarbons, while release of de-icers can result in high biological oxygen demand in surface waters, causing deoxygenation and resulting in impacts to aquatic ecology.

The addition of a third runway and new terminal at Heathrow will result in changes to sewage discharges (potentially to location and amount). If there is insufficient treatment capacity or standard of treatment, this could result in a reduction in water quality downstream of the sewage effluent discharge, and resultant impacts to aquatic ecology.

4.3.4 Water Framework Directive Effects

The impacts discussed above would be likely to result in the deterioration of status in at least four directly impacted water bodies, and potentially on other downstream waterbodies. With no attempt to mitigate the impacts, the scheme could not satisfy Article 4.7 of the WFD or meet the requirements of the directive by any other means.

4.4 Effects after Mitigation

Section 5 presents how the mitigation strategy will address potential adverse effects on the water environment that are identified above. A summary of potential effects for each of the receptors identified at the end of **Section 2** is presented in **Table 4.3**.

The mitigation strategy provides considerable improvement to the wider water environment in the Enhanced Colne Valley, preventing the extensive disruption to the hydrological regime that would have occurred without this mitigation strategy. While it is acknowledged that there will be impacts on some of the existing watercourse as a result of culverting, the strategy will prevent impacts to water quality, and maximises the aquatic habitat opportunities of the local water bodies within the constraints of the overall physical modifications. With respect to the WFD, the strategy has provided an optimal solution for the natural environment, in the context of which any impacts on the water environment have been mitigated as far as feasibly possible, having taken consideration of all plausible options. The strategy clearly sets out that: all practicable steps would be taken to mitigate adverse impacts (part a of Article 4.7); that there are no other better technically feasible options (part b of Article 4.7); that there are no implications for other water bodies upstream or downstream (Article 4.8). In particular, the strategy ensures that impacts to habitat availability and associated ecology are localised and has been designed with the primary aim of ensuring that the existing flow regime is maintained in the downstream reaches of all water bodies. Mitigation will ensure that there are no effects on water bodies further upstream in the Colne Valley, through development of appropriate culvert design, along with enhanced opportunities for fish passage along the Colne Brook.

Further details of the assessment against the requirements of the WFD are presented in **Appendix C**.

Table 4.3 Summary of Effects after Mitigation

Potential Receptor	Summary
Horton Brook	Diversion of the Horton Brook at Colnbrook to accommodate the Colne Brook Spur. Careful design of the diverted channel provides the potential for localised improvements to aquatic and riparian habitat compared to the baseline. No changes to flow regime. No adverse effects on water quality, based on the application of best practice in design and construction, and avoidance of interaction with water from other Colne Valley rivers.
Colne Brook	Approximately 1 km of the Colne Brook will be diverted. Careful design of the diverted channel provides potential for localised improvements to aquatic and riparian habitat compared to the baseline. Design of the flow transfers to Colne Brook Spur will ensure no change to the flow regime of Colne Brook itself. Enhancements will be made to the Colne Brook as a whole by identifying and implementing Mitigation Measures identified in the Thames RBMP, in particular facilitating fish passage along the river. No adverse effects on water quality, based on the application of best practice in design and construction. There will be interaction with water transferred from River Colne, but due to existing upstream connections, will not result in any water quality effects. Water quality in the Colne Brook and Colne Brook Spur will be monitored regularly.
Wraysbury River and River Colne	Loss of habitat due to combining the Wraysbury River and River Colne, and culverting beneath the runway. Mitigation will ensure the culvert is designed to facilitate fish passage, and that the channel downstream is designed to provide habitat potential. Adopting the culverting approach allows the existing channels to be maintained from Stanwell Moor downstream, with no change to the downstream flow regime. Flow in the Poyle Channel will be reduced (by the amount diverted to the Colne Brook Spur). The channel will be redesigned to a two-stage channel, to maintain the habitat potential with reduced flows. No adverse effects on water quality, based on the application of best practice in design and construction. Treated drainage will be discharged to the River Colne, following high standards of treatment to achieve the required water quality limits of the permit (details of which are not known at this stage).. Water quality upstream and downstream of the culvert and the discharge point will be monitored regularly.
Longford River and Duke of Northumberland's River	Loss of habitat due to combining the Longford River and Duke of Northumberland's River, and culverting beneath the runway. Mitigation will ensure culvert is designed to facilitate fish passage (if considered necessary in consultation with the Environment Agency), and that the channel downstream is designed to provide habitat potential. Adopting the culverting approach allows the existing channels to be maintained from Stanwell downstream, with no change to the downstream flow regime. No adverse effects on water quality, based on the application of best practice in design and construction. Treated drainage and sewage discharge will be discharged to the Duke of Northumberland's River, following high standards of treatment to meet discharge permit requirements.. Water quality upstream and downstream of the culvert and discharge point will be monitored regularly.
River Crane	No change to physical habitat availability. Potential to provide improvements to low flows, contributed by increased inflows from the Duke of Northumberland's River (as a result of discharge of treated runoff). High standards of treatment prior to discharge will ensure there would be no reductions in water quality associated with those increased flows. Any supplementary discharges will not be assumed to be the primary discharge mechanism and will only be implemented following a detailed review of needs and feasibility. As part of the review fail safes will be considered to ensure that pollution prevention is not compromised.
Gravel aquifer	An improvement in overall water quality, given that the mitigation strategy seeks to remediate existing groundwater contamination where encountered during construction, plus the reduced risk of further contamination through effective preventative measures and ongoing monitoring.
Water supply reservoirs and other water features of the South West London SPA	No effects: no changes to physical structure of the lakes and reservoirs, or to the availability or quality of water supply.
River Thames	No effects: no changes to flow regime of tributaries at the point of discharge to the River Thames. Application of best practice to construction activities, and high standards of treatment of surface water runoff and foul waters before discharge, will ensure no changes to water quality.

Table 4.3 (Continued) Summary of Effects after Mitigation

Potential Receptor	Summary
Designated sites	
Other water features of the South West London SPA (Wraysbury No. 1 Gravel Pit SSSI and Wraysbury and Hythe End Gravel Pits SSSI)	No effects: no changes to flow regime or water quality of Horton Brook.
Staines Moor SSSI	No changes to the availability of water supply from the Wraysbury River or River Colne, or to water quality. Hence no change to frequency and extent of flooding, changes to groundwater levels, or to water quality.
Arthur Jacob Local Nature Reserve	No effects: no changes to flow regime or water quality of Colne Brook.
Pevensey Road and Crane Park Island Local Nature Reserves	No or minor positive effects: potential for increased low flows in River Crane, which could potentially be beneficial to fringing wetland habitats, although likely to be insignificant.
Bushy Park (Royal Park)	No changes to the availability of water supply from the Longford River, or to water quality.
Water users	
Agricultural abstraction at Harmondsworth (Home Farm)	Borehole locations will no longer be available due to runway positioning. If abstraction is still required, it will be re-located and new borehole(s) provided.
Agricultural abstractions from Colne Brook	All abstractions are from downstream of Poyle Channel, where there will be no change to the flow regime from the existing, hence no implications for water availability for licensed abstractors.
Transfer abstraction from River Colne (Stanwell Moor)	Abstraction is downstream from the realigned reach. There will be no change to the flow regime from the existing.
Consented discharges	Consented discharges within masterplan boundary are unlikely to be needed since properties and businesses will need to relocate. If any are required for any reason, individual discussions will be held as necessary. Consented discharges to Poyle Channel will be reviewed in consultation with consent holders, and revised consent or discharge location agreed with holder and EA if necessary.

5. Mitigation Strategy

This chapter restates the strategy presented within the masterplan submission. This has been undertaken in order fot this report to be read as a 'stand alone' document. Throughout the description of the strategy additional detail has been provided to assist the Airports Commission and their consultees in better understanding the mitigation strategy. However, there is no deviation from the strategy which was set out and costed for in the masterplan submission documents.

The development of the strategy is supported by three key detailed assessments:

- **Appendix A** Surface Water Quality and Ecology Assessment.
- **Appendix B** Groundwater Risk Assessment.
- **Appendix C** Water Framework Directive Assessment.

Sections 5.1, 5.2 and **5.3** describe how effects were first avoided through an evolution of the masterplan and then set out how this Water Quality and Hydroecology Strategy sits within the wider Natural Environment Strategy. **Section 5.4** then details the elements of the strategy that ensure the protection of water quality and hydro-ecology.

5.1 Evolution of the Masterplan

Since the initial submission of the masterplan to the Airports Commission in July 2013 the Masterplan has been developed further to optimise the environmental impacts. The evolution of the north-west runway masterplan has reduced and avoided adverse impacts on the water environment as much as is practically possible in the context of providing an optimal overall environmental solution. The following changes/ additions to masterplan are of most relevance in terms of reducing or avoiding adverse effects on water quality or hydro-ecology:

- **3RNW Runway has been moved southwards.** This decision was made to achieve multiple advantages, one of which was to reduce impacts on the water environment. Moving the 3RNW Runway to the south ensured that gravity driven flow in the Duke of Northumberland's and Longford rivers could be maintained around the airport, and reduced the length of culverting that is required;

- **The western end of 3RNW Runway has moved slightly further east.** This decision had a key aim of providing greater flexibility to divert and manage river flows in the western half of the Colne valley, where otherwise the options would have been very limited and had more effect on the Horton Brook catchment;

- **3RNW Runway has been raised**. The 3RNW Runway has been raised by 2 m at the western end, so that watercourses could pass under the airport in the shortest possible culverts without the need for pumping;

- **A river corridor has been provided along the western boundary.** To minimise the length of culverts under the airport, space for a river corridor has been introduced between the western boundary of the Airport and the M25. The Strategy involves combining the River Wraysbury and River Colne in a single channel under the 3RNW Runway and along the reach adjacent to the M25, with the Longford River and Duke of Northumberland's River in a separate channel. These channels then separate into the existing channels downstream, to ensure that existing downstream flow regimes are maintained.

5.2 Summary of Natural Environment Mitigation Strategy

A strategy has been developed as a part of the masterplan that encompasses flood risk, biodiversity and landscape considerations, and sets out the modifications to the water environment. The strategy has been presented in Part 5.5 (Enhancing the Natural Environment) of Volume 1 of the Technical Submission, with aspects relevant to the water environment described below. The strategy provides the basis for minimising, and mitigating against, potential effects to the water environment in relation to the footprint of the site and associated need for channel diversions.

In order to accommodate a third runway to the north-west of the current development, channels in the Colne Valley will be diverted, and will include the creation of new channels and new floodplain extents. While the new channels have been designed to provide high quality aquatic and riparian habitat, physical alterations have not been extended any further upstream or downstream than is necessary, in order to minimise the overall extent of disruption. A fundamental requirement is to maintain connectivity of flows of all river channels in the Colne valley from upstream to downstream, which is the basis by which habitat, water quality, hydro-ecology, the availability of water for downstream users, and the requirements of the WFD can be maintained.

The strategy is illustrated in **Figure 5.1**, which shows the location of the new channels, as well as the proportion of flow in each channel. Physical changes to the channels are unavoidable to the west of the Airport, with the River Colne, Wraysbury, Longford and Duke of Northumberland's Rivers being culverted beneath the runway, and the Colne Brook being diverted around the western end of the runway. This will be compensated by the creation of a new natural channel with diverse aquatic and riparian habitats, the 'River Colne Spur', in the Enhanced Colne Valley, to the west of the Colne Brook.

In these reaches to the west of the Airport, there will be some local changes in river flow, as a result of flows being diverted to the west from the River Colne to supply the River Colne Spur (although there will be no alterations to the flow in the Colne Brook itself with the exception of the short reach where it is joined by the River Colne Spur). However the flow in the Poyle Channel will be reduced by the equivalent amount of flow that will be diverted in to the River Colne Spur (as illustrated in **Figure 5.1**), which means that downstream of the Poyle Channel, and after the western boundary channels have separated out to the original Wraysbury, Colne, Longford and Duke of Northumberland's channels, there will be no net change to river flows, providing a clear downstream limit to flow regime changes.

5.3 Evolution of the Natural Environment Strategy

Water quality and hydro-ecology, and the requirements of the Water Framework Directive, have been considered as integral parts of the Natural Environment Strategy. The overall aim of the strategy is to manage flood risk sustainably (reducing risk where feasible) and improve local landscape and recreational provision, in addition to protecting both aquatic and terrestrial biodiversity. The strategy has aimed to maximise the ecosystem services elements of the masterplan through the development of a multifunctional landscape.

In developing the strategy, a range of options were considered for managing the rivers, including different approaches to river diversions or culverts. At one extent, complete avoidance of diversions would have required culverting of all watercourses along their current routes. At the other extent, complete avoidance of culverting would have required diversion of all watercourses around the new runway (considerably longer than the current routes). Considerable constraints were identified with all other options.

Options involving a greater proportion of flow passing through culverts beneath the runway were considered but were constrained by the availability of potential flood storage areas upstream of the Airport on the River Colne and Wraysbury River. Such options limited the potential to reduce flood risk in West Drayton – which has been achieved in this strategy. These options would have also caused increasing risk of obstructing passage of fish and other animals along the rivers, with lesser amounts of flow in open, natural channels through the Colne Valley.

It is recognised that culverting of watercourses is discouraged by the EA due to potential ecological effects, including direct habitat loss, as well as maintenance and flood risk concerns. Alternative solutions to avoid or reduce culverting were considered, in particular diverting all rivers to flow around the new Airport boundary. After further analysis, taking into account a range of practical considerations this option was discounted for two reasons. Firstly, it was unlikely to be physically possible to bring the water round the northern boundary due to the constraints associated with the realignment of the M25 (i.e. an aqueduct across the M25 would have been required, but space for this was very limited). Secondly, if the route could have been achieved, the longer length and relative elevations would have meant that channel gradients would have been too shallow to maintain downstream flow regimes, especially along the Longford River and Duke of Northumberland’s River. Pumping in to the Longford River and Duke of Northumberland’s River would be required, which was not a sustainable option.

The option that has been progressed is therefore believed to be technically feasible and is able to meet the key objectives of:

- Maintenance of existing aquatic and riparian habitats where possible, along with the creation of a new river channel and associated habitats; and
- Retention of connectivity of all downstream watercourses, with no net change to the flow regime in any watercourse downstream of the development.

5.4 Discussion of Water Quality and Hydro-ecology Mitigation

The key elements of the Natural Environment mitigation strategy with respect to protection of water quality and hydro-ecology and meeting the requirements of the WFD, are:

- **Maintaining river flow regimes for ecology** by ensuring continuity of flow through the Colne Valley, hence also maintaining the connectivity of aquatic habitat and providing the basis for protection of water quality and aquatic ecology;

- **Ensuring that the development has no impact on the water quality** in rivers or groundwater, through channel design, construction practices or Airport operation;
- **Protecting the overall hydro-ecology of the Colne valley**, including aquatic habitats and the ability of fish to migrate along the rivers, and providing new aquatic and riparian habitat where channels are diverted and realigned; and
- **Ensuring that there are no impacts on other water users** in the vicinity of the Airport due to changes to water quality or quantity.

Each of these aspects is discussed in more detail below.

5.4.1 Maintaining River Flows for Ecology

The river flow management approach that is an integral part of the Natural Environment mitigation strategy will avoid any changes to flows in the Colne Brook, and in the downstream reaches of the Wraysbury River, River Colne, Longford River and Duke of Northumberland rivers. **Figure 5.1** depicts how the mitigation strategy manages flow splits around the airport and illustrates that there is no change to the flow downstream of the airport or areas of physical habitat available for aquatic flora and fauna in those reaches, which provides the basis to maintaining or providing the potential for good water quality and aquatic ecology. It will also maintain the water supply to downstream receptors such as Staines Moor SSSI (from the Wraysbury River and River Colne), Bushy Park (from the Longford River), and agricultural abstractors from the Colne Brook.

The Environment Agency has highlighted that there are particular problems with low flows in the River Crane, which are causing failures under the WFD[5]. The strategy has the potential to help alleviate low flow problems, by releasing treated water from drainage and sewage effluent (with a high level of treatment) to the Duke of Northumberland's River, which flows in to the River Crane. This will assist with increasing the flows to the river.

Clearly the strategy involves considerable re-routing of flows from their current course, and it might be considered whether more flow could have been diverted to the River Crane. One potential option was considered of diverting flows across from the Colne Valley to the River Crane to the north of the Airport, or alternatively the proportions of flow in different channels could have been adjusted. However any such option would have removed or reduced flow in one or more downstream river reaches, thereby failing to meet a fundamental aim of the strategy.

It is for similar reasons that the River Colne Spur will be designed to only to take flow equivalent to the reduction in flow down the Poyle Channel. This is the only approach to ensure no net change to downstream flows. As a result of this change to the flow regime, sensitive reworking of the Poyle channel will be carried out to create a smaller, sinuous channel more suited to the reduced volume of flow. This will be inset within the existing channel, so retaining some water in the Poyle Channel at all times and maintaining a biodiversity and amenity interest.

5.4.2 Maintaining Water Quality

Channel Design

As identified in **Section 3**, there are areas of contaminated land beneath and in the vicinity of the development area. The route of the River Colne Spur flows over an area of known contaminated land (some of which will be remediated during construction). The bed of the new channel will be lined with impermeable material (e.g. clay) wherever it is necessary to prevent contamination entering the river. However the clay-lined areas will be kept to a minimum in order to allow natural interactions between (uncontaminated) groundwater and the surface watercourses, and encourage the aquatic vegetation and habitats to establish naturally. This will require best practice in channel design, along with a detailed assessment of risk of groundwater contamination, and will be considered in detail during the design stage. The strategy is to create natural watercourses with ground remediation where appropriate to facilitate this. Chemical and biological monitoring will be undertaken to monitor the quality of the watercourses. An impermeable lining will also be used if necessary for flood storage areas where they overlie contaminated land.

As has been identified in **Section 5.4.1,** there will be some redistribution of flows between the channels of the Colne Valley as part of the strategy. While in some cases this may lead to concern about transfer of pollutants or aquatic life between rivers, in this case the two rivers (River Colne and Colne Brook) are already connected further upstream. As a result, they have very similar water quality to each other, with the classification of the water quality elements in the RBMP being very similar (as identified in **Table 3.1).** The main difference between the two water bodies is the failing chemical status of the River Colne due to polycyclic aromatic hydrocarbon (PAH) concentrations. The source of that failure has not been established through this assessment, however monitoring data shows that PAHs have not been detected in the river since 2007, with the exception of a single detection in 2011. As a result it is concluded that there is low risk associated with the transfer of water between rivers.

Changes to either physical channel structure or the amount of flow in an existing channel can potentially result in water quality and ecology impacts, by changing water depths and velocities and dissolved oxygen content of the water. The River Colne Spur and the new, smaller channel within the Poyle channel will be designed appropriately for the amount of flow, and with a meandering structure, which will maintain velocities, allow natural colonisation of macrophytes and avoid depletion of dissolved oxygen.

Construction Activities

Best Practice in construction will be adhered to at all times, with Pollution Prevention Guidance and Construction Practice guidance being incorporated in to the Construction Environmental Management Plan, in order to avoid pollution to surface or groundwaters. More detailed consideration of potential effects and associated mitigation relating to groundwater is included in **Appendix B**.

Specific consideration will be given to dewatering, which may be necessary during construction. Due to the physical properties of the Terrace Gravels there is the potential for lowering groundwater levels over a wide area, and engineering solutions (e.g. temporary coffer dams) will be implemented to avoid this where required. Areas of contaminated land may be encountered, and it will be necessary to ensure that contaminants are not mobilised (for example by allowing infiltration through contaminated soil where it would not have occurred previously), or discharged to surface waters (without treatment) during dewatering. Water quality will be regularly monitored during construction to identify and allow mitigation to be implemented against any contaminant migration.

Operational Activities

There are specific hazards associated with aviation that are of concern for water quality, particularly regarding hydrocarbons and de-icants such as glycol. A robust Sustainable Drainage Strategy[3] has been developed that will effectively treat runoff, and allow clean water to be released at a controlled rate to surface waters, avoiding any impacts to chemical status or oxygen demand downstream. This will include improvements to de-icant collection for the existing runways, thereby providing an improvement to the existing situation.

There is potential for releases of treated runoff to be discharged to both (or either of) the River Colne and to the Duke of Northumberland's River, and permits will be agreed with the Environment Agency for those discharges. All discharges will be to surface water, with discharges to groundwater being avoided, due to the risk of mobilising existing contamination. A strategy for fertiliser and pesticide application to grassed areas will also be developed, to prevent nitrate leaching to groundwater or reaching surface waters.

A new Sewage Treatment Works may need to be developed to take sewage from the airport infrastructure and to cope with the increased passenger numbers. Some of the treated water will be re-used for non-potable uses, thereby reducing net water use on site[3] and for the remainder there will be a discharge for treated effluent to the Duke of Northumberland's River. There are current failures of phosphorus levels (against standards applied in relation to WFD) in rivers in both the Crane and Colne catchments, and high levels of treatment will be implemented, with environmental permits agreed with the EA, to ensure that there is no further contribution to the phosphorus failures.

Existing airport procedures will be revised and updated to address any additional risks from the new infrastructure.

5.4.3 Preserving Hydro-ecology

Channel Design

The 'Enhanced Colne Valley', in which the River Colne Spur will be located, will become a high quality area of open space that will support biodiversity and provide a re-distribution of flows away from the River Colne. The River Colne Spur and the diversions of the Colne Brook and Horton Brook will be created as natural, meandering channels, with high quality and diverse habitats including pools and riffles that will be colonised naturally by plants and animals. The channels will be designed with natural banks and bed materials wherever possible (with the only exception being to avoid contaminated groundwater where necessary, as described above). The channels will have sufficient space and flexibility for natural evolution of the channel structure. Best practice measures such as transfer of cobbles and boulders from the current rivers, which can harbour plant growth and invertebrate life, will be explored. Where appropriate, electro-fishing to transfer fry, parr and other life stages of fish from existing channels will assist colonisation of the new channels.

For the re-aligned channels (combined Wraysbury River and River Colne, and combined Longford River and Duke of Northumberland's River) running between the Airport boundary and the M25, natural materials will be used for the bed and banks wherever possible. Variety in channel width and depth will be designed, within the constraints of the available space, in order to provide opportunities for marginal vegetation to develop. This will include the use of two-stage channels, to allow a smaller area of flow with improved habitat during flow flows, which can then spill out in to the larger channel during high flows, meandering of the channel where possible (and use of in-channel flow deflectors to vary the velocities and direction of flow elsewhere), and providing connectivity to floodplain and creation of backwaters and areas of refuge.

A minimum number of flow management structures will be used in the new and diverted channels. Where structures (for example weirs) are unavoidable, they will include appropriate fish passes. The fish passes would be designed to accommodate medium swimming strength coarse fish; thus there are likely to be limits on the water velocity and slope associated with such fish passes.

In addition to creation of new and alternative habitats, opportunities for enhancements of existing habitat will be considered in the Colne and Crane catchments. In particular this will aim to provide opportunities to enable the implementation of Mitigation Measures already identified for the relevant water bodies in the Thames RBMP, as well as seeking to identify further opportunities for enhancement. Opportunities will be identified and progressed in consultation with the Environment Agency and the Colne and Crane Catchment Partnerships.

Culverting

The River Colne and Wraysbury River (combined) and the Longford River and Duke of Northumberland's Rivers (combined) will flow beneath the runway in culverts. In relation to the WFD, culverts need to be considered both in terms of their influence on the status of the waterbody in which the culvert is located (in this case the River Colne), as well as the potential influence on contiguous water bodies, particularly those upstream (the entire catchment of the upper River Colne and its tributaries) due to connectivity impacts (i.e. ability of upstream migrating fish, or other species, to access the upper catchment via a culvert).

Alternative watercourse alignments have been investigated in order to avoid the necessity for culverting however, as discussed in **Section 5.3**, no feasible alternative options were found that could ensure the continuity of flow to all downstream watercourses. Thus, the strategy has focussed on ensuring that fish passage through the Colne Valley is not compromised, by two means:

- Detailed culvert design will be undertaken in close consultation with the Environment Agency in order to provide all practicable means to ensure the culvert design is as environmentally sensitive as possible. Box 1 discusses some of the likely concerns with regards to a culvert of the length proposed, and identifies they key areas for focus in detailed design. This will include ensuring appropriate depths and velocities of flow, avoiding steps and perched sections, use of a two-stage channel, and consideration of the potential use of lighting options;

- Removing existing barriers to migration on the Colne Brook, thereby enhancing the potential for migration by this route, which also allows the main River Colne to be reached further upstream. Opportunities for identifying barriers and making the Colne Brook an attractive route for upstream fish movement will be identified in consultation with the Environment Agency and catchment partnerships.

It was considered whether the latter of these options should form the entirety of the strategy for fish passage through the Colne Valley, with fish being deterred from attempting to pass through the culverts. However it was considered that this approach would be largely inappropriate, because diversion of (upstream migrating) fish would have to be achieved at the confluences of the Colne Brook and River Colne with the River Thames, which would then effectively deprive fish access to several kilometres (in total) of habitat along the lower reaches of the Wraysbury River and River Colne. It is considered that total exclusion of fish from extensive lengths of river in this way could be detrimental to the overall ecological diversity and result in deterioration of the fish classification for the Colne & GUC water body. As a result, the mitigation strategy presented in this report is deemed much more appropriate, as it provides culverts that will be designed as far as possible not to deter fish passage, while also improving opportunities for movement along the Colne Brook.

Box 1 Culvert Design in Relation to Fish Passage

Increased flow velocities through culverts pose one of the primary reasons that culverts can represent a barrier to fish migration. Flow velocities through the main culvert during flood events will be limited through the effective use of the associated upstream flood storage areas. At such times, fish are unlikely to be moving (especially upstream) but rather are likely to be seeking refuge, preferring to move at times that would expend less energy. Control of flow velocities at low flows is most critical in the consideration of fish passage. Fish passage restrictions associated with an increased water velocity propagate when the water velocity is greater than the particular fish species sustainable swimming velocity. It is critical to consider a sustainable swimming velocity, rather than burst speed capability given the length of the culvert required to pass beneath the proposed runway. Recommendations made by the Environment Agency (2014[13]) for coarse fish in long culverts will therefore be accounted for in detailed design, and further mitigation against increased flow speeds through the culvert may be made by appropriate design measures i.e. in-culvert baffles and fish refuges (resting places).

Parallel to consideration of water velocity is consideration of water depth. Inadequate water depths i.e. shallow sections, will be avoided through appropriate cross section design of any new channel bed. Retaining a natural bed form and substrate where possible i.e. avoiding perched sections, steps or extensive concrete bed sections would seek to avoid any deterrent effect on fish. Any implications of culverting for water quality (e.g. dissolved oxygen concentrations, which could feasibly be expected to decrease with distance through an enclosed culvert assuming consistent oxygen demand) would be anticipated to be so negligible as to be insignificant, particularly with regards to effects on fish passage. A programme of upstream and downstream monitoring of dissolved oxygen concentrations and other dependent parameters such as soluble metals will be implemented in order to monitor and address any potential water quality effects.

It is postulated by some that fish passage may be influenced to some degree by the effect of light/darkness e.g. the contrast of light and dark at the mouth of a culvert or by the prospect of traversing a lengthy culvert in darkness. A review of the scientific literature confirms that there is little rigorous evidence to support the conclusion that fish do not pass through extended culverts in darkness. Rogers and Cane (2008) found that salmon were able to successfully navigate a 2.2km long unlit tunnel which was created on the River Gwynedd system in North Wales following implementation of a pumped storage reservoir system[14]. Consultations with the Environment Agency are likely to identify further potential for best practice culvert design. The possibility for artificial lighting (or use of light tunnels) may be considered to be beneficial in order to break up culvert darkness. These techniques have been employed elsewhere however are not without drawbacks because fish, although generally attracted to light, often do not like the transition/interfaces between light and dark.

The only fish species of conservation interest identified through historical survey was the European eel. Migration of eels is highly unlikely to be affected by a tunnel in darkness (eel passes are routinely covered in order to encourage passage numbers).

Regular maintenance will be undertaken of river channels and culverts using best practice approaches (in agreement with the EA), including management of aquatic vegetation and clearing of debris where necessary.

[13] Environment Agency (2014). Environment Agency website: Structural modification of culverts. http://evidence.environment-agency.gov.uk/FCERM/en/SC060065/MeasuresList/M7/M7T1.aspx?pagenum=2 (accessed 09/05/2014)

[14] Rogers and Crane (2008) Upstream Passage of Adult Salmon Through an Unlit Tunnel. Aquaculture Research (10: 87–92) describe the unlit tunnel with notes on water velocities under various discharge conditions. A fish counter, mounted at the peak of the fish pass in the upstream (intake) weir of the tunnel, indicated that, in the first spawning season following construction of the tunnel, numbers of adults have succeeded in negotiating the tunnel and weir, despite the previously assumed unattractive conditions of low velocity (with regards salmonids) and complete darkness

5.4.4 Managing Impacts on other Water Users

Abstractions and Discharges

In the vicinity of the Airport there are activities licensed by the EA relating to use of the water environment, including water abstractions, discharges to water, and existing flow diversions. These have been considered and mitigation incorporated in to the strategy where necessary. A review and consultation will also be undertaken closer to the time of development, in case of any changes to consents or licences.

Abstractions

There are no water abstractions from the rivers in the realigned reaches. There are a number of abstractions for agricultural use from the Colne Brook, downstream of the Poyle Channel. In that reach there will be no changes to the river flow or water quality, so abstraction will be able to continue as it does currently.

There is one licensed abstraction from the River Colne at Stanwell Moor, which is downstream of the length that will be modified. The abstraction is for a diversion of water in to a flood alleviation scheme to reduce the risk of flooding at Stanwell Moor. As this abstraction is downstream from the modifications, there will be no effect on the ability of the abstraction to continue, although discussions will be held with the Stanwell Moor Residents Association as to whether the Flood Strategy can further support their flood protection aims.

Most groundwater abstractions in the area are from the Chalk aquifer and will not be affected by the development because they are protected by the London Clay. There is one abstraction licence with three abstraction points from the gravel aquifer at Home Farm in Harmondsworth. These will be inside the masterplan boundary and are unlikely to be able to remain in situ. It is possible that the water may no longer be required, if the agricultural land for which it is used is also disrupted by the runway, however if the water is still required, an alternative location will be identified, licence changes agreed with the EA, and a new borehole installed.

There will be no impact on any Thames Water abstractions from the River Thames.

Discharges

There are a number of consented discharges within the masterplan boundary (as identified in **Section 2**), which are unlikely to be needed since the properties and businesses with which they are associated will need to relocate. If any of the discharges do continue to be required for any reason, individual discussions will be held as necessary, identifying an alternative discharge location and agreeing a change to the discharge consent with the EA.

Consented discharges to Poyle Channel may be affected by the reduced flow in the Poyle Channel. Those discharges will be reviewed in consultation with consent holders, and revised consent or discharge location agreed with the consent holder and EA if necessary.

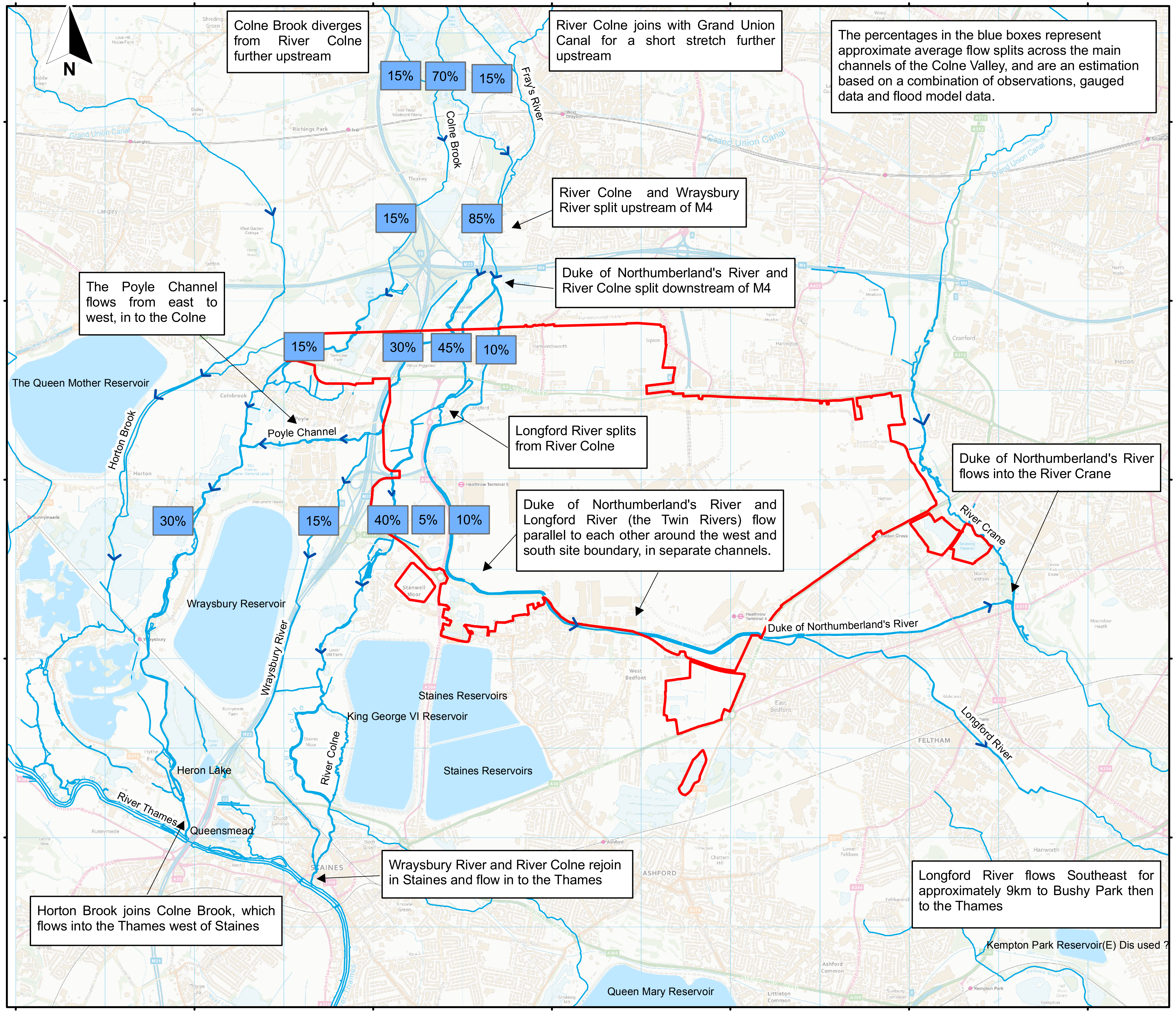
Downstream Amenity and Biodiversity Features

Section 3 identified a number of downstream sites that have some dependence on water in the rivers that are affected by the development. However since the strategy that has been developed has focussed on ensuring that there are no changes to the downstream flow regimes in any river (with the exception of the River Crane, where improvements to low flows will be sought), this will avoid any water supply issues to those sites. In addition, the application of best practice in construction and operation, and high standards of treatment of surface water runoff and foul waters before discharge, will ensure no reduction to water quality downstream and avoid any effects such as eutrophication at downstream sites.

6. Conclusions

This report describes the technical assessment that has informed Part 5.5 (Enhancing the Natural Environment) of the submission to the Airports Commission[3]. It has focussed on how the strategy will protect and manage the water environment with respect to water quality and hydro-ecology. Specific consideration has been given to implications under the WFD[5].

The mitigation strategy associated with the masterplan has evolved over time, with consideration of alternative options, to provide an enhanced solution that is in keeping with the WFD, clearly demonstrating compliance with Article 4.7. The strategy will prevent impacts to water quality, and maximises the aquatic habitat opportunities of the local water bodies within the constraints of the overall physical modifications. It provides a solution for mitigating effects on the natural environment, specifically the water environment. In particular, the strategy ensures that impacts to habitat availability and associated ecology are localised and has been designed with the primary aim of ensuring that the existing flow regime is maintained in the downstream reaches of all water bodies. The strategy ensures that there are no effects on water bodies or water users either further upstream in the Colne Valley (through development of appropriate culvert design, along with enhanced opportunities for fish passage along the Colne Brook), or downstream (through maintenance of the existing flow regime in the downstream reaches of all water bodies).



Key:

- Site boundary
- Existing river channels
- Lakes & Reservoirs

0 250 500 1,000 1,500 2,000 Metres

Scale: 1:25,000 @ A3

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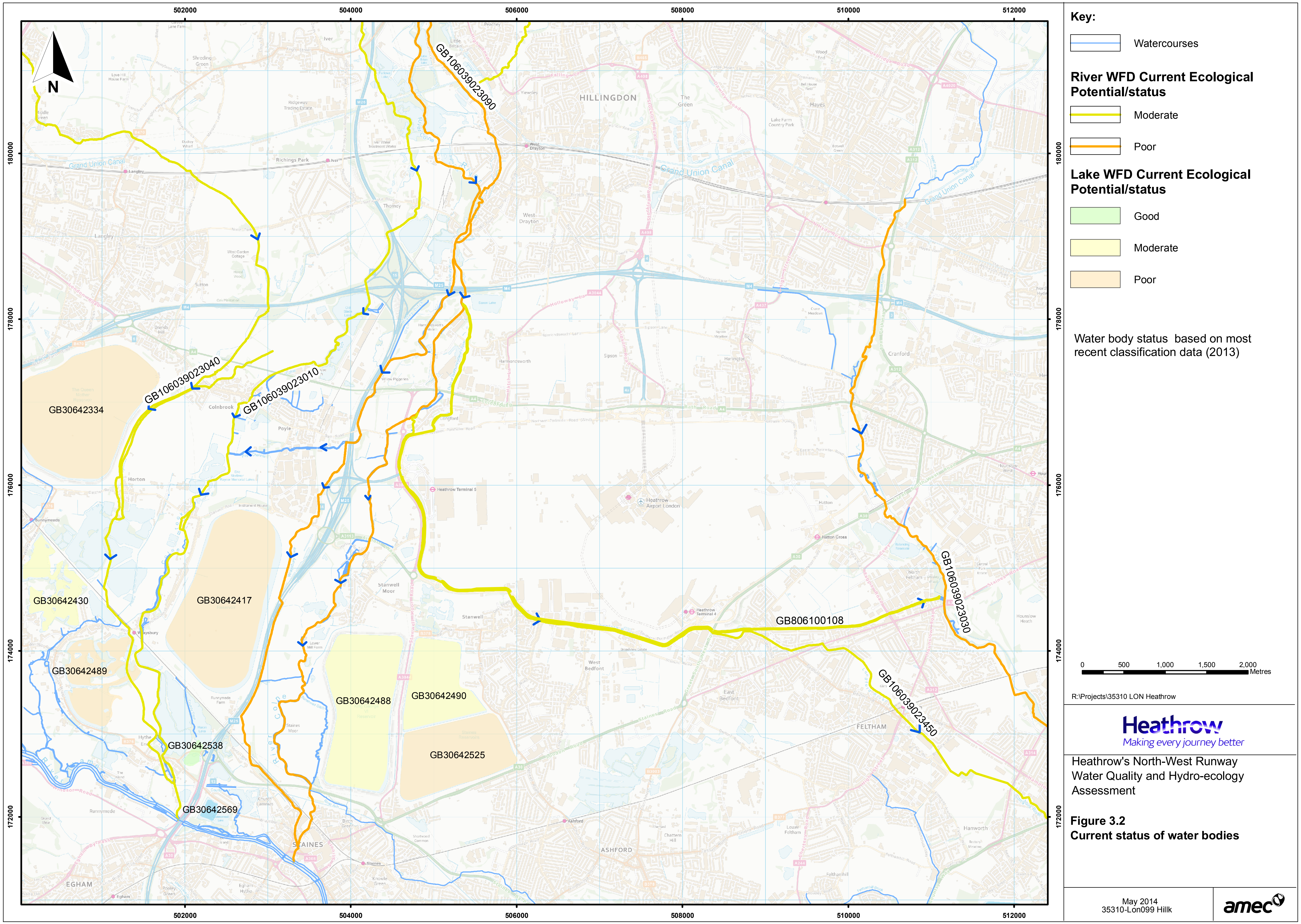
Heathrow's North-West Runway Water Quality and Hydro-ecology Assessment

Figure 3.1
Water Features

May 2014
35310-Lon098 Hillk

amec



Key:
Watercourses
River WFD Current Ecological Potential/status
Moderate
Poor
Lake WFD Current Ecological Potential/status
Good
Moderate
Poor
Water body status based on most recent classification data (2013)
GB106039023090
GB106039023040
GB106039023010
GB106039023030
GB106039023450
GB806100108
GB30642334
GB30642430
GB30642417
GB30642489
GB30642488
GB30642490
GB30642525
GB30642538
GB30642569
HILLINGDON
FELTHAM
ASHFORD
STAINES
EGHAM
Grand Union Canal
N
0 500 1,000 1,500 2,000 Metres
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Figure 3.2
Current status of water bodies
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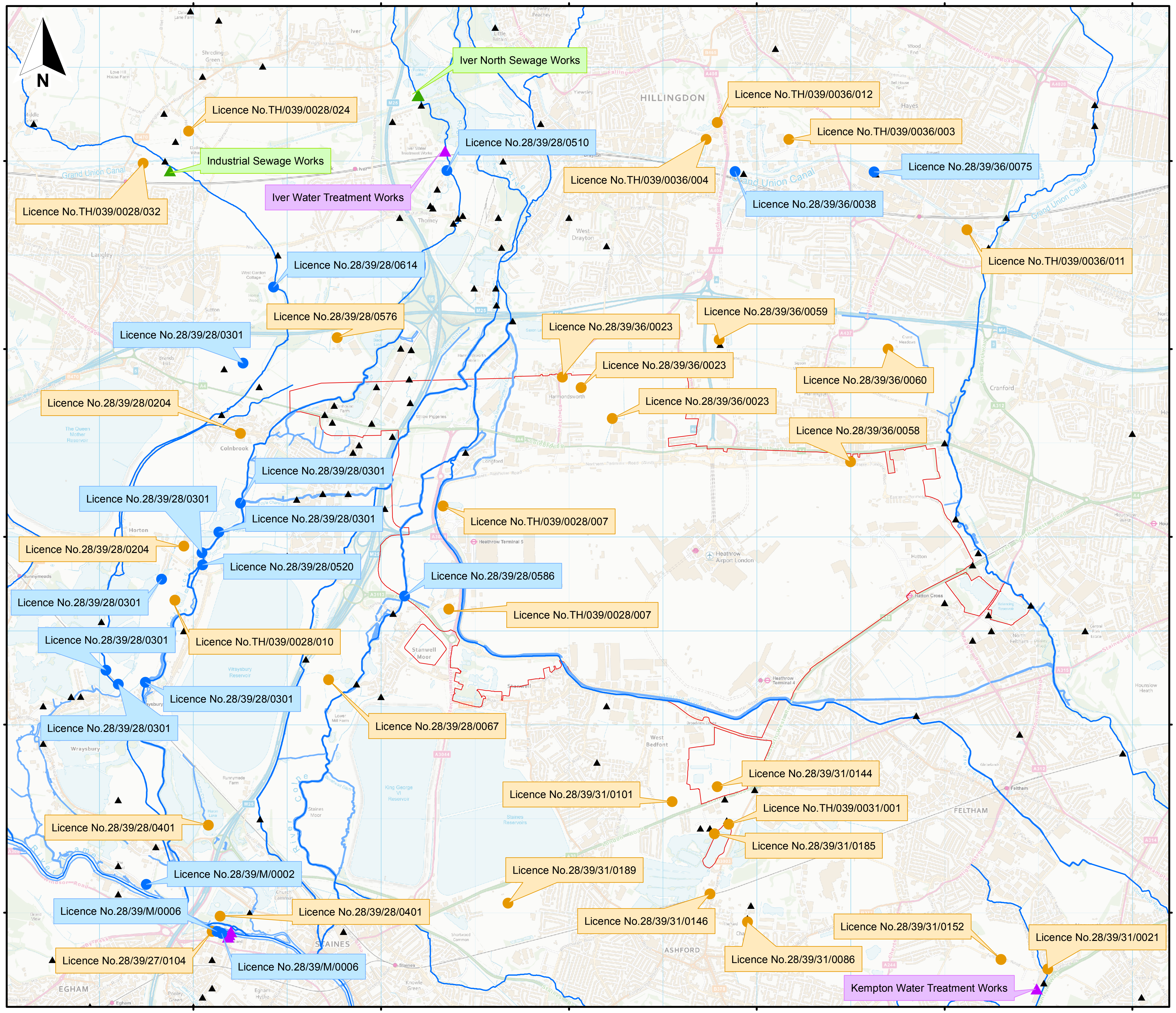
amec



Key:

Waterourses

Abstractions

- Groundwater
- Surfacewater

Discharges

- Sewage Disposal Works
- Water Treatment Work Discharges
- Other Discharges

0 500 1,000 1,500 2,000 Metres

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Figure 3.3
Licensed abstractions and consented discharges in the vicinity.

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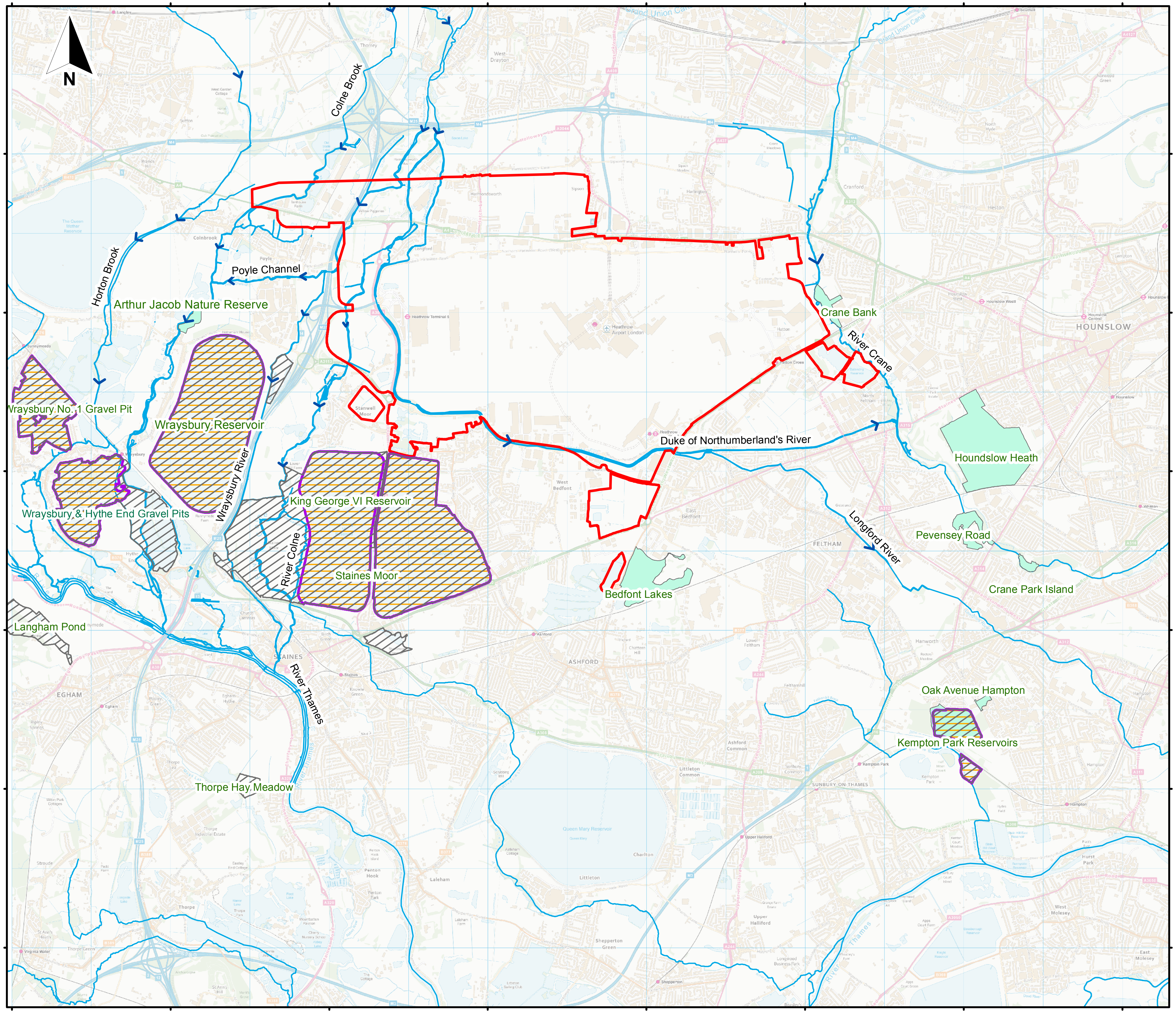

Key:

- Site boundary
- Existing river channels

Designated sites

- SSSI Site
- SPA Site
- RAMSAR Site
- Local Nature Reserves

0 250 500 1,000 1,500 2,000 Metres

Scale: 1:25,000 @ A3

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Heathrow's North-West Runway
Water Quality and Hydro-ecology
Assessment

Figure 3.4
Sites designated for nature conservation with potentially water-dependent features

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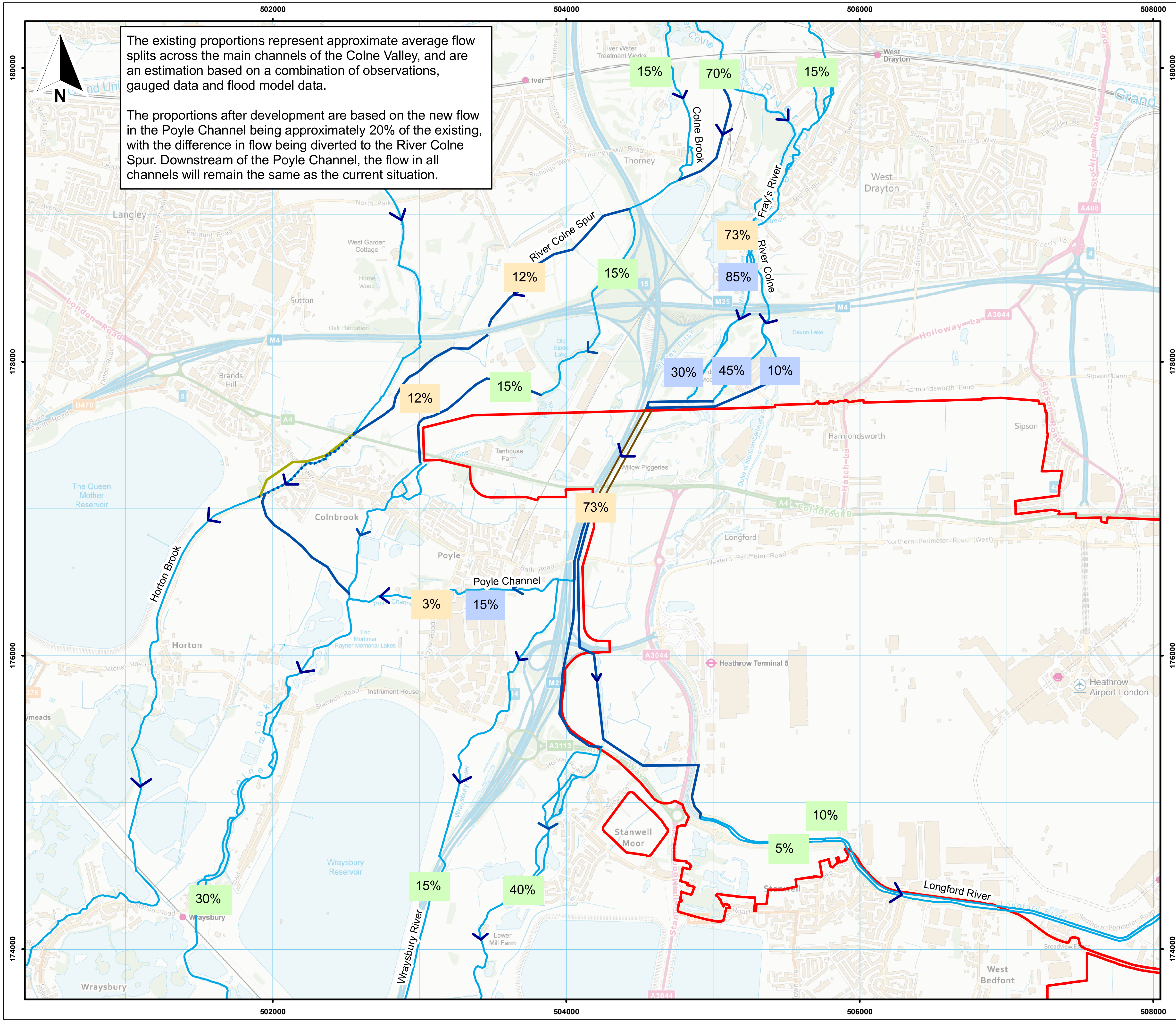

Key:

- Site boundary
- Existing river channels
- New river channels
- Culvert
- Modification to existing Horton Brook channel to accomodate flow from new river channel
- Re-routed Horton Brook
- Existing proportion of flow in each channel (will be affected by development)
- Proportion of flow in each channel after development
- Existing proportion of flow in each channel (unaffected by development)

0 250 500 1,000 Metres

Scale: 1:25,000 @ A3

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Heathrow's North-West Runway Water Quality and Hydro-ecology Assessment

Figure 5.1
Influence of Mitigation Strategy on River Flows

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Appendix A
Surface Water Quality and Ecology

Baseline data relating to water quality, aquatic ecology and habitat availability have been obtained from the Environment Agency. Aspects of the data that are of most relevance to the mitigation strategy are presented and discussed here, including water quality, fish and River Habitat Surveys.

Water Quality

Biochemical Parameters

Monthly water quality data was received from the EA for a number of points along watercourses or at lake outlets within the study area, taken between January 2004 and March 2014. Summary results of the data can be seen in **Tables A1 and A2** below, with the average or respective percentile value calculated for the data, to allow comparison to water quality targets associated with the WFD. The status of each element for each waterbody was also listed in the 2009 RBMP. **Table A1** confirms failures listed in the RBMP due to levels of phosphorus both within the lakes and rivers. There are no failures of the other parameters that are considered within the assessment of Ecological Status, including dissolved oxygen, biological oxygen demand or pH.

Priority Substances and Specific Pollutants

Priority Substances and Priority Hazardous Substances are those listed in the Environmental Quality Standards Directive (2008/105/EC) as being of particular concern at the European level. These are identified in RBMPs for water bodies where such substances are discharged in to the water body in significant quantity, or where there is a risk of discharge. The only failure of a Priority Substance in the 2009 RBMP for these water bodies is the Colne and GUC water body, which has a failing chemical status for the Priority Hazardous Substance Benzo (ghi) perelyene and Indeno (123-cd) pyrene (PAHs). The water quality data (as summarised in **Table A3**) show that these substances have been detected intermittently in the lower River Colne. The last detection of Benzo (g,h,i) perylene was in 2006, and of Indeno (123-cd) pyrene in 2011 (a single detection, prior to which there had been no concentrations above the detection limit since 2007). The substances have been analysed for, but not detected, in more recent samples. It is therefore assumed that the source of the substances is no longer present, and that the failure may no longer be recorded in the second RBMP (due in 2015).

There are also Specific Pollutants highlighted within the RBMP for a number of the river and lake waterbodies in the area surrounding Heathrow, which are substances of national concern. Similarly to Priority Substances, Specific Pollutants are only listed where there are known or possible discharges to a water body. All river waterbodies under consideration have at least one identified Specific Pollutant from zinc, copper, arsenic, iron and ammonia. For all lake waterbodies the Specific Pollutants are zinc and copper. The EA website that maps the WFD status shows that for all the identified waterbodies, specific pollutant concentrations are consistent with High status, indicating that these pollutants are not contributing to existing waterbody failures to meet Good Ecological Status.

Table A.1 **River Water Quality Monitoring Data January 2004 – March 2014 (as received from EA, April 2014)**

			P		BOD		Amm		DO		pH	
Sample Site Name	**NGR**	**WB ID**	**Av. (ug/l)**	**No. Samples**	**90 %ile (mg/l)**	**No. Samples**	**90%ile (mg/l N)**	**No. Samples**	**% Sat 10%ile**	**No. Samples**	**Av.**	**No. Samples**
COLNE ABOVE THAMES	TQ0330 071600	GB106039 023090	403.55	121	0.50	121	0.02	121	116.10	120	7.97	122
FRAYS ABOVE COLNE	TQ0544 379046	GB10603 9023090	400.53	113	0.50	46	0.02	113	107.96	113	7.65	113
HORTON BROOK ABOVE COLNE BROOK	TQ0184 772413	GB10603 9023010	91.73	60	0.50	44	0.04	60	100.20	60	7.53	60
PINN ABOVE FRAYS	TQ0576 780939	GB10603 9023070	277.00	112	0.50	41	0.02	112	104.82	110	7.57	111
WRAYSBURY RIVER ABOVE COLNE	TQ0333 171752	GB10603 9023090	936.71	72	0.50	30	0.02	72	114.00	73	7.85	73
COLNE BROOK AT WRAYSBURY ROAD	TQ0173 772706	GB10603 9023010	327.46	13	-	-	0.02	13	105.74	13	7.98	13
CRANE AT THE CAUSEWAY, HOUNSLOW	TQ1063 775510	GB10603 9023030	350.34	29	1.29	29	0.05	29	99.20	29	7.60	29
CRANE BELOW EASTERN BALANCING RESERVOIR	TQ1095 575234	GB10603 9023030	253.43	35	1.06	35	0.02	35	100.60	35	7.67	35
CRANE ABOVE DUKE OF NORTHUMBERLANDS RIVE	TQ1115 774642	GB10603 9023030	229.56	79	1.20	76	0.02	79	103.19	80	7.64	80
G.U.C. AT HORTON ROAD BRIDGE	TQ0664 080075	GB10603 9023070	364.72	123	0.50	46	0.02	123	142.43	122	7.59	123
YEADING BROOK AT NORTH HYDE ROAD, HAYES	TQ1042 578896	GB10603 9023030	316.70	114	0.86	58	0.08	114	95.80	113	7.60	113

Table A.2 Lake Water Quality Monitoring Data January 2004 – March 2014

	NGR		Total Phosphorus		BOD		Amm		DO		pH	
Sample Site Name		Current WB status	Av. (ug/l)	No. Samples	90 %ile	No. Samples	90 %ile	No. Samples	Av. mg/l	No. Samples	Av.	No. Samples
WRAYSBURY OUTLET	TQ0227074890	poor	203.31	76	0.86	42	0.02	116	11.12	116	8.45	116
DATCHET (QUEEN MOTHER) OUTLET	TQ0115076820	poor	217.84	33	0.85	40	0.02	116	11.36	116	8.48	116
QUEEN MARY OUTLET	TQ0761070400	poor	174.92	111	1.23	42	0.02	117	11.48	117	8.45	118
KING GEORGE VI OUTLET	TQ0405072380	moderate	203.69	77	0.90	41	0.02	115	11.45	116	8.62	116
STAINES NORTH OUTLET	TQ0465073050	moderate	232.04	75	1.41	33	0.02	105	11.43	105	8.64	105
STAINES SOUTH OUTLET	TQ0465072970	poor	267.16	75	3.22	110	0.02	116	11.56	116	8.71	116

Table A.3 **Concentrations of PAHs detected in River Colne above Thames (TQ0330071600), 2004-2014**

	Benzo(g,h,i)perylene ug/l			Indeno(1,2,3-cd)pyrene ug/l		
	No. samples	**No. samples > detection limit**	**Max conc.**	**No. samples**	**No. samples > detection limit**	**Max conc.**
2004	12	5	0.036	12	1	0.022
2005	12	6	0.0206	12	1	0.0234
2006	17	1	0.0128	17	0	0
2007	12	1	0.029	12	1	0.0357
2008	12	0	0	12	0	0
2009	13	0	0	13	0	0
2010	13	0	0	13	0	0
2011	12	0	0	12	1	0.0107
2012	13	0	0	13	0	0
2013	14	0	0	14	0	0
2014	2	0	0	2	0	0

Fish

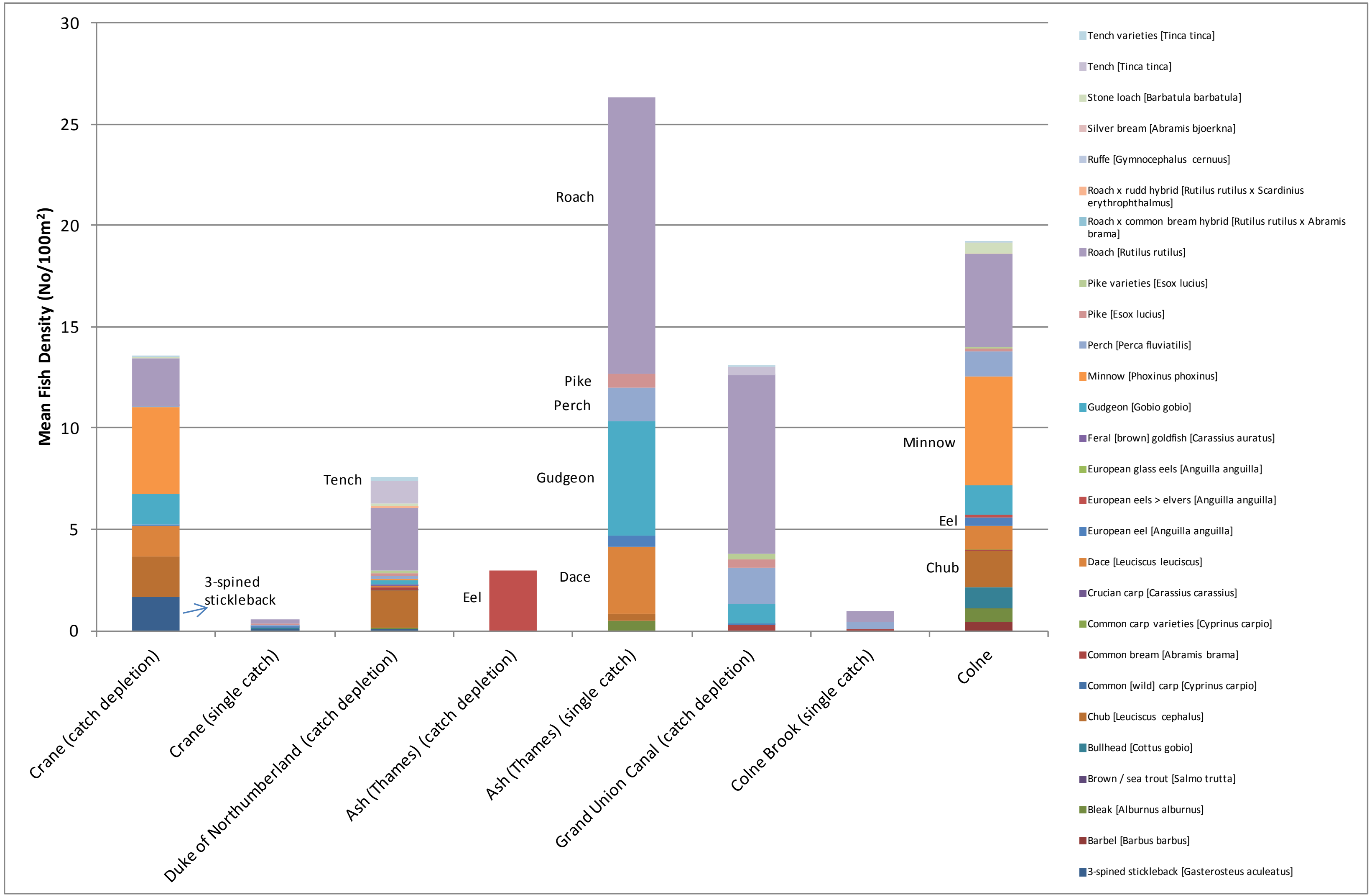
The EA supplied data for fish surveys carried out in the watercourses surrounding the airport at 23 separate sites. In total they have supplied data for 78 surveys predominantly between 2000 and 2014 (and also 1986). The survey details are summarised in **Table A4**. The survey method employed at each site was either a single electrofishing catch survey or standard depletion electrofishing catch surveys.

Table A4 Summary of EA Fish Surveys

Reach	Site	NGR	No of Catch Depletion Surveys	No of Single Catch Surveys
Crane				
	Cranford Park	TQ1030077800	4	2
	Hounslow Heath	TQ1180973907	3	3
Duke of Northumberland's				
	Hatton Road	TQ0838074240	3	
	Moor Lane	TQ0540677713	3	
Ash (Thames)				
	Ford Bridge Roundabout	TQ0614571030		1
	Woodthorpe Road	TQ0563871330	1	
Grand Union Canal				
	Slough Arm at B470 Road	TQ0210079900	1	
	Slough Arm at Iver North STW	TQ0440080600	1	
Colne Brook				
	Horton U/S Backloop	TQ0182575159		1
Colne				
	Moor Roundabout	TQ0500077600	2	
	Staines	TQ0350072100	1	
	Moor roundabout 2	TQ0510077800	1	
	Staines Moor	TQ0280073000	1	
	Poyle Channel	TQ0280076500	1	
	Cricketfield Lane	TQ0530078900	1	
	Horton Middle Site	TQ0183275145	1	
	Horton D/S Site	TQ0166174521	1	
	Horton U/S Site	TQ0197275462	1	
	Stanwell Road	TQ0020905757*	1	
	Thorney Golf Course	TQ0471380014	11	
	Hythe End	TQ0175072770	10	
	Stanwell Moor	TQ0379574607	12	
	Harmondsworth Moor	TQ0495277992	11	

Notes: * Environment Agency provided NGR is suspected to be incorrect.

Figure A.1 Mean Fish Density by Species within each River



The species recorded in these surveys are shown in **Table A5** along with a brief summary of their habitat preferences.

Detailed data was provided such as numbers and weight of species caught. Quantitative fish densities were calculated using standard good practice[15]. The method assumes that the catch per unit of effort is proportional to the population number. A series of samples taken with the same effort from a closed population should therefore show a decline in number per sample. These data are summarised on **Figure A1** which shows the mean fish density of each species for each study reach (split also by single catch and catch depletion survey type). **Figure A1** provides an indication of the relative population structures i.e. relative prevalence of different fish species. Fish biomass data has not been plotted since this type of data can be skewed by the presence of just one large fish.

Flow is a key factor influencing the composition of fish communities, interacting with other factors such as distance from source, temperature, gradient, substrate type and oxygen content. The combination of these factors leads to zonation of fish communities, determined primarily by gradient and flow velocity. This zonation ranges from salmonid fisheries associated with faster flows and steeper gradients in upper catchments (sometimes referred to as the 'trout zone'), overlapping fish assemblages in the middle reaches characterised by increasing numbers of rheophillic coarse fish, such as chub (*Leuciscus cephlus*) and dace (*Leuciscus leuciscus*), to lowland cyprinid fisheries, characterised by increasing numbers of fish suited to slow flow velocities and homogenous habitats such as bream (*Abramis brama*). Cyprinids generally tend to be more tolerant of lower flow velocities and oxygen concentrations than salmonids and are typically associated with lowland watercourses with slow to moderate flow velocities.

The fish communities in the watercourse reaches around the airport are diverse and dominated by Cyprinids (including roach, gudgeon, dace and minnow), perch, chub, 3-spined stickleback, pike and eel. The species present are typical of middle and lower river reaches and have a variety of flow requirements which also depends on their life stage. Most typically the fish species present (e.g. roach) prefer slower flowing water (relatively lower densities of rheophilic Cyprinids such as dace and chub) and a good vegetative community.

The only UK BAP priority species present (identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UK BAP)), were the Brown/ Sea trout and the European eel. Brown/ Sea trout were only found on the River Colne and only 2 individual fish out of a total of 12,799 fish from the River Colne were found to be Brown/ Sea trout; thus the population is considered to be very small and potentially not self-sustaining within these lower reaches, but rather associated with passive downstream drift (of fry or smolts). It is likely that local populations of Brown trout are a characteristic of the rivers further upstream. The EA's State of the Environment in London report[16] states that Brown Trout are relatively scarce but present and spawning at discreet locations in the River Colne, although locations are not stated. Barbel, a popular species fished for by anglers, was found on the River Colne.

Good numbers (see several category types on **Figure A1** e.g. glass eels, European eel etc) of European eel were surveyed in these reaches.

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[15] Carle, F. L. and Strub. M. R. (1978). A New Method for Estimating Population Size from Removal Data. Biometrics 34. 621-630
[16] Environment Agency (2011) London's Environment Revealed -State of the Environment Report for London.

Table A5 Species Recorded during EA Surveys

Species Name	General Habitat Preferences
3-spined stickleback *Gasterosteus aculeatus*	Generally slow flowing or still, shallow water (juveniles found in shallow reaches or near banks with moderate flow, adults found in depths greater than 20cm with slow flows). Spring migration (within rivers or anadromous) to breeding areas prompted by water temperature and day length. Spawn in a constructed nest (usually among weeds) in late spring/early summer. Spawn in silt/sand sediment. Tolerant of habitat degradation and poor water quality.
Barbel *Barbus barbus*	Middle reaches; Fry occupy shallow slow-flowing margins before moving to faster flowing reaches with clean gravel substrate (high oxygenation) and weed growth. Spawn on shallow gravel riffles during June/July when water temperatures reach 18°C. Will remain in suitable home range, occupying small groups, but capable of migrating long distances and passing low weirs and fish passes designed for salmonids.
Bleak *Alburnus alburnus*	Middle and lower reaches (still and moving waters) of moderate to high productivity rivers with silt/sand/gravel substratum. Shoaling. Spawning on gravel, stones and aquatic macrophytes in spring /early summer when temperature reaches 15°C.
Brown / sea trout *Salmo trutta*	Clean, well-oxygenated flowing waters with cobble and gravel substrates in upper reaches and with cover provided by deeper pools, undercut banks and vegetation. Spawning in redds excavated in gravel/pebble substrate during October to December in flowing water. Migrates to spawning grounds in autumn and requires unimpeded migration. Difficult to distinguish between brown and sea trout juveniles, thus usually treated as the same within assessments.
Bullhead *Cottus gobio*	Stony streams and rivers and some lakes. Seek refuge under cobbles, boulders and woody debris and juveniles usually found in stony riffles. Spawn in a nest excavated under cobbles/boulders in March to April.
Chub *Leuciscus cephalus*	Middle and lower river reaches, sand/gravel/cobble substratum, strongly associated with tree and macrophyte cover, large woody debris, rocks, moderate to high productivity. Young occupy slower flowing pools in shoals, adults occupy deeper water and often solitary.
Common carp varieties *Cyprinus carpio*	Often occupying small shoals, inhabit lowland, slow flowing rivers with abundant vegetation. Tolerant of a range of conditions e.g. larger backwaters, productive rivers, occasionally brackish conditions. Spawning on macrophytes/roots and firm substrates in river margins in May/June when water temperatures reach 18°C.
Common bream *Abramis brama*	Nutrient-rich slow flowing rivers/lowland reaches with silt/mud substrate and relatively homogenous habitats. Shoaling and can undergo long migrations. Spawning in shallow water on dense vegetation in May/June when temperature between 12°C to 20°C.
Crucian carp *Carassius carassius*	Slow-moving lowland waters with numerous pools and secondary branches. Can tolerate low oxygen and associated with turbid or marshy waters. Spawns in overgrown shallows, on weeds, in May and June.
Dace *Leuciscus leuciscus*	Clean middle and lower reaches and small lowland tributaries, sand/gravel/cobble substratum, moderate to high productivity. Juveniles shoal and larger adults often solitary. Spawn communally in gravelly well-oxygenated shallows of rivers and streams, between February and early May when water temperatures are 8°C to 14°C.
European Eel *Anguilla anguilla*	Avoids swiftly flowing waters, but otherwise occurs everywhere. Nocturnal, spending day in benthic mud. Undertake migration through freshwaters as part of a complex life cycle.
Gudgeon *Gobio gobio*	Generally middle and lower reaches, slow to moderate flow, silt/sand/gravel substrata, moderate to high productivity rivers. Shoaling. Spawning on gravel and macrophytes in shallow water in May and June.
Minnow *Phoxinus phoxinus*	Occupying large shoals in upper to middle reaches of clean well-oxygenated water with gravel substrate. Spawn in late spring on gravel/pebble when water temperatures reach14°C to 16°C. Tolerate a degree of organic pollution.
Perch *Perca fluviatilis*	Lowland reaches; slow-flowing, occasionally moderate flow. Shallow water with emergent and submerged vegetation. Moderately productive waterbodies. Shoaling. Spawn on vegetation in shallower water in early spring when water temperatures reach 10°C.

Table A5 (continued) Species Recorded during EA Surveys

Species Name	General Habitat Preferences
Pike *Esox lucius*	Middle and lower reaches; slow-flowing to moderately-flowing, range of habitats. Often associated with emergent vegetation e.g. juveniles with weed beds in shallow sheltered areas and larger pike often associated with more turbid waters. Spawn on emergent/ submerged macrophytes in shallower water.
Pike varieties *Esox spp.*	
Roach *Rutilus rutilus* Roach x common bream hybrid *Abramis buggenhagii*	Range of habitats (bankside vegetation or open water), mainly lowland, low velocity, shallow to moderate depth rivers, tolerant of poor water quality. Daily and seasonal migrations. Spawn on macrophytes when water temperatures reach 14°C. Juveniles shoal, preferring weed cover and low velocity. Larger fish occupy smaller shoals in deeper less turbulent river reaches. Roach x common bream hybrid: Similar habitat to roach /bream in middle to lower reaches of rivers.
Stone loach *Noemacheilus barbatulus*	Streams and rivers (and some lakes) with cobble/gravel/sand/silt substrate in moderate flows often in lower trout zone and high organic enrichment. Often seeking refuge beneath cobbles/boulders. Spawn on gravel and aquatic vegetation in spring/summer. Absorption of oxygen through the gut (gulping) may assist tolerance of low oxygen.

Source: Various, Habitat/Flow Requirements predominantly from Cowx et al[17].

Changes in flow within individual channels (arising for example from potential flow diversions) could influence the fish assemblage at a given location. The influence of flow on different species is partly determined by their breeding systems. Lithophils lay eggs on gravel; phytolithphils on submerged plants, or bed substrates in the absence of plants; phytophils on submerged macrophytes; and psammophils on sand or fine roots. Flow velocity and depth play an important role in determining the condition/ suitability and distribution/ availability of spawning substrates for different species. The majority of fish species identified within EA surveys prefer slow to moderate flow velocities. Depth preferences are more variable, and vary between age classes of the same species and between species.

There are no records of Atlantic salmon (*Salmo salar*) or of any Lamprey species, which are each migratory species of conservation interest, within the local watercourses. In addition to salmonids, many cyprinid species rely to a greater or lesser extent on migrations to spawning areas. Within river accessibility for fish is thus an important consideration for development that may affect the river corridor.

Flow and Habitat Requirements

Design targets for flow and habitat in the watercourses that may be affected by the development will consider the requirements of a mixture of cyprinids. **Table A6** provides further details beyond those already provided in **Table A5.** The differing habitat and flow requirements of different Cyprinid species emphasises the importance of habitat variability in rivers that support diverse, productive cyprinid fisheries. Flow control and variability may be achieved by introduction (via soft engineering) of riffles and runs with gravel substrates that are within the optimum range for spawning of for example dace, chub and minnow throughout the period March to July. Meeting

[17] Cowx I.G., Noble R.A., Nunn A.D., Harvey J.P., Welcomme R.L. and Halls A.S. (2004) Flow and Level Criteria for Coarse Fish and Conservation Species. Science Report SC020112/SR, Environment Agency, Bristol. 173pp.

optimum flow targets for these species at these key riffle/ run locations and throughout the spawning period may optimise the value of these features in sustaining spawning fish.

The EA defines eight distinct types of fish community associated with undisturbed sites, including three main cyprinid communities[18]. Type 6 communities are typical of smaller cyprinid rivers and are characterised by roach, gudgeon, chub and bream, with dace and perch listed as further complementary species. The Heathrow fish survey data is most consistent with a Type 6 community. EA models have identified mean flows within Type 6 Cyprinid communities of 1.632 $m^3 s^{-1}$ and an average depth of 0.63m and a wetted width of 6.92m. However these details in isolation do not dictate fish community composition and it is more likely that the magnitude and nature of temporal flow variation are the key elements of the hydrograph that influence fish community structure[18]. An example of the hydrograph of a river supporting a Type 6 fish community had very limited flow variation, with periods when flow exceeded 10 $m^3 s^{-1}$ being confined to a handful of specific events in the winter months (November to March)[18].

For the first RBMP cycle, the supporting fish status classification was determined via application of the Fisheries Classification Scheme 2 (FCS2)[19]. The FCS2 indicators comprise the 23 most prevalent fish species in England and Wales. For modelling purposes, these species are classified as being of low, moderate and high tolerance to environmental disturbance. The only fish species of 'Low tolerance' to environmental disturbance captured within the EA's historical surveys at Heathrow was Brown/ Sea trout and numbers of this species were very low (River Colne only; 2 fish out of the 12,799 River Colne total). Six of the ten species indicative of medium tolerance to environmental disturbance were evident within the Environmental Agency data. Seven of the eight fish species indicative of high tolerance to environmental disturbance were found within the EA's historical surveys, including Roach, which was the most abundant species across all EA monitoring sites. All of the rivers of interest around the airport are designated and managed as 'Freshwater Fish Directive'[20] Cyprinid waters. The Freshwater Fish Directive was repealed in 2013 and the WFD (via the system of river basin management) supersedes and offers the same level of protection to freshwater fisheries as previous.

A wide range of pressures are considered to be able to influence the status of the WFD fish community of an individual waterbody but the primary pressures as presented by the EA[21] (Environment Agency 2011) are abstraction of water and morphological alterations. Fish obviously respond to all existing pressures in combination, including for example water quality and can be thought of as indicators of general disturbance.

The WFD assessments of fish populations and flow taken together with the raw EA survey data indicate a cyprinid fishery that is modest in abundance, capable of medium or high tolerance to environmental disturbance and relatively low in density of rheophilic coarse fish. Given the habitat characteristics, the fish population dynamics are potentially attributable, at least in part, to extensive river modification or flow perturbation, or a combination of the two. Improvement in diversity of flow types achieved by a combination of river restoration and changes in flow could be expected to enhance fish populations within the channels that surround the airport.

[18] Environment Agency (2004) Flow and level criteria for coarse fish and conservation species. Science Report SC020112/SR.
[19] WFD UKTAG (2008) UKTAG Rivers Assessment Methods Fish Fauna (Fisheries Classification Scheme 2 (FCS2)) Water Framework Directive - United Kingdom Technical Advisory Group (WFD-UKTAG).
[20] Freshwater Fish Directive 2006/44/EC
[21] Environment Agency (2011) Method statement for the classification of surface water bodies. Monitoring Strategy; April 2011.

Table A6 Habitat Requirements of selected Cyprinids (EA, 2004)

Species	Behaviour	Habitat	Swim* (cm.s^{-1})	Spawning		Depth / Flow Preference		
				Timing (Opt. temp)	*Substrate*	*Life stage*	*Depth (cm)*	*Flow velocity cm.s^{-1}*
Bream	Home range, shoaling	Lowland, slow flow, deep. Mud/silt	87/96 (120/280mm fish at 18ºC)	April-June (12 – 20ºC))	Macrophyte (Glyceria, Sagittaria, Nuphar)	Larvae: Juvenile: Spawning:	20 - <150 <100 - 125 25 – 50	<5 <5 <20
Chub	Juvenile shoal, solitary adults, migrate to spawn	Middle/lower reaches. Slow-moderate flow. Assoc. with tree/macrophyte, woody debris/rocks Sand/gravel/cobble	82-106 (48-87mm fish at 16-18ºC)	May-June (14 – 20ºC)	Gravel (occasionally hydrophytes)	Larvae: Juvenile: Spawning:	20 - <100 <20 - <100 >0 - 128	<5 <5 <5 – 75
Dace	Home range migrate to spawn	Middle and lower reaches. Moderate flow. Sand/ gravel/cobble	46-90 (100-214mm fish at 14ºC)	March-July (6 - 9ºC)	Gravel/ Hydrophytes/ root wad	Larvae: Juvenile: Adult: Spawning:	2 – 50 <50 17 – 113 25 – 40	<2.5 still to elevated 0 – 57 20 to 50
Gudgeon	Shoaling	Middle and lower reaches, slow to moderate flow. Silt/sand/ gravel	45/55 (118mm fish at 4/18ºC)		Gravel (hydrophytes occasional)	Larvae: Juvenile: Adult: Spawning:	Shallow <20 - <100 5 - 8	<20 0 – 40 <55 2 – 80
Minnow	Shoaling	Moderate flow. Sand/gravel/cobble subs.		May–July	fine gravel (no hydrophytes)	Larvae: Juvenile: Adult: Spawning:	<15 - >40.5 <34 - >53.4 10 - >50 10 - 25	<1.9 - >3.46 <3.85 - >12.8 0 – >35.9 20 - 30

Table A6 (continued) Habitat Requirements of selected Cyprinids (EA, 2004)

Species	Behaviour	Habitat	Swim* (cm.s^{-1})	Spawning		Depth / Flow Preference		
				Timing (Opt. temp)	*Substrate*	*Life stage*	*Depth (cm)*	*Flow velocity cm.s^{-1}*
Perch	Juvenile shoal. Adults more solitary. Migrate to spawn. Active dawn and dusk, inactive at night.	Lowland reaches, slow (occ. Moderate) flow. Shallow, sand/gravel. and emerge/submerge vegetation.	121/126 (100/220mm fish at 18ºC)	April-June	Macrophyte	Larvae: Juvenile: Spawning:	<150 - ~300 200 - 300	 Still or slow
Pike	Non-territorial but solitary. Peak activity at dusk/dawn	Middle and lower reaches, slow to moderate flow. Mud/sand	297 (425mm fish at 18ºC)	March-May	Macrophyte	Larvae: Juvenile: Spawning:	<150 - ~175 50 - 500	 Still <5
Roach	Home range, migrate to spawn	Lowland reaches, slow flow, bankside vegetation or open water. Sand/gravel	45 – 100 (91-110mm fish at 16-18ºC)	April-June (14 - 18ºC)	Macrophyte, Fontinalis, Elodea, Scirpus, salix roots	Larvae: Juvenile: Spawning:	20 – 150 (<100) 20 - ~175 (~50-175) 15 - 45	<5 (lentic) 0–40 (lentic) ->20

Table notes: * Examples of critical swimming speeds (EA, 2004). This varies considerably with size and temperature only examples are provided.

Habitats

A summary of the RHS survey data provided by the EA and the derived indices are presented in **Table A7.**

Table A7 Summary of Environment Agency River Habitat Survey (RHS) Data and Metrics for those Watercourses around the Airport

River	RHS Site ID	NGR of Site	HMS Score	HMS Class	HQA
Colne	25169	TQ0188172379	3270	5	48
Colne	25170	TQ0395974922	1785	5	46
Colne	1179	TQ0420075300	3610*	5*	23*
Colne	5251	TQ0320073100	740*	4*	34*
Colne	6338	TQ0320073400	150*	2*	50*
Colne Brook	6201	TQ0480079400	0*	1*	43*
Counts Ditch	25168	TQ0263471975	2564	5	38
Crane	21731	TQ1092075244	735	4	47
Crane	25401	TQ1249973023	1280	4	47
Duke of Northumberland's River	3597	TQ0760074100	3246*	5*	5*
Thames	18258	SU9958575806	570	4	44
Thames	19646	TQ0346271412	3030	5	19
Thames	20571	TQ0080172589	750	4	22
Trib of Thames	3569	TQ0590081100	535*	4*	40*
Un-named channel	20877	TQ0284979009	1345	4	41
Wraysbury River	25175	TQ0272473282	1160	4	39

* RHS survey forms changed in 2003. Those marked with asterisk denote pre-2003 data.

Habitat Modification Score (HMS) is an indication of artificial modification to river channel morphology. To calculate the HMS for a site, points are allocated for the presence and extent of artificial features such as banks and bed re-sectioning, banks and bed reinforcements, embankments, culverts, weirs, dams and sluices and outfalls and deflectors. Greater and more severe modifications result in a higher score. The cumulative points total provides the HMS. A Habitat Modification Class (HMC) protocol has been developed which allocates the condition of the channel in a site to one of five modification classes, based on the total score (1 = near-natural; 5 = severely modified).

All HMS class data in **Table A7** on watercourses around the airport, with the exception of two reaches, found the HMS class to be either significantly modified (Class 4) or severely modified (Class 5). The only data for the Colne Brook found a single reach to have a HMS Class of 1, or Pristine/ Semi-natural. One of the five Colne survey reaches resulted in a HMS description of predominantly unmodified (Class 2), although this survey reach was notably located in very close proximity to a separate survey on the same watercourse which returned a significantly modified (Class 4) result. All the data collected post 2003 (when RHS survey forms were changed) found the watercourses to be either significantly modified or severely modified.

The Habitat Quality Assessment (HQA) is a broad indication of overall habitat diversity provided by natural features in the channel and river corridor. Points are scored for the presence of features such as point, side and mid-channel bars, eroding cliffs, large woody debris, waterfalls, backwaters and floodplain wetlands. Additional points reflect the variety of channel substrata, flow-types, in-channel vegetation, and also the distribution of bank-side trees and the extent of near natural land-use adjacent to the river. Points are added together to provide the HQA score. In contrast to HMS, higher HQA scores represent more diverse sites. The character and pattern of features in a site is influenced by natural variation and also the extent of human intervention both in the channel and adjacent land. HQA scores for UK rivers tend to vary from 10 to 80. It is important to ensure comparison of HQA scores is across rivers of similar types and it is not possible to assign a simple classification based on HQA score. The HQA scores for the watercourses around the airport would tend to be around average or below average compared to other lowland, highly modified watercourses. The low score for the Duke of Northumberland's river is evidence of extremely low natural habitat diversity within this watercourse.

Appendix B
Groundwater Risk Assessment

This Appendix summarises the groundwater risk assessment and presents a conceptual model of the groundwater environment. Potential risks associated with the construction and operation of the north-west runway masterplan are identified using the "source-pathway-receptor" concept. Mitigation measures against contamination impacts as a result of construction and upon site completion and operation are also detailed.

Baseline Geology and Hydrogeology

Geology

Heathrow Airport and the surrounding area is underlain by shallow deposits known as the Taplow Gravels. These gravels are of Quaternary age, and form part of a wide expanse of terraced river sands and gravels across the Thames floodplain. They represent successive levels of the river and were formed under the variable climatic conditions of the last half a million years. The gravels overlie the Tertiary London Clay, which in turn overlies the regionally important Chalk aquifer. Consisting predominantly of sand and gravel, but with local with lenses of silt, clay or peat, the Taplow Gravels are generally permeable and range from 3 to 6 m thick (the thickness varying across the site both to natural variation and to past gravel extraction). The groundwater levels in the gravels are usually shallow and within 2 m of the ground surface[8]. The London Clay is more than 50 m thick and prevents direct groundwater interaction between the gravel and chalk aquifers.

Alluvium

Loose, unconsolidated alluvium is present immediately west of the airport in the Colne Valley (**Figure B1**). Typically the deposits are 1 to 2 m thick[8], comprising silts and clays deposited previously along the course of the River Colne, Colne Brook and Wraysbury River.

Gravels

Heathrow airport and surrounding area is underlain by superficial deposits of glacial Terrace Gravels. The Taplow Gravels underlie Heathrow, west of Heathrow the deposits are classified as the Shepperton Gravels and south of Heathrow is the Kempton Gravels (**Figure B1**). The hydro-geological differences between the classifications are minimal with the main components for each member being poorly sorted sand and gravel, but also containing silt and clay. The thickness of the gravels varies across the site due to past gravel extraction, but Terrace Gravel deposits may be up to 6 m thick.

London Clay

The underlying London Clay is of Tertiary Age and dips southwards, as part of the northern limb of the symmetrical syncline in Cretaceous and Tertiary Deposits known as the London Basin. The London Clay is a firm to very stiff grey clay, with occasional shell and fossil fragments, silt and claystone[22]. Of particular relevance to this study is low permeability of the clay material, which prevents groundwater interaction between the overlying gravel aquifer and the underlying Chalk.

[22] BGS lexicon (http://www.bgs.ac.uk/lexicon/)

Lower London Tertiaries

The Lower London Tertiaries include the Bleakheath Beds (gravels), Reading & Woolwich Beds (clay and sands), and the Thanet Sands (BGS lexicon Website). The combined thickness of the London Clay and the Lower London Tertiaries may be over 50 m, with typically less than 1m of the London Clay surface weathered to stiff brown clay (Terrace Clay).

Chalk (Cretaceous)

The Chalk is a major aquifer composed of chalk with flints. A BGS borehole drilled in Langley, north-west of Heathrow, found the Chalk to be 185 m thick, overlying 102 m of Gault Clay and 16 m of Lower Greensand[23].

Groundwater

Groundwater Levels & Flow Direction

The groundwater levels in the Gravels are variable across the site, but are usually shallow and within the top 2 m of the ground surface. **Figure B2** displays the regional groundwater direction from contours produced by Clark & Sims (1998). Of note is the shallow hydraulic gradient across Heathrow with groundwater flowing in general north-east to south-west direction

Locally, groundwater levels and flow direction may differ from the general pattern. For example, an impermeable 'clay curtain' surrounding the former Perry Oaks site (now Terminal 5) hydrogeologically isolates much of the gravels from the rest of the shallow aquifer (**Figure B3**), resulting in a diversion of groundwater flow around the former sewage works site. Subsequent construction activities of Terminal 5 may also have influenced the current groundwater flow direction.

Timeseries groundwater level data for sites in the surrounding area of the north-west runway masterplan, received by the EA, show that the seasonal fluctuation in the gravel deposits are variable. North of Heathrow, at Stockley Park (TQ0754080393), groundwater elevations have seasonal variations of approximately 5 m. Groundwater levels at Coppins, (TQ0354082000) north-west of Heathrow, have seasonal variations of less than 2 m.

Groundwater Quality

Previous investigations[24,25] have highlighted areas of groundwater and land surface contamination within Heathrow airport. The reviews of documentation and data received have not highlighted potential zones or events of contamination within the north-west runway masterplan. Further investigation will be required to confirm the land and groundwater quality, however using knowledge of past land-uses, potential contaminants can be defined. Further details of the potential sources of contamination are described in the following section.

[23] Dames and Moore, 1994 Phase I Report.pdf.
[24] SKM Enviros (2010)
[25] Mott MacDonald (2001)

Conceptual Site Model

The risk to groundwater quality, associated with the construction and operation of the north-west runway masterplan, is identified in the following sections using the source-pathway-receptor approach, as described in the EA's 'Groundwater protection: Principles and practice (GP3)' guidance document[26].

Sources

The Colne Valley is known to contain large areas of potential sources of contamination due to the historic land-fills after gravel extraction. There are also known pollution incidents to land and groundwater which have the potential to pose ongoing sources of contamination.

The north-west runway masterplan extends further west and north of the current Heathrow airport boundary where previous reports and investigations have focussed their analysis; for example during the construction of Terminal 5 many of the site investigations focussed on the former Perry Oaks site. These reports have been analysed due to similarity of land-use and the possibility of migration of pollution off-site.

Landfill

Current potential sources of contamination will be a result of previous land use. From data received by the EA, it is known that large areas along the Colne Valley have been quarried for gravel extraction and have been infilled with waste to form landfills (**Figure B4**). Many of these landfills have since closed; however, they are historically important as potential sources of contamination. During the construction of Terminal 5, it is likely that ground remediation will have taken place close to the terminal building. Therefore, it is likely that the risk of contamination from landfill is greatest in the areas of the north-west runway masterplan which are not included in the current Heathrow airport boundary.

Pollution Incidents

Water

There are seven reported 'significant' to water pollution events (category 2) in the borough of Hillingdon (**Table B1**) and 195 'minor' (category 3) water pollution events. Many of the 'minor' pollution events are a result of failure in containment of sewage or unauthorised disposal (of waste/ oils etc). There is one 'significant' pollution event which is in the catchment of rivers which flow along the western boundary of Heathrow; the event at Hithermoor Road, Staines where there was a containment failure of inert materials and waste (**Figure B4**).

[26] Environment Agency (2013) Groundwater protection: Principles and practice (GP3)

Table B.1 Category 2 (Significant) Water Pollution Events

ID No.	Date	Location	Air Event Rating	Land Event Rating	Water Event Rating	Cause	Pollutant
1141242	30/07/2013	Heathrow Airport	Category 4 (No Impact)	Category 4 (No Impact)	Category 2 (Significant)	Extreme Weather Conditions	Not Identified
745545	15/01/2010	Cherry Lane Cemetery	Category 4 (No Impact)	Category 4 (No Impact)	Category 2 (Significant)	Extreme Weather Conditions	Not Identified
180821	11/08/2003	Cranford, Hounslow	Category 4 (No Impact)	Category 4 (No Impact)	Category 2 (Significant)	Fire	Alcohols/ Aldehyde
134381	31/01/2003	Waye Avenue, Cranford,Houn slow	Category 3 (Minor)	Category 3 (Minor)	Category 2 (Significant)	Not Identified	Oils and/or Fuel
126437	17/12/2002	Hithermoor Road, Stanwell Moor, Staines	Category 4 (No Impact)	Category 4 (No Impact)	Category 2 (Significant)	Other Inadequate Control or Containment	Inert Soils and Clay
37091	16/10/2001	Dawes Road, Uxbridge	Category 4 (No Impact)	Category 3 (Minor)	Category 2 (Significant)	Sewer failure or overflow	Crude Sewage
14720	08/07/2001	Willow Tree Marina, Hayes	Category 4 (No Impact)	Category 4 (No Impact)	Category 2 (Significant)	Drainage Failure	Landfill Leachate

Land

There are nine significant (category 2) and one major (category 1) land pollution events in the Hillingdon Borough (**Table B2**). The events in Harmondsworth are the most relevant due to their proximity of the proposed site, although the exact locations of these events are not known (**Figure B4**). These events occurred during 2006 and are therefore likely to be near the ground surface, and potentially re-mobilised during run-off events or through recharge. The details of the pollutants are varied but include organic waste and potentially toxic chemicals; further investigation will be required to identify the contaminants.

There are 153 reports of minor (category 3) land pollution events, including unauthorised disposal, fires and containment failure.

Table B.2 Category 2 (Significant) Land Pollution Events

ID No.	Date	Location	Air Event Rating	Land Event Rating	Water Event Rating	Cause	Pollutant
163848	06/06/2003	Delamere Road, Hayes	Category 4 (No Impact)	Category 1 (Major)	Category 4 (No Impact)	Unauthorised Waste Management Activity	Inert Materials and Waste
510437	29/06/2007	Cowley Peachy	Category 4 (No Impact)	Category 2 (Significant)	Category 4 (No Impact)	Unauthorised Waste Management Activity	Not Identified
457314	18/12/2006	Harmondsworth	Category 3 (Minor)	Category 2 (Significant)	Category 3 (Minor)	Unauthorised Discharge or Disposal	Commercial Waste
457314	18/12/2006	Harmondsworth	Category 3 (Minor)	Category 2 (Significant)	Category 3 (Minor)	Unauthorised Discharge or Disposal	Contaminated Construction & Demolition Material Waste
457314	18/12/2006	Harmondsworth	Category 3 (Minor)	Category 2 (Significant)	Category 3 (Minor)	Unauthorised Discharge or Disposal	Asbestos
457314	18/12/2006	Harmondsworth	Category 3 (Minor)	Category 2 (Significant)	Category 3 (Minor)	Unauthorised Discharge or Disposal	Vegetable Cuttings and deposits
456226	12/12/2006	Harmondsworth	Category 4 (No Impact)	Category 2 (Significant)	Category 3 (Minor)	Sewer Failure or Overflow	Sludge
69338	06/04/2002	St Stephens Road, Yiewsley, West Drayton	Category 3 (Minor)	Category 2 (Significant)	Category 4 (No Impact)	Fire	Firefighting run-off
69338	06/04/2002	St Stephens Road, Yiewsley, West Drayton	Category 3 (Minor)	Category 2 (Significant)	Category 4 (No Impact)	Fire	Atmospheric Pollutants and Effects
47701	11/12/2001	Ashdown Road, Hillingdon, Uxbridge	Category 4 (No Impact)	Category 2 (Significant)	Category 4 (No Impact)	Fly - Tipping	Household Waste

Contaminants in Area of Terminal 5

The area in which Terminal 5 is located was known to be heavily contaminated as a result of previous land-use and activities. The terminal is situated on the former Perry Oaks site, which historically contained a Sewage Works, Fuel Farm and a fire fighting training area. In this area the soil and groundwater (in the made ground and gravels) was found to contain:

- Heavy metals e.g. Arsenic, Chromium, Nickel, Cadmium, Mercury, Zinc, Lead;
- Ammonia;
- PAHs (Polyaromatic hydrocarbons e.g. Naphthalene);

- BTEX (Benzene, Toluene, Ethylbenzene, Xylenes) compounds;
- TPH (Total Petroleum Hydrocarbons);
- VOC (volatile organic carbon);
- Low oxygen levels; and
- High total organic carbon (TOC) levels.

Many of these contaminants are likely to be a result of fuel spillages and the former sludge treatment works. During the construction of Terminal 5 the contamination located in the area would have been remediated. However, it is possible that these contaminants may have migrated, or similar spillages occurred, and so contamination may also be found in the area of the north-west runway masterplan (west and northwest of Terminal 5). Although the regional groundwater levels flow is towards the south-west, there are local differences where groundwater flows west and north-west in the former area of Perry Oaks, and north of the 'clay curtain' (**Figure B3**). There is uncertainty in the groundwater flow directions as construction activities have occurred since the contours were produced; further investigation will be required to confirm the current groundwater flow directions.

Construction Activities

This section briefly summarises the potential sources of contamination which may arise during site construction.

Temporary Fuel Storage

Fuel will be required for various site activities during construction. The storage of fuel on site, as well as re-fueling or transportation of fuel is a potential source of contamination. Spills may occur which may result in contamination of the land surface, aquifers and water courses.

Discharging Water

Temporary dewatering of the shallow gravel aquifer may be necessary to enable construction. The water may be contaminated, e.g. with hydrocarbons or dissolved metals, or may contain particulate matter ('cloudy' water), making the water unsuitable for immediate discharge into water courses. Untreated water may reach surface water sewers, nearby watercourses or may form runoff and recharge into the underlying aquifer.

Pathways

Groundwater flow is the main pathway for contamination, migrating around and off the site. Locally, the direction of flow may change as a result of temporary or permanent construction activities such as dewatering or impermeable basement foundations.

Recharge

Any contamination on the surface may be mobilised through recharge of surface-runoff or rainfall, into the groundwater system, unless suitable the water is collected and treated.

Groundwater

The flow of groundwater will be the main pathway for the contamination. Pollutants on the surface may also recharge through the sub-surface, where recharge is the pathway. Contamination in the sub-surface may be mobilised as a result of changes in groundwater flow direction. Groundwater levels in the gravels under Heathrow airport are near the surface and have a very shallow gradient across the site. Therefore, any changes in the groundwater elevations could impact across a large area.

Boreholes

Boreholes can act as pathways as they provide a direct route from the land surface to the aquifer. There are two abstractions from the Chalk for commercial, industrial and public services at the Compass Centre (Heathrow). The boreholes are located close to the site of construction for Terminal 6. Any spillages near these boreholes may pose a direct and serious contamination risk to thus Principal Bedrock aquifer (as defined by the EA).

The reverse may also occur; boreholes may abstract contaminated groundwater which will be a hazard if it is not treated before re-use or disposal. It is unlikely to occur with abstractions from the Chalk aquifer, however dewatering activities from the gravel aquifer may abstract polluted groundwater.

The construction of new boreholes, either for monitoring or dewatering, has the potential to introduce contaminants into un-polluted layers or groundwater.

Receptors

As the main pathway is the groundwater, any feature in hydraulic connection may be regarded as a receptor to contamination. The aquifers, both the near surface gravels and the confined Chalk, are also key receptors. **Figure B5** displays receptors, such as water courses and abstractions.

Rivers & other Surface Water Features

There are six rivers which may be potential receptors:

- Wraysbury River;
- River Colne;
- Longford River;
- Duke of Northumberland's River;

- Colne Brook; and
- Horton Brook.

As well as other rivers downstream of these, many of these rivers will be relocated or have short stretches of their reaches diverted as part of the masterplan.

There are three reservoirs south-west of Heathrow, however these are clay lined and above the natural groundwater level:

- Staines Reservoirs;
- King George VI Reservoir; and
- Wraysbury Reservoir.

Heathrow has settling ponds located in the south-west of the site, which are used for storage of runoff from Heathrow. These ponds have impermeable bases preventing groundwater-surface water interaction.

Many of the surface-water features have impermeable bases, and therefore are not regarded as receptors. However, further investigation would be required to confirm the integrity of the lining material.

Abstractions

From information provided by the Agency, there are five licensed groundwater abstractions from the Gravels, and one from the Chalk, within the north-west runway masterplan. The Chalk licence (TH/039/0028/007) is held by Heathrow, as are three Gravel abstractions (28/39/36/0058, TH/039/0031/001 & 28/39/31/0185). The remaining Gravel abstractions belong to private licence holders; however one appears to be located within the current Heathrow airport boundary at Mayfield Farm (28/39/31/0144). The licensed gravel abstraction at Home Farm (28/39/36/0023) is for three wells located near Harmondsworth. The location of 'Borehole B' is in the proposed site of the runway, with the other two wells located north and south of the runway. One of the Chalk boreholes at Heathrow is in the proposed location of a tunnel(s) connecting Terminal 6 with the Satellite building. If the water from this borehole is still needed, an alternative location will be identified, agree changes to the licence with the EA, and install a new borehole.

There is one abstraction south-west of the masterplan, in the location receiving groundwater flowing through the gravels beneath Heathrow, at Hithermoor Road (28/39/28/0067). The water is used for mineral washing, and there is the possibility that water may impact upon the quality and resource. There are many Gravel abstractions directly south of the masterplan near Ashford; although the potential impact of construction activities to the north and west on water quality or water resources is considered to be very low.

Humans may come into contact when working or visiting the site during construction. There is also the potential of a long-term risk to human health during operation of Heathrow airport, within the airport boundary and also in the downstream areas of the airport.

Groundwater Quality Mitigation Strategy

During Construction

Mitigation against Mobilisation of Contaminants

The possible sources of contaminated material which may be found during construction are likely to be a result of the historic landfills in the Colne Valley and local pollution events. Excavated material will not be left exposed at the ground surface or stored on a permeable surface, to prevent surface-runoff or direct recharge and potential migration into the aquifer or surface-water features. The excavated material from different waste horizons, geological formations, or of distinctly different quality, should be separated to prevent the potential for cross-contamination. Material will be sampled and treated (if possible), ensuring any material used as back-fill will not be contaminated. Any materials which cannot be treated will be safely disposed of off-site in line with UK legislation and Duty of Care requirements.

This method of containment, treatment and disposal, will prevent mobilisation and deterioration of the gravel aquifer.

Mitigation against Aquifer Deterioration

Shallow Gravel Aquifer

The gravel aquifer is of poor quality and action will be taken to prevent further deterioration. Any excavated material will be sampled and treated before it is re-used as infill. If treatment is not possible the material will be disposed of in line with UK legislation and Duty of Care requirements. This method prevents deterioration and locally remediates the aquifer.

Chalk Aquifer

The Chalk aquifer is confined by the London Clay. Contamination to the Chalk aquifer will therefore be a result of the construction of new boreholes or the development of preferential pathways into the chalk. Spillages near the current chalk boreholes are potentially hazardous as the borehole provides a direct pathway to the aquifer. Prevention of the contaminants entering the chalk aquifer will be to follow good practice during borehole drilling and development, and site activities near the boreholes.

Good Practice (Legislation)

During Drilling

Caution needs to be taken during drilling, especially to avoid contamination to the aquifer as a result of smearing contaminated soil or made ground. Connections between the discrete aquifer units should be avoided, using good drilling practices and sealant material (e.g. bentonite), to prevent changes to the groundwater levels and flow patterns.

Storage of Fuel

It is essential that the correct storage procedures are adhered to[27]; including bunding and impermeable ground surface to prevent migration off site and into the ground.

Emergency Response Plan

Create, check and update accordingly, an emergency response plan for possible pollution incidents and extreme weather events.

Keep emergency equipment accessible on site, such as drip mats, bentonite seals or absorbent plugs for surface water drains.

Mitigation against Contamination of Groundwater-fed Features

The surface water features which interact with the groundwater will need protection against any potential contaminants in the groundwater. The channels of the relocated rivers will either be culverted or have impermeable lining (such as clay) to prevent groundwater entering the channels, in reaches where there is a risk of contaminated groundwater. The reservoirs and Heathrow's settling ponds have impermeable bases preventing contamination from the groundwater.

Monitoring boreholes will be installed, allowing sampling and analysis of groundwater quality during construction, to identify any contamination and the direction of migration. Surface waters will be monitored before, during and after construction.

Mitigation against Dewatering Impacts

During construction it is likely that dewatering will be necessary in order to construct basement structures. To prevent the possibility of the radius of impact extending across a significant area the temporary use of -impermeable structures such as cofferdams, will be used. The temporary structures would allow dewatering of the necessary construction area, not the surrounding area of the aquifer, thereby reducing the area of impact. The impermeable sheeting can be removed on completion. As a result the volume of water abstracted and the impact on the aquifer, and its users, will be reduced. The water will be sampled, and treated if necessary, before re-use, for example. in dust-suppression.

Treatment of Suspended Solids (mitigating against turbid water')

The 'cloudy water' generated on site, from dewatering or other construction activities, is a result of suspended solids in the water which have not settled out. Suspected solids and oil will be separated from pumped groundwater prior to discharge.

[27] The Control of Pollution (Oil Storage) (England) Regulations 2001

Mitigation against Human Health impacts

Site workers and visitors will have the appropriate PPE (Personal Protective Equipment) to reduce the risk of exposure to potential sources of contamination.

During Operation

This section outlines the mitigation measures to reduce contamination once the site is in its operational phase; monitoring groundwater levels and quality, maintenance of structures in place to prevent contamination, as well as adhering to good practice.

Monitoring

Monitoring groundwater quality is essential to identify any contaminants in groundwater and their location. Combining water quality analysis with groundwater elevations, either from installed piezometers or dips taken at the same time as sampling, allows identification of the possible flow direction and migration of any contamination. Monitoring will be established prior to construction to allow measurements of the 'baseline' condition. Sampling and analysis will continue throughout construction and upon completion, as an indicator for any contamination breaches or changes to the baseline conditions.

Maintenance

Maintenance of the impermeable surface water features is necessary to prevent groundwater-surface water interaction as a result of deterioration. The abstraction and monitoring boreholes will be maintained to a good standard; with a secure and clean site, to prevent contamination from surface to aquifer, but also to ensure structures are safe and do not fall into disrepair.

Apply Good Practice

Around Boreholes

The area surrounding abstraction and monitoring wells will be secure and kept clean and tidy, with a suitable cover on the well for protection against the weather, vandalism and rodents. No storage of potential contaminants will be kept in the area, and the area surrounding the well will allow efficient drainage to prevent pooling of water.

Mitigation against Human Health impacts

The long term risk to human health as a result of the site will be significantly reduced as a result of the remediation practices.

Appendix C
Water Framework Directive Assessment

An introduction to the Water Framework Directive and its requirements has been presented in the main text of this report. In this appendix, the WFD requirements are considered in more detail, including an assessment of the likely effect on the status of each water body as a result of the development.

Application of Article 4.7

The range of potential effects as a result of the development of a third runway to the north-west of the Airport, before and after mitigation, was outlined and discussed in **Sections 2.1 and 5**. The mitigation that is provided to the water environment through the Natural Environment strategy must be considered in the context of Article 4.7 of the WFD. To recap, in relation to the water environment itself, Article 4.7 requires:

- (a) All practicable steps are taken to mitigate the adverse impact on the status of the body of water;
- (b) The beneficial objectives served by those modification or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option;
- (Article 4.8) A Member State shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district.

The mitigation strategy has clearly set out how items a and b of Article 4.7 are satisfied. Alternative options, including those that would have avoided culverting, have been considered and were found to be technically infeasible without either failing to reconnect flow to all downstream water bodies, or requiring pumping to ensure that connectivity. **Sections 4 and 5** showed how the mitigation strategy provides considerable improvement to the water environment relative to an un-mitigated state, preventing the extensive disruption to the hydrological regime that would have occurred without the strategy. The strategy will prevent impacts to water quality, and maximises the aquatic habitat opportunities of the local water bodies within the constraints of the overall physical modifications. It has provided an optimal solution for the natural environment, in the context of which any impacts on the water environment have been mitigated as far as possible. In particular, the strategy ensures that impacts to habitat availability and associated ecology are localised and has been designed with the primary aim of ensuring that the existing flow regime is maintained in the downstream reaches of all water bodies. The requirements of Article 4.8 are also met, as a result of mitigation to ensure that there are no effects on water bodies either further upstream in the Colne Valley (through development of appropriate culvert design, along with enhanced opportunities for fish passage along the Colne Brook), or downstream (through maintenance of the existing flow regime in the downstream reaches of all water bodies).

Impacts on Classification Elements of Individual Water Bodies

To provide further detail, potential effects arising from the development, before and after mitigation, are considered here in relation to the requirements of the Water Framework Directive on a water body basis. **Table C1** sets out the range of potential impacts by water body. The effects have been considered under broad categories relating to the WFD of:

- Hydromorphology: this term has been brought in to more common use as a result of the WFD, and describes the combined effects of modifications to the physical structure of water bodies and changes to the amount of river flow. Morphology and flow changes have been considered separately here;
- Biological elements may include fish, macrophytes, macroinvertebrates, diatoms and phytoplankton, depending on the type of waterbody and what monitoring has been carried out. Not all of these elements have been assessed in detail here, but general commentary is given in relation to changes to habitat and sensitivity of particular species to changes in hydromorphology or water quality;
- Water quality is considered under two categories. Biochemical water quality includes the nutrient and dissolved oxygen status of the waterbody. Chemical status is set in relation to a defined list of chemicals and other pollutants that may be found in water;
- For HMWBs and AWB, Mitigation Measures are defined, which are the measures which are expected to be put in place to improve the hydromorphology and management of the water body as far as is possible while still retaining the recognised use of the waterbody.

Only waterbodies where there may be some effect are listed: none of the reservoirs or gravel pits that are listed in the Thames RBMP are included since there will be no impact on those waterbodies. The groundwater bodies are not included in the assessment, having been considered separately in **Appendix B**.

Table C1 Overview of Potential Effects of the Mitigation Strategy on Morphology, Flow, Biology and Biochemistry of Water Bodies in the Vicinity of the Development

WB ID **WB name**	**GB106039023090** **Colne and GUC**	**GB106039023010** **Colne Brook**	**GB106039023040** **Horton Brook**	**GB106039023450** **Port Lane Brook**	**GB806100108** **(Duke of Northumberland's River)**	**GB106039023030** **Crane**
Current ecological status/ potential	Poor	Moderate	Moderate	Moderate	Poor	Poor
Morphology	Significant changes since separate River Colne and Wraysbury River channels will be diverted, combined in to a single channel and routed beneath the Third Runway through a wide culvert, and then in an open channel along the western site boundary.	Approximately 1km reach of Colne Brook will be diverted, around the western end of the Third Runway. New 'Colne Brook Spur' may be incorporated in to Colne Brook waterbody.	Horton Brook will be diverted to the west at Colnebrook to avoid interactions with the Colne Brook Spur. Potential for morphology and habitat to be improved from current condition.	Upstream reaches of Duke of Northumberland's River and Longford Rivers (from diversions from R.Colne) will be combined in to a single channel and routed beneath the Third Runway through a wide culvert, and then in an open channel along the western site boundary.	Upstream reaches of Duke of Northumberland's River and Longford Rivers (from diversions from R.Colne) will be combined in to a single channel and routed beneath the Third Runway through a wide culvert, and then in an open channel along the western site boundary.	No changes from baseline.
Flow	Flow in the physically altered reach will be reduced below the existing total flows. Downstream, the existing flow regime will be restored to both existing channels.	No change to flow regime, except for short reach where Colne Brook Spur crosses the Colne Brook	No change to flow regime.	Downstream, the existing flow regime will be restored to both existing channels. There will be no change to the total flow between the two channels in the physically altered reach, compared to the baseline.	Downstream, the existing flow regime will be restored to both existing channels. There will be no change to the total flow between the two channels in the physically altered reach, compared to the baseline. Potential for increased baseflows in Duke of Northumberland river along the southern airport boundary due to discharges of treated surface and foul waters.	Potential for increased baseflows due to discharges of treated surface and foul water to the Duke of Northumberland River.

Table C1 (Continued)

WB ID WB name	GB106039023090 Colne and GUC	GB106039023010 Colne Brook	GB106039023040 Horton Brook	GB106039023450 Port Lane Brook	GB806100108 (Duke of Northumberland's River)	GB106039023030 Crane
Biology	Loss of habitat on Wraysbury River and River Colne. Complete loss of habitat in culvert, although culvert will be designed to allow fish passage. Downstream of culvert, natural bed and bank materials will be used where possible and heterogeneity (e.g. areas of backwater) will be included to improve biodiversity.	Transfer of water from River Colne to Colne Brook could transfer biota. However the two channels are connected further upstream so there is little risk of transfer of (e.g.) invasive species. No loss of habitat or physical or chemical changes that may affect biology in this WB. Improvements to fish passage potential by removal of barriers.	Some disturbance to habitat. Re-aligned reach will use natural bed and bank materials and provide equivalent or improved habitat opportunities.	Loss of habitat. Complete loss of habitat in culvert, although culvert will be designed to allow fish passage. Downstream of culvert, natural bed and bank materials will be used where possible and heterogeneity (e.g. areas of backwater) will be included to improve biodiversity.	Loss of habitat. Complete loss of habitat in culvert, although culvert will be designed to allow fish passage. Downstream of culvert, natural bed and bank materials will be used where possible and heterogeneity (e.g. areas of backwater) will be included to improve biodiversity. Risks of eutrophication and high BOD from new discharges if treatment is insufficient. This will be avoided by high standards of treatment and regular monitoring.	Potential for improvements to biota as a result of improved low flows.
Biochemistry	Use of best practice in construction and operation will avoid any effects.	Transfer of water from River Colne to Colne Brook could influence biochemistry. However the two channels are connected further upstream, so water quality does not differ significantly between them. Use of best practice in construction and operation will avoid any effects.	Use of best practice in construction and operation will avoid any effects.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality. Use of best practice in construction and operation will avoid any effects.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality in Duke of Northumberland's River and downstream Crane. Use of best practice in construction and operation will avoid any effects.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality in Duke of Northumberland's River and downstream Crane.

Table C1 (Continued)

WB ID	**GB106039023090**	**GB106039023010**	**GB106039023040**	**GB106039023450**	**GB806100108**	**GB106039023030**
WB name	**Colne and GUC**	**Colne Brook**	**Horton Brook**	**Port Lane Brook**	**(Duke of Northumberland's River)**	**Crane**
Chemical	Use of best practice in construction and operation, including in dewatering, will avoid any effects.	Transfer of water from River Colne to Colne Brook could transfer chemical pollutants. However the two channels are connected further upstream, so water quality does not differ significantly between them (status of individual elements is the same between WBs). Use of best practice in construction and operation, including in dewatering, will avoid any effects.	Use of best practice in construction and operation, including in dewatering, will avoid any effects.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality. Use of best practice in construction and operation, including in dewatering, will avoid any effects.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality in Duke of Northumberland's River and downstream Crane.	Discharges of treated surface and foul waters to Duke of Northumberland. High levels of treatment will avoid impacts on water quality in Duke of Northumberland's River and downstream Crane.
Mitigation measures	There are existing MMs relating to fish barriers and culverts. The extent of these structures will be increased by the proposal and may mean that the MMs cannot be put in place.	Opportunities will be identified to remove or reduce barriers to fish passage in the Colne Brook. Opportunities will be identified in consultation with EA and ColneCAN.	n/a (not HMWB)			Opportunities will be identified to remove or reduce barriers to fish passage in the Crane. Opportunities will be identified in consultation with EA the Crane Partnership.

Impacts on overall Status of Individual Water Bodies

Based on the impacts discussed above to individual classification elements, this section provides overall conclusions regarding the status of each water body. The assessment **(Table C2)** considers both the potential to cause deterioration, and the potential to prevent future improvements (both in these water bodies and in other water bodies). This shows that there is greatest potential to affect the (current and future) status of waterbodies GB 106039023090 (River Colne and GUC), GB 106039023450 (Port Lane Brook) and GB 806100108 (Duke of Northumberland's River). The reasons for this, as can be seen from **Table C1**, result from the extent of physical modification on these water bodies. Sections 4 and 5 of this report have discussed how these effects have been minimised through development of the strategy, and how channel diversions and design will utilise best practice to maximise habitat opportunities in these, and all, water bodies.

Table C2 Overview of Potential Effects on Status of Water Bodies in the Vicinity of the Development

WB ID	**GB 106039023090**	**GB 106039023010**	**GB 106039023040**	**GB 106039023450**	**GB 806100108**	**GB 106039023030**
WB name	**Colne and GUC**	**Colne Brook**	**Horton Brook**	**Port Lane Brook**	**Duke of Northumberland's River**	**Crane**
Deterioration of status	YES Already HMWB. However purpose of HMWB will change, and extent of modifications will increase significantly. More Mitigation Measures will be required.	NO Already HMWB. Diversion will create channel of equivalent or improved habitat quality.	NO Diversion will create channel of equivalent of improved habitat quality.	YES Already HMWB and a highly artificial channel. New modifications will be extensive, although will be designed to create channel of equivalent of improved habitat quality.	YES Already HMWB and a highly artificial channel. New modifications will be extensive, although will be designed to create channel of equivalent of improved habitat quality. Potential for improvement of status by support of low flows.	NO. Potential for improvement to status by support of low flows.
Preventing future improvements (this WB)	YES The length of channel alterations may impede putting in place Mitigation Measures currently listed in the RBMP. A revised list of MMs should be devised, for which HAL will take responsibility for implementation	NO Opportunities will be identified with EA and catchment partnerships for HAL to address Mitigation Measures and improve fish passage potential through the Colne Valley via this water body	NO Diversion will create channel of equivalent of improved habitat quality.	YES The length of channel alterations may impede putting in place Mitigation Measures currently listed in the RBMP, at least within the intended timescale. A revised list of MMs should be devised, for which HAL will take responsibility for implementation	YES The length of channel alterations may impede putting in place Mitigation Measures currently listed in the RBMP, at least within the intended timescale. A revised list of MMs should be devised, for which HAL will take responsibility for implementation	NO. Potential for improvement to status by support of low flows.

Table C2 (Continued)

WB ID **WB name**	**GB106039023090** **Colne and GUC**	**GB106039023010** **Colne Brook**	**GB106039023040** **Horton Brook**	**GB106039023450** **Port Lane Brook**	**GB806100108** **Duke of Northumberland's River**	**GB106039023030** **Crane**
Preventing future improvements (other WBs)	NO Modifications to the channel, resulting in a length of artificial channel and a long culvert beneath the runways, will reduce habitat connectivity between upstream and downstream reaches. However culvert design, and improved connectivity along the Colne Brook, will aid connectivity overall in the Colne Valley. No change to downstream flow regime.	NO Opportunities will be identified with EA and catchment partnerships for HAL to address Mitigation Measures and improve fish passage potential through the Colne Valley via this water body. No change to downstream flow regime.	NO No change to flow regime	NO No change to downstream flow regime	NO. Potential for improvement to status of downstream water body (River Colne) by support of low flows.	NO. Potential for improvement to status by support of low flows.

Appendix D
Legislative and Policy Review

Table D.1 Key Relevant European Directives (excluding WFD) and Domestic Regulations

Policy/ Legislation/ Guidance	Relevance
Key European Directives	
Water Framework Directive 2000/60/EC	Directive aiming to achieve 'good' status of all surface waters and groundwaters. As described in **Section 1.2.1**
Habitats Directive 92/43/EEC	Promotes maintenance of biodiversity by requiring measures to maintain or restore natural habitats and wild species considered to be of European importance.
Groundwater Directive 2006/118/EC	A daughter directive of the WFD that establishes specific measures to prevent and control groundwater pollution.
Environmental Quality Standards Directive 2008/105/EC	A daughter directive of the WFD that lists pollutants of particular concern in water , and sets standards for acceptable concentrations of those pollutants.
Key Domestic Legislation, Regulations and Policy	
Control of Pollution Act 1974;	An Act to make provisions with respect to waste disposal, water pollution, noise, atmospheric pollution and public health.
Environmental Protection Act 1990 (as amended by the Environment Act 1995)	An Act to make provision for the improved control of pollution arising from certain industrial and other processes; to re-enact the provisions of the Control of Pollution Act 1974 relating to waste on land with modifications as respects the functions of the regulatory and other authorities concerned in the collection and disposal of waste and to make further provision in relation to such waste.
Water Resources Act 1991	Regulates water resources, water quality and pollution, and flood defence. It explains the standards expected for controlled waters; and what is considered as water pollution.
Water Act 2003	Sets out licensing requirements for abstractions and impoundments (amended those requirements in the Water Resources Act 1991).
Wildlife and Countryside Act 1981 and (Amendment) Act 1985 (as amended by the Countryside and Rights of Way Act 2000)	Gives protection to native species (especially those at threat), controls the release of non-native species, enhances the protection of SSSIs.
The Groundwater (England and Wales) Regulations 2009	Implements parts of the WFD relating to groundwater, and Article 6 of the Groundwater Directive.
Environmental Permitting Regulations (2010)	Provide a consolidated system of environmental permitting, including waste operations, water discharges, groundwater discharges and radioactive substances.
Control of Pollution (Oil Storage) (England) Regulations 2001	Places controls on the above-ground storage of oils.
Thames River Basin Management Plan (RBMP)	Local implementation of the Water Framework Directive for the River Thames catchment. The current plan covers 2010-2015, and a draft plan is currently in preparation for 2016-2021.
London Plan	Development proposals should: • Incorporate appropriate elements of green infrastructure that are integrated into the wider network; • Protect and improve water quality having regard to the Thames River Basin Management Plan; • Development proposals must ensure that adequate wastewater infrastructure capacity is available in tandem with development. Proposals that would benefit water quality, the delivery of the policies in this Plan and of the Thames River Basin Management Plan should be supported while those with adverse impacts should be refused; • Wherever possible, make a positive contribution to the protection, enhancement, creation and management of biodiversity

There are a wide range of policies and best practice guidance that influence the management of the water environment and prevent pollution. Key guidance and policies include EA's Pollution Prevention Guidance (PPGs) and CIRIA design guides:

Environment Agency PPG:

- PPG1 General guide to the prevention of water pollution;
- PPG2 Above ground oil storage tanks;
- PPG3 The use and design of oil separators in surface water drainage systems;
- PPG5 Works and maintenance in or near water;
- PPG6 Working at construction and demolition sites;
- PPG7 Safe operation of refuelling facilities;
- PPG8 Safe storage and disposal of used oils;
- PPG13 Vehicle washing and cleaning;
- PPG21 Pollution incident response planning; and
- PPG22 Dealing with spills.

CIRIA guidance:

- CIRIA Culvert Design and Operation Guide (C689);
- CIRIA The SUDS Manual (C697);
- CIRIA Control of Water Pollution from Construction Sites (C532); and
- CIRIA Environmental Good Practice on Site (C692).

Environment Agency Requirements

Consultation with the EA during development of the mitigation strategy led to some specific questions[28]. Those relating to hydro-ecology, water quality and the WFD are addressed in this report, and can be summarised as:

- There are risks of potential contamination and/ or possible implications of construction activities on local groundwater resources, which could have implications for existing abstraction licences (or non-licensed protected rights). A comprehensive preliminary risk assessment desk study for groundwater

[28] Reference NE/2014/20109/01, 7 April 2014.

and contaminated land should be carried out, including a Conceptual Site Model. In order to address these requirements, this report covers groundwater contamination risks, as well as risks to water users, with a specific Groundwater Risk Assessment and Conceptual Model included in **Appendix B**;

- Consideration of any implications for reservoir capacity and lake habitats, and hence on the Southwest London Special Protection Area (SPA). However, the final masterplan design does not interact with the reservoirs or gravel pits in the Southeast London SPA, or their habitats. Therefore there is no significant concern in this regard;

- A preliminary WFD compliance assessment should be carried out. This should assess the impacts of new activities, including the possibility of rendering proposed improvement or mitigation measures ineffective. This assessment considers impacts with respect to the WFD throughout, with a specific WFD assessment included in **Appendix C**;

  - It was noted that the River Crane currently fails its objectives, and that one reason for failure is impacts on low flows. It was indicated that any approaches to improving the low flows on the River Crane would be welcomed, and this has been considered in the submitted masterplan;

- There must be foul and surface water containment and treatment strategies that uphold PPG22. A Sustainable drainage Strategy is presented in Part 5.9 of Volume 1 of the Technical Submission to the Airports Commission[3]. This report summarises how the Sustainable Drainage Strategy protects the water environment; and

- It was highlighted that the EA has a general position against culverting, and stated that "It should be demonstrated that all opportunities to either divert or realign watercourses have been considered and given priority. Culverting should only be considered if these options are not physically possible and we would expect to see full justification of why culverting is the only option." Discussion of culverting requirements and consideration of alternative options is included within this assessment.