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9. Water and Flood Risk: Water Quantity and Water Quality Assessment

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Airports Commission

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Jacobs U.K. Limited

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Executive Summary

Jacobs has been commissioned to undertake a high level assessment of the potential impacts and subsequent mitigation measures that would be required if an additional runway (and associated airport development) were to be developed at Gatwick or Heathrow Airport. Three schemes put forward by promoters have been assessed:

- Gatwick Airport Second Runway (Gatwick 2R) proposed by Gatwick Airport Limited (GAL),
- Heathrow Airport Northwest Runway (Heathrow NWR) proposed by Heathrow Airport Limited (HAL), and
- Heathrow Airport Extended Northern Runway (Heathrow ENR) proposed by Heathrow Hub Limited (HH).

This assessment has been undertaken in accordance with the Airports Commission's Appraisal Framework (2014) Water and Flood Risk Module and covers the water quality and water quantity aspects of the three proposed schemes. Water quality focuses on the implications in terms of the Water Framework Directive (WFD) requirements and water pollution risks while the water quantity assessment considers water demand and supply impacts. The assessment draws on information from the Water and Flood Risk Baseline report (Jacobs, 2014).

For both water quality and quantity, Jacobs' assessment of the potential impacts and mitigation of each scheme is provided. The promoters' proposals for addressing potential impacts on the water environment are also reviewed and key differences between the assessments are discussed.

Water Quality

The water quality assessment of this report outlines the extent to which the three airport schemes meet the Airports Commission's objective to assess the impact of proposed schemes on the water environment, and ensure there is no deterioration to any WFD water body status. Each scheme is assessed as detailed in the Airports Commission: Appraisal Framework (April 2014) to analyse the water environment in terms of:

- Surface waters, groundwaters, estuaries and coastal waters (surface waters include streams, rivers, lakes, reservoirs and wetlands); and
- WFD classification system, considering impacts on protected areas and ensuring no deterioration of water body status.

The water quality assessment is undertaken in relation to EU designated WFD water bodies and this considers whether (on the basis of available information) the scheme developments could lead to deterioration in water body status, or to preventing a water body from achieving Good Ecological Status or Good Ecological Potential.

The three developments: Gatwick 2R; Heathrow NWR; and Heathrow ENR, all have the potential to impact on the water environment, particularly without appropriate mitigation in place. Even with mitigation there would likely be residual impacts for all three proposals which would be of concern to Regulators such as the Environment Agency.

Each of the three development proposals would need to provide mitigation through design. Best practices would need to be followed but where there was residual uncertainty about effectiveness of this mitigation then monitoring regimes would probably be required by the Environment Agency. Mitigation measures could potentially reduce some of the impacts to varying degrees. It would also be incumbent on each Proposer to take account of cumulative impacts on the water environment.

Gatwick Airport Second Runway – Water Quality

For the Gatwick Airport Second Runway scheme, it is estimated that approximately 7km of existing watercourse would be replaced with diverted/realigned channels. Diversion of approximately 1km of the River Mole to the west of the airport and diversion of the Crawter's Brook would present considerable technical challenges and would be likely to result in residual adverse effects on the hydromorphology and geomorphology.

The addition of a weir to compensate for a 2m reduction in bed level at the Crawter's Brook/River Mole confluence would also be likely to have a significant residual impact. No culverting is proposed and it is likely that a significantly positive outcome would arise from removing the River Mole from approximately 600m of existing culvert. The water bodies at Gatwick (designated under the EU Water Framework Directive) are sensitive and activities such as culvert removal are in keeping with wider recent environmentally-acceptable approaches taken in the Upper Mole catchment for flood protection by the Environment Agency. However, any deterioration of ecological status (e.g. through realignment or the addition of a weir) would potentially be opposed by Regulators.

There could also be residual water quality impacts arising from polluted runoff, although GAL state that they believe that these impacts are mitigable (i.e. through a positive drainage system and attenuation in pollution storage lagoons). It is recognised that despite mitigation commitments at airports, contaminants such as de-icers do reach receiving watercourses at certain times. If this were the case then there could be an adverse residual effect on WFD physico-chemical status despite mitigation commitments.

Heathrow Airport Northwest Runway – Water Quality

For the Heathrow Airport Northwest Runway Scheme, approximately 12km of existing watercourse would be replaced with diverted/realigned channels. Diversion of approximately 1km of the Colne Brook around the western end of a new runway, diversions of parts of the Duke of Northumberland's River and River Colne to the south of the new runway and creation of a new channel (the 'River Colne Spur') would not only present enormous technical challenges but would probably have residual adverse effects on the hydromorphology and geomorphology. Combining the River Colne and Wraysbury River into a single culvert and the Duke of Northumberland's and Longford Rivers into a single culvert would be likely to have significant adverse residual impacts. Such an approach would potentially be regarded as detrimental by the Regulators. From a WFD and general regulatory perspective, combining two water bodies/watercourses would reduce total channel length significantly and fundamentally alter the channel morphology including sediment processes with concurrent ecological implications.

Approximately 3km of currently open channels would be culverted. The water bodies (now protected under the Water Framework Directive) are sensitive and extensive diversions/culverting would run counter to the considerable work put in by the

Environment Agency and its predecessors to provide environmentally-friendly flood schemes (as part of the Lower Colne Catchment flood scheme) and also in successfully rebutting culverting proposals at the Heathrow Terminal 5 Public Inquiry.

There could also be residual water quality impacts arising from polluted runoff, although HAL states that they believe that these impacts are mitigable. It is recognised that despite mitigation efforts at airports, contaminants such as de-icers do reach receiving watercourses at certain times. If this were the case there could be an adverse residual effect on WFD physico-chemical status.

Heathrow Airport Extended Northern Runway - Water Quality

For the Heathrow Airport Extended Northern Runway, approximately 12km of existing watercourse would be replaced with diverted/realigned channels. Diversions of the Colne Brook and Poyle Channel (approx. 5km) around the west end of an extended north runway would not only present enormous technical challenges but would probably have residual adverse effects on the hydromorphology/ geomorphology due to the changed gradients and other associated uncertainties. Culverting the Longford River, the Duke of Northumberland's River, River Colne and Wraysbury River beneath the proposed runway would probably have significant adverse residual impacts. An initial estimate suggests that there could be in excess of 12km of additional culverts. The water bodies (now protected under the Water Framework Directive) are sensitive and extensive diversions/culverting would run counter to the considerable work put in by the Environment Agency and its predecessors to provide environmentally-friendly flood schemes (as part of the Lower Colne Catchment flood scheme) and also in successfully rebutting culverting at the Heathrow Terminal 5 Public Inquiry.

There could also be residual water quality impacts arising from polluted runoff. It is widely recognised (for example) that despite mitigation, contaminants such as de-icers do reach receiving watercourses at certain times. If this were to be the case then there could be an adverse residual effect on WFD physico-chemical status.

Water Quantity

The water quantity assessment of this report outlines how three airport schemes meet the Airports Commission's objective to use water resources efficiently. Each scheme is assessed as detailed in the Airports Commission: Appraisal Framework (April 2014) to ensure that:

- The impacts on water resources in terms of the availability, reliability, rarity and substitutability are fully considered; and
- Measures are proposed to mitigate any detrimental impact on water resources.

The south-east of England is already water stressed and therefore any additional demand must be mitigated to prevent further stress being placed on water resources.

The Jacobs' Water and Flood Risk Baseline report (2014) calculated baseline demands at each airport for 2012/2013, 2025 (Gatwick), 2026 (Heathrow), 2050, 2085 (Gatwick) and 2086 (Heathrow), assuming constrained growth based on forecasts from the Airports Commission. For the baseline, Jacobs assessed the water resource position by reviewing the River Basin Management Plan (RBMP),

Catchment Abstraction Management Strategies (CAMS) and Water Resource Management Plans (WRMP) covering the airport locations. This allowed for a baseline to be calculated with which to compare the proposed airport schemes.

Submissions for each scheme have been assessed to determine the changes to airport water consumption and proposed mitigation measures to limit the impact of these changes. The changes have been compared to the baseline consumption as described in the Water and Flood Risk Baseline report (2014), and to Jacobs' assessment of potential rates of consumption with the implementation of water efficiency measures, to determine their potential impact on water resources.

Whilst each submission is valid, they have all used different assumptions in their approach to assessing impacts on water resources. The Jacobs review of the submission documents and subsequent comparison of demand against the baseline led to the conclusions set out below:

Gatwick Airport Second Runway - Water Quantity

The Airports Commission has forecast a doubling of 2012 passenger numbers after the completion of the second runway at Gatwick, resulting in an increase in demand for water at the airport. The Jacobs assessment of water consumption at Gatwick and demand mitigation measures adopted at other airports indicate that per passenger consumption can be reduced by approximately 10% to mitigate this increased demand. However, there will still be an overall increase in total demand which needs to be met by the incumbent water supplier, Sutton and East Surrey Water which state they currently have a surplus in the water resource zone.

Following completion of the scheme, GAL has forecast a reduction in the water consumption per passenger as a result of water efficiency measures and a rise in total water consumption. Given GAL's track record for reducing per passenger consumption and evidence from an assessment of the success of other water efficiency measures adopted at other airports, the forecast reduction in per passenger consumption appears reasonable

Heathrow Airport Northwest Runway - Water Quantity

The Airports Commission has forecast that an additional runway and associated development at Heathrow would provide capacity to double the number of existing passengers that use the airport each year. This will result in an increase in water demand in an already water stressed region. Affinity Water are already reporting deficits in their supply demand balance and predict this deficit to increase in the future. The Jacobs assessment of water consumption at Heathrow and of water efficiency and recycling schemes available to Heathrow indicate that per passenger consumption can be reduced by approximately 10 to 15% to mitigate a proportion of this increased demand. However, even with the implementation of these measures there is still an increase in water demand at the airport and meeting this will require investment in additional water reuse schemes and consultation with Affinity Water and its neighbouring water companies to consider imports from other sources.

The HAL submission however proposes to achieve a significant reduction in demand at Heathrow following the implementation of water efficiency and recycling measures across the site. HAL has forecast a doubling of passenger numbers by 2026 whilst halving the 2010 per passenger consumption rate; resulting in lower total demands than are currently being recorded. Achieving this level of efficiency is likely to be highly dependent on water recycling, particularly the introduction of a sewage treatment works and the use of reverse osmosis technology to allow

wastewater recycling. This would be a high capital cost and would be energy intensive to operate.

Heathrow Airport Extended Northern Runway – Water Quantity

Based on the Airports Commission's forecasts, the proposed extension of the runway at Heathrow would result in a significant increase in passenger numbers, and ultimately in water demand. The Jacobs assessment of water efficiency and recycling schemes available to Heathrow indicate that per passenger consumption can be reduced by approximately 10 to 15% to mitigate a proportion of this increased demand. Affinity Water is already reporting deficits in their supply demand balance and predict this deficit to increase in the future. However, even with the implementation of these measures there is still an increase in water demand at the airport and meeting this will require investment in additional water reuse schemes and consultation with Affinity Water and its neighbouring water companies to consider imports from other sources.

The HH submission did not provide estimates of water consumption either for the baseline or with-scheme scenarios for the airport extension alone. The estimates of water consumption are based on predicted increases in demand for the combined airport extension and hub interchange. This indicates an increase in total consumption compared to 2013, although the level of increase associated with the airport extension alone will be lower than those reported in the submission document. The implementation of water efficiency measures and reduced demand resulting from the demolition of properties within the scheme footprint, result in a demand increase that the promoters believe can feasibly be met by abstracting from the neighbouring surface water sources or chalk aquifer. Although, given the water stressed nature of the South-east the feasibility of this would need further consultation with the Environment Agency and Affinity Water. The lack of distinction between the two components, airport extension and hub interchange, of the scheme has led to a level of uncertainty with regard to the calculation of impacts on water resources from the HH submission.

1 Introduction

Jacobs has been commissioned to undertake a high level assessment of the potential impacts and subsequent mitigation measures that would be required if an additional runway (and associated airport development) were to be developed at Gatwick or Heathrow Airport. Three proposals have been assessed: Gatwick 2R, Heathrow NWR and Heathrow ENR. This assessment focuses on the water quality, Water Framework Directive (WFD) and water quantity aspects of the three airport expansion schemes. The assessment draws on information from the Water and Flood Risk Baseline report (produced by Jacobs) and is assessed as specified in the Airports Commission Appraisal Framework which is discussed further in section 1.3 (Airports Commission, 2014).

Chapters 2 to 5 presents the methodology and assessment of water quality and Water Framework Directive aspects, whilst Chapters 6 to 9 presents the methodology and assessment of the water quantity aspects.

2 Water Quality Assessment Methodology

This section covers:

- Scope of the water quality assessment in relation to the Airports Commission Appraisal Framework
- An outline of the methodology applied to the assessment covering inputs and approach to the assessment and how the baseline information has been used
- Assumptions and limitations associated with Jacobs' assessment

2.1 Context and Scope

Chapters 3 to 6 of this report aim to make a preliminary assessment of the potential impact of the three individual airport scheme proposals on surface water and groundwater; this is typically referred to as the 'water environment' throughout this report.

Each scheme is assessed as specified in Airports Commission: Appraisal Framework (Airports Commission, 2014) to analyse:

- The water environment in terms of surface waters, groundwaters, estuaries and coastal waters (surface waters include streams, rivers, lakes, reservoirs and wetlands); and,
- The water quality, assessed using the WFD classification system, considering impacts on protected areas, no deterioration of water bodies, status and achieving good status in water bodies (this includes ecological and chemical quality as well as quantitative status).

Estuarine and coastal waters have not been considered within this report due to the inland nature of the three scheme locations.

The following is a list of the key documents used to inform this assessment; a more comprehensive list is provided in the References at the end of the report. It included the submissions from the promoters in response to the Airports Commission Appraisal Framework and additional data collected specifically for the Jacobs assessment. All of the information collected has informed both the Jacobs Water Quantity and Water Quality Assessment and the assessment of the promoters' submissions.

- GAL submission (prepared by CH2MHILL) (2014) Appendix A12 Water and Flood Risk in A Second Runway for Gatwick
- Heathrow Airport Limited (HAL) (prepared by AMEC Environment and Infrastructure UK Ltd) (2014a) Water Quality and Hydro-ecology Assessment in Heathrow's North-West Runway
- Heathrow Hub (HH) submission (prepared by URS for Runway Innovation Ltd) (2014) Heathrow Expansion - Stage 2 Submission, Attachment 5-1
- Environment Agency (2009) Chapter 8: Works in the river channel in The Fluvial Guide. Available online at: http://evidence.environment-agency.gov.uk/FCERM/Libraries/Fluvial_Documents/Fluvial_Design_Guide_-_Chapter_8.sflb.ashx
- Rickard, C., Day, R. and Purseglove, J (prepared for the Environment Agency). 2003. River Weirs – Good Practice Guide. R&D Publication W5B-

023/HQP (Research Contractor: Mott MacDonald Ltd and University of Hertfordshire). Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/290655/sw5b-023-hqp-e-e.pdf

- National Rivers Authority (1997) Scoping Guidance for the Environmental Assessment of Projects
- Environment Agency (2002) Scoping Guidance for Projects at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296952/geho0411btrf-e-e.pdf
- Jacobs (2014a) Water and Flood Risk Baseline
- Environment Agency (2009) Thames River Basin Management Plan

2.2 Methodology

The report specifically addresses water quality and the European Water Framework Directive (WFD) water bodies. In relation to WFD water bodies, it assesses whether the developments could lead to a deterioration in water body status or the prevention of a water body from achieving Good Ecological Status (GES) or Good Ecological Potential (GEP). There have been several examples of good practice restoration, mitigation and enhancement on watercourses close to (or directly affected by) the existing Heathrow and Gatwick Airports and a selection is given for information. Consideration is given to mitigation likely to be required to minimise/eliminate impacts and the subsequent residual impacts that could potentially remain even after mitigation.

This assessment has been undertaken as a desk-based review of potential impacts that could arise from the promoters' proposals and the potential mitigation measures that they have suggested as compensation. This draws on the information provided in the Water and Flood Risk Baseline report (Jacobs 2014a), a description of the developments provided by the three promoters' submission documents and other readily available information. The report contains a summary of the baseline conditions, based on the Water and Flood Risk Baseline report completed by Jacobs (2014a). A search of literature and web-based information concerning potential impacts and mitigations has also been undertaken and where gaps remain a degree of professional judgement based on experience has been provided. Jacobs has undertaken an impact assessment (including potential mitigation) of the proposals. This is followed by a separate assessment of the specific impacts and mitigation measures detailed by the individual promoters in their submissions (where available).

Further details on the methodology are contained in Appendix A.

2.3 Assumptions and Limitations

This review of the submissions is based on a comparison with the Jacobs' Baseline Report (2014a) and our assessment of the impacts on water resources resulting from the proposed schemes. We have used this as a basis for commenting on the submissions. In defining the Baseline, Jacobs made a number of assumptions. The assumptions made and their limitations are summarised below:

- The assessment of the high level baseline water resource position was determined at a high level by the review of publicly available documents listed in section 2.1;

- Information stated in the promoters documents has not been check for accuracy at this stage in relation to proposed works and mitigation measures;
- Information stated on promoters maps is correct (including location and lengths of realigned/diverted(re-routed)/created channels, culverts, structures (e.g. weirs), mitigation areas (e.g. attenuation ponds, treatment areas, flood storage areas, flood bunds) and average flow proportions); and
- No changes to de-icing practice or management would occur (other than an increase in load proportional to the increase in peak winter aircraft movements). There would be no new technologies that would substantially change the issues relating to de-icer recycling.

Each submission is unique in its approach and the level of detail provided varies between the short-listed schemes. All submissions are treated equally.

3 Water Quality Impacts - Gatwick Airport Second Runway

This section presents and assesses the Gatwick Airport Second Runway (2R) submission, providing the following information:

- Outline of proposed works;
- Summary of baseline conditions in 2014 and projected to 2050 without a scheme in place;
- Jacobs' assessment of the potential impacts of the promoter's scheme on water quality and WFD water body status including river realignment and weirs;
- Assessment of potential options available to mitigate any impacts;
- Commentary on the proposers' submission;
- Assessment of residual risks.

3.1 Proposed Works

The proposal submitted by GAL involves creating a second runway to the south of the current airport parallel to the existing east-west runway. The development would involve:

- Removing the River Mole from approximately 600m of culvert;
- Diverting the River Mole to the west of Gatwick 2R (increasing the channel length by approximately 1km);
- Diverting the Crawter's Brook to the south of the airport (increasing the channel length by approximately 100m);
- The addition of a weir to compensate for the 2m reduction in bed level at the Crawter's Brook/Mole confluence; and
- Structures including a permanent clear span bridge, with abutments set-back from bank top, fishing platforms and outfalls.

Based on information from Appendix A – Engineering Drawings in the GAL report (CH2MHILL, 2014) (A.1 Schedule of drawings, 005-C-2C001 River Mole and Crawter's Brook Proposed Diversion General Arrangement), it is estimated that the following approximate lengths of watercourses would be replaced with diverted/realigned channels due the proposed Gatwick 2R development.

Table 3.1 - Approximate lengths of original channels replaced/diverted due to scheme development

River	Length (km)
Crawter's Brook	2.69
River Mole	3.83
Total	**6.52**
Ditch[1]	0.64
Total (with ditch)	**7.16**

[1] Ditch is a tributary of the River Mole to the South of Gatwick Airport. Length of Ditch is used here as it is referred to in Appendix A of the Gatwick Airport Limited (GAL) report (CH2MHILL, 2014).

3.2 Summary of Baseline Conditions

The Gatwick 2R Study Area (Figure 3.1) is located within the Mole Management Catchment in the Thames River Basin District (RBD). The Study Area is underlain by Weald Clay Formation and Upper Tunbridge Wells Sand and has superficial deposits dominated by alluvium and river terrace deposits (BGS, 2014).

Figure 3.1 - Location and current status of WFD water bodies within the Gatwick 2R Study Area

Table 3.2 details the Water Framework Directive (WFD) water bodies present within the Gatwick 2R Study Area (Environment Agency, 2009b), including seven watercourses and one groundwater body. Two of the water bodies are classified as Heavily Modified Water Bodies.

Table 3.2 - Water Framework Directive classifications of water bodies within the Gatwick 2R Study Area

Type	Number	Current Overall Ecological Quality	Hydromorphological Status
Watercourses	2	**Moderate Status**	Not Designated
	2	Moderate Potential	Heavily Modified Water Bodies
	2	Poor Status	Not Designated
	1	Bad Status	Not Designated
Groundwater	1	Good Quantitative Quality	N/A

The overarching aim of the WFD is to achieve at least Good Ecological Status/ Good Ecological Potential in all water bodies by 2027. The main pressures detailed in the Thames River Basin Management Plan for the Mole Management Catchment

is pollution from sewage treatment works and agricultural sources (Environment Agency, 2009a). This has the potential to prevent water bodies from improving towards, and achieving, Good Status. Thames Water (2010) state that during the period of 2010 to 2015 there are plans to investigate the potential presence of specific trace substances in discharges to the River Mole that are not completely removed by the sewage treatment process.

The predicted 18% increase in passengers from 2025 to 2050 at Gatwick Airport, along with an increase in population in the vicinity of the airport, is likely to put increasing pressure on the water environment. This pressure could affect the biological, physico-chemical and hydromorphological elements assessed under the WFD, which could prevent these water bodies from achieving Good Ecological Status by 2027.

The Thames River Basin Management Plan states that "*over the period to 2027, the pressures on the environment will change, particularly because of climate change. It is not known how the water environment will respond to this*" (Environment Agency, 2009a). Given uncertainty and changeability of projected climate scenarios and associated impacts on the water environment, any adaptation actions or mitigation measures should be resilient to a range of plausible climate change scenarios, rather than led by a single scenario (WWF and Natural England, 2010).

3.3 Assessment of Potential Impacts

3.3.1 River Realignment

In the Gatwick 2R scheme, it is proposed to replace an existing culverted and engineered channel with two realigned channels. Table 3.3 displays approximate lengths of the River Mole and Crawter's Brook following river realignment based on information taken from Appendix A – Engineering Drawings in the GAL report (CH2MHILL, 2014) (A.1 Schedule of drawings, 005-C-2C001 River Mole and Crawter's Brook Proposed Diversion General Arrangement). It is important to acknowledge that these lengths have been calculated taking into consideration the remeandering proposed by GAL.

Table 3.3 - Approximate length of realigned channels

River	Length (km)
Crawter's Brook	2.78
River Mole	4.01
Total	**6.79**

Fundamentally, these works could lead to an improvement in the River Mole and Crawter's Brook. As a result, this could have the potential to improve the current WFD statuses of these water bodies by removing sections of modification and reinstating a more 'natural' channel.

However, without appropriate mitigation, negative impacts could arise from realignment. Without a sustainable design, natural adjustment of the realignment could also cause erosion and land loss, particularly to the south-west of the airport where the channel realignment design shows a near-90° bend.

Potential changes in gradient, discharge and velocity associated with realigned channels could cause alterations to the baseline flow and sediment regime. This

could potentially lead to localised deposition or erosion of a river bank and/or bed. Deposition associated with changed velocities could lead to siltation over the river bed, consequently impacting on aquatic ecology including fish, invertebrates and macrophytes. As a result, this could affect the biological elements of one or more of the WFD water bodies. Changed rates of erosion could also potentially cause impacts such as loss of riparian land, increased sediment delivery and potential release of contaminants into the water column. Changes to channel length caused by diversions, realignments or through purposeful increases of sinuosity, could also potentially impact existing sediment and flow regimes within the affected channels.

Although it is assumed that channel realignments would be designed to be self-maintaining as far as possible, a lack of full understanding of the uncertainties concerning channel dynamics/processes at the design phase could result in disruption to an existing channel equilibrium and channel instability. This could then lead to the need for future intervention to cope with adjustment, such as additional bank protection measures to protect against loss of land (National Rivers Authority (NRA), 1997; Environment Agency, 2002).

Changes to the physical channel structure or flow regime in a realigned channel could also have a potential to impact water quality and ecology both upstream and downstream of the directly affected reach. Although it is unlikely, without the appropriate mitigation this has the potential to cause a deterioration to the water bodies' status or prevent them from achieving Good ecological status in the future.

The Jacobs assessment acknowledges that the river realignment would not only replace engineered and culverted sections of channel as mentioned in the report, but would also result in the loss of a meandering section of the River Mole and a low sinuosity section of the Crawter's Brook to the south of Gatwick 2R. This has the potential to lead to the loss of aquatic and riparian habitat currently present within these more natural sections of watercourses, which would be backfilled following the scheme development. This is currently not mentioned within the promoter's report.

Box 3.1 - Lessons Learned: Upper River Mole Flood Alleviation Scheme - Environmental Mitigation

This £20 million project was initiated by the Environment Agency and Jacobs (as consultants) assisted at the feasibility/design stages through to construction (site supervision). This project, on the Upper Mole upstream of Gatwick 2R, was largely completed from 2011 to 2014. Climate change had caused the town of Crawley in South-east England to be at risk from increased flood levels. In 2000, when the last significant flood occurred, 109 properties were flooded as well as wide tracts of land close to Gatwick 2R. Following these floods an Upper Mole Flood Alleviation Scheme was developed by the Environment Agency to adapt to future changes in climate and provide an improved level of flood protection. The project involved creating new, or improving existing reservoirs to store large amounts of water during spells of heavy rainfall. The stored water is intended to be slowly be released back into the river, helping to reduce flood peaks downstream. The proposed storage reservoir sites included:

- Tilgate Lake in Tilgate Park (raising of an existing dam)
- Gatwick Stream at Worth Farm (new flood detention reservoir)
- Stanford Brook at Clay's Lake Pease Pottage (replacement of an existing dam)

The value of the case study is that it demonstrates a very recent approach of a developer to environmentally-sensitive design and mitigation in the Upper Mole catchment. The approach is summarised in the Environmental Statement for the project (see Environment Agency, 2011, Upper Mole Flood Alleviation Scheme Environmental Statement). In particular as compensation under the Water Framework Directive (and other legislation) river restoration works were carried out to an artificially straightened watercourse in Grattons Park, providing multiple environmental benefits.

For example, the Worth Farm project involved building a new embankment dam to a height of 6.5 metres above the surrounding land. Water is only temporarily stored and the land can be used for farming for most of the year. The scheme is designed such that in ties of high river flow the water is throttled and starts to build up behind the dam. The water remains there for a few days, before being slowly released back into the river (avoiding downstream flooding). The new dam required a supply of earth and bedrock, some from a nearby borrow pit. The existing environment was found to have some ecological sensitivity but there were no know archaeological sites. A culvert was required at the dam outlet. Although this allows for fish passage it is still regarded as contrary to policy and Water Framework Directive requirements and disrupts natural processes. So the mitigation for this included the replacement of a concrete lined channel at Grattons Park with a meandering watercourse.

3.3.2 Weir Structures

The implementation of weir structures in a channel can have a number of potential impacts, namely the removal of the natural channel cross-section, longitudinal and lateral connectivity of the river and creating a barrier to sediment and flow processes. If weir structures disrupt the transfer of sediment from upstream to downstream, the longitudinal connectivity of a river may be interrupted. Without mitigation this could lead to an increased area of sedimentation in turn potentially affecting channel flow.

Increased channel depth and decreased flow velocity upstream of a weir could also potentially lead to a number of negative impacts including loss of marginal vegetation, raised groundwater levels, potential for algal blooms and siltation (Rickard et al, 2003).

The proposal to implement a weir on the River Mole could potentially lead to impacts not only to the existing River Mole but also to the newly diverted Crawter's Brook and proposed River Mole channels. A weir could disrupt the transfer of sediment from upstream to downstream, interrupting the longitudinal connectivity of the river. Without mitigation this could lead to an increased area of sedimentation, potentially affecting channel flow.

The proposed reinforced banks around hydraulic structures could potentially negatively impact the water environment by:

- Acting as a barrier to floodplain connectivity;
- Decreasing hydraulic roughness;
- Removing morphological diversity of the bank;
- Removing areas of shade and reducing velocities important for fish, invertebrates and macrophytes; and,
- Eliminating sources of sediment to the channel.

Implementing a weir on a WFD water body has the potential to cause a deterioration in the overall Ecological Status if not mitigated sufficiently, and could prevent the water body from achieving Good status.

3.3.3 Structures

Little information is provided about the proposed structures and therefore, only generic impacts can be assessed.

Implementation of permanent outfall structures within a watercourse has the potential to locally alter the channel cross-section as well as the flow dynamics within a channel. Outfall headwalls would be likely to have localised impacts by removing a small section of natural bank and riparian vegetation, replacing this with artificial materials such as concrete and brick. A small section of channel bed could potentially be impacted upon depending on the detailed design of an outfall structure. A headwall could also have a localised impact on lateral connectivity of a watercourse with its floodplain and could potentially lead to erosion upstream and downstream of the structure itself. Flow directed by a set angle of an outfall could potentially cause localised erosion of the bed and opposite bank. It is possible that the small overall increase in the range of flows and the local scouring of areas surrounding an outfall could cause gravels to be cleaned, a potential benefit to fauna.

Fishing platforms could have the potential to alter local flow patterns and impact a small section of channel bank and bed. This would be dependent on the size and encroachment into the water body.

A clear span bridge is unlikely to have in-channel impacts due to the nature of the structure. However, abutments in the floodplain could potentially impact on the floodplain area and the lateral connectivity of the watercourse.

Each of the structures detailed above is unlikely to have a significant impact on a watercourse and are unlikely to cause a deterioration in the WFD. If more than one structure is implemented within a watercourse/water body, there could be the potential for cumulative impacts, e.g. a greater proportion of bank removal and replacement with hard engineering which could affect hydromorphological elements of the channel.

3.3.4 Water Quality

Increases in the volume of fuel and oils stored, conveyed and used on the site, could all lead to enhanced risk of an impact to the water environment. Fuel and oil storage would not be limited to aviation fuel but would also include heating oil for buildings, stand-by generator fuel and fuel for site vehicles. An increase in storage and use could lead to an increase in the likelihood that a release of contaminants (pollution incident) could occur even with precautionary measures in place. An increase in volume stored could also potentially increase the magnitude of the impact if a release did take place.

Operations including aircraft washing (cleaning agents and cadmium from aircraft), aircraft stand wash-down and aircraft maintenance could all potentially increase the volume of effluent generated. This could lead to an increase in the contaminant loading on interception, storage and attenuation/treatment facilities and increase the potential risk to the receiving water environment.

As well as this an increase in the use of de-icing chemicals on aircraft, runways, aprons and taxiways could all increase the risk to the water environment.

A potential positive impact could be a decrease in pesticides, herbicides and other pollutants, due to the replacement/ covering of open ground with hard impervious surfaces.

Limited information is provided with respect to the potential impacts to the water environment with the exception of de-icer. The report does however indicate that water would not be discharged before being treated to a standard consistent with the WFD Good water quality status. The assessment assumes that de-icer contaminated runoff would be managed through a positive drainage system and attenuated in pollution storage lagoons. Two sub options have been identified for the treatment of wastewater.

There is one historic landfill within the proposed footprint of the development and further assessment would be required prior to construction to identify potential hazards (Jacobs, 2014e). Areas of contaminated ground have the potential to impact the water environment if contaminants were mobilised during construction and operation activities.

The principal issues with respect to water quality are associated with the increase in the storage and use of hazardous materials (especially fuels and de-icer) during operations. Appropriate management procedures and protocols as well as physical interception, storage and treatment of contaminated water prior to discharge to the water environment, would be required.

3.4 Assessment of Potential Mitigation

Appendix D compares the mitigation measures recommended within this section and those detailed by the promoter. The following provides a summary of the mitigation measures. Any gaps that have been identified in the proposals provided by GAL are also detailed.

3.4.1 River Realignment Mitigation

There are a number of mitigation measures and best practices that could be potentially implemented to reduce the generic impacts detailed above:

- Design should incorporate variations in flow, depth and width to provide a variety of habitats;
- Materials used should be environmentally-appropriate and include timber and local rock rather than concrete or sheet piling;
- Realigned channels should be similar in length, width, depth and gradient to the old (original) channel (if appropriate to the flow and sediment regimes);
- Design should incorporate naturalised bed material (which could be characteristic of natural reaches of the same watercourse or neighbouring watercourses);
- Banks should be vegetated with native species (to promote stability);
- Channel design should be such to naturally convey the full range of flows from high to low;
- Possible storage and transfer of original/natural substrate from a redundant channel to a realigned channel should be considered;
- New river lengths, widths, depths and gradients should not compromise flow conveyance in adjoining downstream or upstream reaches; and,
- Design should consider location of areas of contaminated land. Mitigation could include lining of the channel.

If the mitigation were to be incorporated in the channel realignment design and operation, there would be likely to be no deterioration in the water body statuses or prevention from achievement of Good Status in the future.

3.4.2 Weir Structures

The following should be considered when designing and implementing weir structures into watercourses. Where possible the use of weirs should be avoided and alternatives, such as smaller check weirs made from natural boulders, implemented.

- Installation of fish passes and/or diversion channels to bypass the main weir structure;
- Careful design of weir layout;
- Headwalls and wing walls to be set within the line of the bank and married into the surroundings;
- Use of soft engineering (i.e. willow and reed pilling or imported natural stone) rather than hard engineering solutions. This should minimise the risk of downstream erosion;
- Careful selection of construction materials. Soft engineering techniques would be preferred to lessen the impact on hydromorphological quality;
- Planting of weir sides with native plants for channel stability;
- Seeking latest advice on weir design and mitigation measures from the Environment Agency and Natural England; and,
- Using alternative/compensation ecological mitigation measures (e.g. nesting boxes, backwaters, bankside planting, otter ramps).

In taking into consideration the mitigation measures detailed above, the potential impacts on the River Mole water body could potentially be reduced and deterioration

in the water body status avoided. However, the extent of the mitigation and the design of the weir would have a vital role in ensuring this is the case.

3.4.3 Structures

The following should be considered when designing and implementing some of the structures that are potentially proposed Gatwick 2R development:

Outfall
The following are some of the key best practices and mitigation measures that could be implemented in outfall design, to ensure that at the operation phase the outfalls have a minimal impact on the surrounding environment:

- The outfall should be directed in a downstream direction to minimise impacts to flow patterns;
- The outfall should be directed away from earth river banks to minimise any potential risk of erosion; and,
- The size/extent of an outfall should be minimised wherever possible to reduce the extent of potential impact on the banks.

Fishing Platform
The placement and design of fishing platforms would need to take into account natural channel processes and flow dynamics. It would be recommended that the encroachment of the fishing platform on the channel is reduced as far as possible, and that the natural channel bank and bed are maintained where possible. Implementing wooden structures as opposed to hard engineering would also be recommended.

Clear Span Bridge
A clear span bridge would be designed to ensure that a suitable corridor is left either side of the river to maintain some connectivity and passage for fauna as applicable. The channel cross-section would be unlikely to be altered due to the span of the structure and therefore no mitigation is anticipated to address this.

Each of the structures detailed above would be unlikely to have a significant impact on watercourses and unlikely, individually, to cause a deterioration in the status of WFD water bodies. The mitigation outlined should reduce potential impacts, However if multiple structures were to be built then there would be a potentially greater adverse impact.

3.4.4 Water Quality

There are a number of mitigation measures and best practice guidelines relevant to reducing any potential impacts on water quality, these are as follows:

Construction
- Development and implementation of a Construction Environmental Management Plan (CEMP) which would include:
  - Procedures to respond to any environmental incidents
  - Pollution prevention and material storage handling measures to be implemented
  - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location.
  - Groundwater and surface water monitoring requirements to be carried out before and during construction and during operation.

- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.
- Storage of excavated materials would be minimised and any temporary storage located away from surface watercourses and areas with permeable soils.
- Any contaminated water from excavation or dewatering activities would be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There would be no direct discharge of contaminated water to surface watercourses.

Operation

- Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing take place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase.
- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.

Whilst the mitigation measures identified in the proposal are in accordance with what is expected at this stage of the proposal with respect to de-icer, little consideration is provided with respect to other potential contaminant sources. Further detailed characterisation of hazardous materials with the potential to impact upon the water environment is required to ensure incorporation of appropriate mitigation measures into the construction and design phases of the development. However, it is likely that mitigation measures could be implemented that would manage water quality to ensure an appropriate discharge could be achieved from the site.

3.5 Promoter Submission – Potential Impacts and Mitigation

A summary of proposed works and mitigation measures related to WFD water bodies are set out in Appendix H.

3.5.1 River Mole and Crawter's Brook Realignment

Potential Impacts

GAL proposes to replace over 2km of culvert and engineered channel with two realigned channels running along the west and south side of the proposed development. The twin box culvert, which currently transfers water in the River Mole northwards under the existing runway, would be retained for drainage purposes.

Realignment of the River Mole and Crawter's Brook is seen by GAL as a potential opportunity to improve the water environment.

Potential Mitigation

The following are the key mitigation measures detailed in the GAL proposals for the realignment of several water bodies within the development:

- Gradient would match that of the original channel (to be replaced);
- Channel would be designed to be similar to the original channel (to be replaced);
- Sediment transport analysis would be undertaken to ensure no excessive erosion or deposition within the realigned channel;
- Further analysis would be required to determine suitable size of bed sediment; and,
- Locally-sourced materials would be used where possible.

The mitigation measures detailed by GAL encompass the majority of the basic mitigation detailed in Section 3.4.1. As the realignments would be in two channels, specific attention should be given to ensuring that the length, width, and depth (etc.) dimensions could accommodate the combined flow of two merged channels. Consideration should also be given to the location of the realignments to ensure that they do not cross contaminated land and if they do that there is appropriate mitigation.

3.5.2 River Mole Weir

Potential Impacts

GAL proposes to insert a broad crested weir structure on the existing River Mole to the south of the airport development to compensate for the 2m change in bed caused by diverting Crawter's Brook. GAL states that potential impacts could include a reduction in flow quality upstream of the impoundment, a reduction in downstream sediment transport, loss of natural bed and bank and a change in local composition of invertebrate communities.

In addition to the weir, the promoter proposes to implement artificial bank reinforcement around the structure and on any bank assessed to be at risk of erosion as a result of increased flow velocities.

Potential Mitigation

The GAL proposal details potential mitigation for the River Mole weir structure, including the following:

- Specific requirements and mitigation measures stipulated by the Environment Agency (and other bodies) would need to be followed for the structure to allow for suitable fish migration;
- Weir design would need to be compliant with current legislation and policy;
- A fish and eel pass would be incorporated in the design; and,
- EA would need to input to and approve design of fish passes.

The mitigation measures proposed to be provided by GAL for the implementation of a weir on the River Mole appear to consider all aspects of the design and the need for liaison with the Environment Agency. Other mitigation measures that could also be considered include: the installation of a diversion channel to maintain longitudinal connectivity, soft engineering rather than hard engineering solutions and the precise weir layout.

GAL also propose to assess the possibility of removing any need for impoundment by grading the upstream channel to fall with an average bed slope of 1 in 100 and include a series of features, including small head losses and pools, over a 250m channel length.

3.5.3 Structures

Potential Impacts

GAL proposes to implement a number of structures on the Crawter's Brook and River Mole. These would include a permanent clear span bridge, with abutments set-back from bank top, fishing platforms and outfalls. There is little information provided on the structures proposed and as such no potential impacts have been detailed at this stage.

Potential Mitigation

There are no specific details provided by GAL for mitigation of any of the structures detailed above that could be incorporated into the development proposals.

Section 3.4.3 outlines some potential mitigation that could be implemented to mitigate the structures proposed on the Crawter's Brook and River Mole. For the outfall structures these include minimising the size of the outfall headwalls and directing the discharged water downstream to avoid erosion of the adjacent or opposite banks. For the fishing platforms, potential mitigation measures include reducing the size of the structure where appropriate and using soft-engineering techniques (such as wood) over hard engineering techniques (such as concrete). Clear span bridges are not anticipated to require mitigation; however, incorporating a corridor either side of the channel bank top would enable some floodplain connectivity and passage for fauna.

3.5.4 Water Quality

Potential Impacts

A waste stream analysis is presented in Appendix F of the Water and Flood Risk Report (GAL, 2014), indicating that there are 3 airport operations activities creating waste water requiring treatment: de-icing, aircraft cleaning and aircraft servicing. GAL recognise that without mitigation de-icing activities and the cleaning/servicing of aircraft could present a particular pollution risk to the water environment.

Potential Mitigation

The following are detailed within the GAL proposals as potential mitigation measures to address the potential water quality impacts from the development:

Surface Water

- Active wetland treatment designed to improve existing water quality at the discharge point would be considered (aspirational design);
- Slot drains would be laid along the edges of taxiways and runway shoulders;
- Combined filter drains with grass or swales would be installed around the edges of the taxiways and the side of the runway;
- A detention basin (or 'clean' pond) would be included to discharge water with a concentration of biological oxygen demand of less than 14milligrams per litre (mg/l);
- A 'dirty' pond would be built to treat water with a concentration of biological oxygen demand of greater than 14mg/l;
- All runoff flows would be pumped to a balancing tank and treated via an active wetland treatment system;

- Centralised de-icing facilities would be used to limit contaminated runoff; and,
- De-icer contaminated runoff would be managed through a positive drainage system and storage lagoon.

Wastewater treatment

- Contaminated water would continue to be sent to an expanded Crawley Sewage Treatment Works (STW) for treatment (in a similar manner to that at present). Alternatively a local treatment plant would be installed to allow contaminated runoff to be treated on-site; and,
- An additional sewage and waste water wetland treatment system would be built.

Groundwater

- Excavated material from different water horizons, geological formations, or of distinctly different quality, would be separated to prevent potential cross-contamination; and,
- Material would be sampled and treated (if necessary) before being used as backfill.

The following are detailed within the GAL proposal as mitigation measures to address impacts from increased impermeable surfaces associated with the development:

- Attenuation storage would be provided to ensure no increase in flood risk up to the 1 in 100 year flood event (including an allowance for climate change); and,
- Slot drains along the edges of taxiways and runway shoulders.

Mitigation measures are focussed on de-icer much like the impact assessment. No mitigation measures are considered with respect to other potential hazards. The assessment assumes that de-icer contaminated runoff would be managed through a positive drainage system and attenuated in pollution storage lagoons. Two sub options have been identified for the treatment of wastewater. Option 1 is to continue to send contaminated water to an expanded Crawley STW for treatment in a similar manner to that at present. Option 2 is to install a local treatment plant to allow contaminated runoff to be treated on-site. This could potentially be sufficient. An extended or new treatment plant would need to be cognisant of the contaminant loading and volumes.

3.6 Gatwick Airport Second Runway Residual Risks - Conclusions

The GAL proposal report currently does not state any residual impacts as a result of the development.

The report identifies that there would still be additional opportunities in some areas for further mitigation, but this would need to be reviewed as the design progressed (including weir design and channel grading). It is mentioned that the chosen option would require further work to complete the detailed design to minimise some of the residual risks, including:

- Design of fish and eel passes and completion of fish pass approval forms (allowing for Environment Agency comments);
- A full hydraulic design is to be progressed, to establish flood risk;

- Full structural calculations and concrete designs to be completed; and,
- Assessment of river bank reinforcement impacts on channel processes.

Information and mitigation provided by the promoter regarding the realignment of the River Mole and the Crawter's Brook is sufficient and a diversion design approach has been agreed with the Environment Agency. However, consideration of other aspects, including contaminated land and riparian vegetation, should also be incorporated into the detailed design of the channel diversions.

The development has the potential to impact on the water environment, particularly without appropriate mitigation in place. Even with mitigation, there could be some residual impacts of concern to Regulators such as the Environment Agency. This issue is recognised by the promoter of 2R and explored in the Jacobs assessment.

It is estimated that approximately 7 kms of existing watercourse would be replaced with diverted/realigned channels as a result of this proposal. Diversion of approximately 1km of the River Mole to the west of the airport and diversion of the Crawters Brook would present technical challenges and would probably have residual adverse effects on the hydromorphology/geomorphology due to the changed gradients (increased channel lengths in both instances) and other associated uncertainties.

The addition of a weir to compensate for a 2m reduction in bed level at the Crawter's Brook/River Mole confluence would also probably have a significant residual impact. No culverting is proposed and there is a potential positive impact arising from removal of approximately 600m of existing culvert on the River Mole. There may also be other additional opportunities for mitigation (including as part of the design). The water bodies in the Gatwick study area are sensitive and activities such as culvert removal are in keeping with wider approaches promulgated in the upper Mole catchment for flood protection by the Environment Agency. In Grattons Park, for example, the Environment Agency allowed for mitigation of impacts arising from storage reservoirs elsewhere in the catchment. These works (now constructed) involved decommissioning an artificially straight urbanised channel and replacing it with a more natural meandering channel with varied channel features contained within it.

Several of the watercourses potentially affected by the GAL proposals now have the added protection (as water bodies) from the European Water Framework Directive. Any deterioration of ecological status (e.g. through realignment or the addition of a weir) would potentially be opposed by Regulators. In view of this, the development would probably need to progress through an Article 4.7 (of the WFD) route and a case proven that any environmental damage is outweighed by a greater public need (for an airport development). There could also be residual water quality impacts arising from polluted runoff, although GAL state that they believe that these impacts are mitigable (i.e. a positive drainage system and attenuation in pollution storage lagoons). The assessment by Jacobs recognises (from other case studies and prior experience) that (for example) despite mitigation at airports, contaminants such as de-icers do reach receiving watercourses at certain times. If this were the case then there could most likely be an adverse residual effect on WFD physico-chemical status despite mitigation commitments.

4 Water Quality Impacts - Heathrow Airport Northwest Runway

This section presents and assesses the Heathrow Airport Northwest Runway (NWR) submission, providing the following information:

- Outline of proposed works;
- Summary of baseline conditions in 2014 and projected to 2050 without a scheme in place;
- Jacobs' assessment of the potential impacts of the promoter's scheme on water quality and WFD water body status including river realignment and culverting;
- Assessment of potential options available to mitigate any impacts;
- Commentary on the proposers' submission;
- Assessment of residual risks.

4.1 Proposed Works

HAL is proposing to create a 3,500m runway to the north-west of the existing airport, along with two new terminal buildings, aircraft movement areas and taxiways, aircraft stands and car parking. The promoter is proposing to include the following modifications to the water environment:

- Diverting approximately 1km of the Colne Brook around the western extent of the new runway;
- Diverting part of the Duke of Northumberland's River, Longford River and the River Colne to the south of the runway;
- Creating a new channel (the 'River Colne Spur');
- Modifying a section of the Colne Brook, Horton Brook and Poyle Channel;
- Combining the River Colne and Wraysbury River in a single culvert underneath the new runway; and
- Combining the Duke of Northumberland's River and Longford River in a single culvert underneath the new runway.

Based on information from Appendix 25 in the HAL (2014a) report, it is estimated that the following approximate lengths of watercourses shown in Table 4.1 would be replaced with diverted/realigned channels due the proposed HAL development.

Table 4.1 - Approximate lengths of original channels replaced/diverted due to scheme development

River	Length (km)
Colne Brook	1.17
Wraysbury River	0.54
River Colne	2.91
Duke of Northumberland River	3.6
Longford River	2.22
Poyle Channel	1.81
Total	**12.25**

4.2 Summary of Baseline Conditions

The Heathrow NWR Study Area (Figure 4.1) is located within the Thames River Basin District (RBD) and lies within the Colne, London (Maidenhead to Sunbury) and London Management Catchments. The Study Area comprises London Clay Formation bedrock and superficial deposits dominated largely by alluvium[2] and sand/gravel (BGS, 2014).

Figure 4.1 - Location and current status of WFD water bodies within the Heathrow NWR Study Area

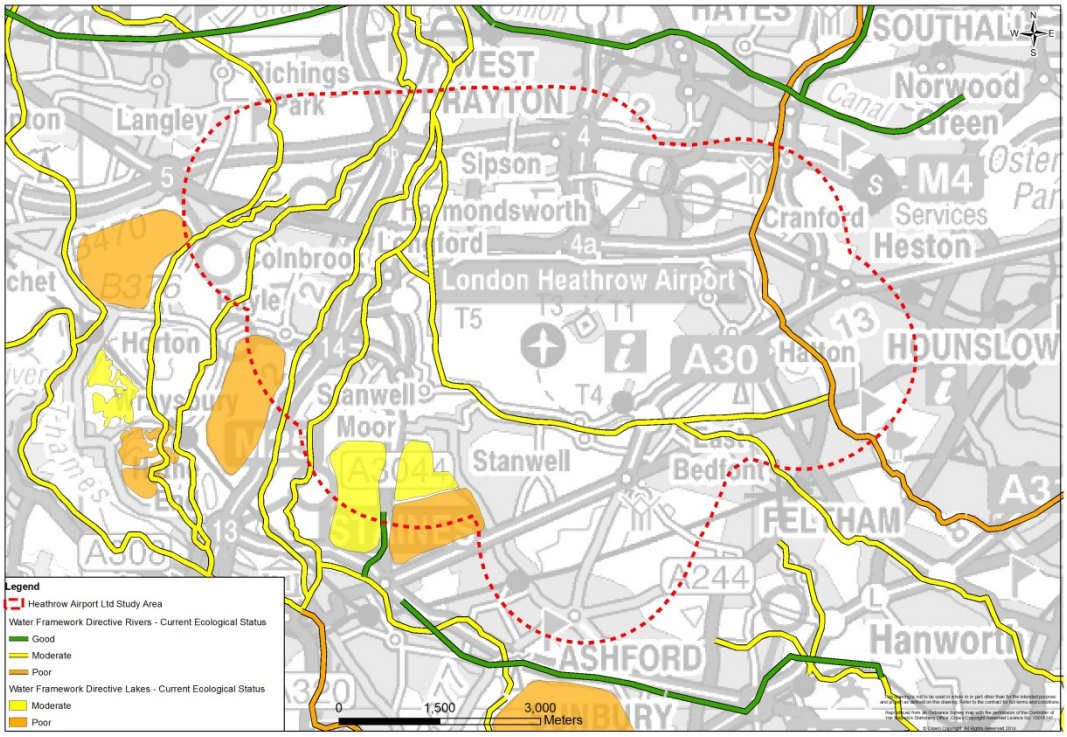

Table 4.2 details the Water Framework Directive (WFD) water bodies present within the Heathrow NWR Study Area (Environment Agency, 2009b), which include eight watercourses, five lakes/reservoirs and one groundwater body. The majority of the water bodies are classified as Artificial/Heavily Modified Water Bodies (A/HMWB) and are not expected to improve in ecological status by 2015.

Table 4.2 - Water Framework Directive classifications of water bodies within the Heathrow Study Area

Type	Number	Current Overall Ecological Quality	Hydromorphological Status
Watercourses	2	Good Potential	Heavily Modified Water Bodies
	4	Moderate Potential	Heavily Modified Water Bodies
	1	Moderate Status	Not Designated
	1	Poor Potential	Heavily Modified Water Bodies
Lakes/ Reservoirs	2	Moderate Potential	Artificial
	3	Poor Potential	Artificial
Groundwater	1	Good Quantitative Quality	N/A

[2] Alluvium – Unconsolidated sediments deposited by rivers

All of the lake water bodies within the Study Area are detailed as being artificial and deep with high alkalinity. All of the lake water bodies are reservoirs which are sources of water supply for London.

The overarching aim of the WFD is to achieve at least Good Ecological Status/Potential in all water bodies by 2027. However, it is acknowledged in the River Basin Management Plans that this is an ambitious and significant challenge. According to the Thames River Basin Management Plan the greatest pressure on the Colne and London (Maidenhead to Sunbury) Management Catchments, potentially preventing water bodies from achieving Good Status, is over abstraction and pollution (both agricultural and urban) (Environment Agency, 2009a).

The predicted 15% increase in passengers from 2026 to 2050 at Heathrow airport, along with an increase in population in the vicinity of the airport, is likely to put increasing pressure on the water environment. This pressure could affect the biological, physico-chemical and hydromorphological elements assessed under the WFD, which could prevent these water bodies from achieving Good Ecological Status by 2027.

The Thames River Basin Management Plan states that "*over the period to 2027, the pressures on the environment would change, particularly because of climate change. It is not known how the water environment would respond to this*" (Environment Agency, 2009a). Given uncertainty and changeability of projected climate scenarios and associated impacts on the water environment, any adaptation actions or mitigation measures should be resilient to a range of plausible climate change scenarios, rather than led by a single scenario (WWF and Natural England, 2010).

4.3 Assessment of Potential Impacts

4.3.1 Channel Creation

Channel creation can be used as a means to mitigate and potentially improve, enhance or restore natural variability to flow, sediment dynamics and habitats in river systems; they could also potentially cause impacts in themselves.

Potential changes in gradient, discharge and velocity associated with diverted channels could cause alterations to the baseline flow and sediment regime. This could potentially lead to localised deposition or erosion of a river bank and/or bed. Deposition associated with changed velocities could lead to siltation over a river bed, consequently impacting on aquatic ecology including fish, invertebrates and macrophytes. As a result, this could affect the biological elements of one or more of the WFD water bodies. Changed rates of erosion could also potentially cause impacts such as loss of riparian land, increased sediment delivery and potential release of contaminants into the water column. Changes to channel length caused by creation of a new channel or through purposeful increases of sinuosity, could also potentially impact existing sediment and flow regimes within the potentially affected channels.

Although it is assumed that channels would be designed to be self-maintaining as far as possible, a lack of full understanding of the uncertainties concerning channel dynamics/processes at the design phase could result in disruption to an existing channel equilibrium and channel instability. This could then lead to the need for future intervention to cope with adjustment, such as additional bank protection

measures to protect against loss of land or maintenance dredging (National Rivers Authority (NRA), 1997; EA, 2002).

Changes to the physical channel structure or the flow regime in a new channel could also have a potential to impact water quality and ecology both upstream and downstream of the directly affected reach.

HAL proposes to create a new channel running south-west called the Colne Brook Spur. Using information from Appendix 25 in the HAL (2014) report, the approximate length of the Colne Brook Spur can be calculated as 4.45km. The channel creation would be longer than that already existing. Although it is acknowledged that there would not be a net loss in discharge downstream of the site, increasing channel length would potentially lead to slower velocities, reduced sediment conveyance and increased sedimentation. This could alter hydromorphological elements (under WFD) of the Colne Brook such as quality and dynamics of flow, leading to a deterioration of water body status.

HAL has identified that the alignment of the new Colne Spur could interact with the Horton Brook, potentially for 400m. The two watercourses are currently likely to have differing biological, physico-chemical and hydromorphological characteristics and if interaction between the two occurs it could alter the status of the Horton Brook.

There is the potential for water quality to be impacted as a result of excavating the new channel (of the new Colne Spur) in an area of contaminated land. Contamination entering the watercourse through groundwater flow could adversely impact not only chemical quality of water within the River Colne Spur, but also compromise the physico-chemical status of receiving European WFD water bodies such as the Horton Brook. The deterioration of water quality could also impact upon ecological elements in the watercourse.

Without mitigation and careful consideration for channel design, it is possible that the creation of the Colne Brook Spur could cause a deterioration to upstream and downstream WFD water bodies.

It is unlikely that the scheme would impact on the Staines Moor Special Site of Scientific Interest (SSSI) which is located approximately 1.5km downstream of the scheme footprint. The SSSI is dependent on the flow within the semi-natural section of the River Colne, specifically for the continued existence of the brown galingale *Cyperus fuscus* (which is only present in two other locations within the British Isles). Further information is provided on this within the Biodiversity Assessment (Jacobs, 2014c.

4.3.2 Channel Realignment

HAL proposes to realign five WFD water bodies either around the development or under the runway in a culvert. The river realignments would need to ensure no deterioration to the overall Ecological Statuses of the water bodies or that they are not prevented from achieving Good status.

At present there are no specific detailed designs for the realignments. However, the following shown in Table 4.3 are approximate lengths that have been taken from Appendix 25 of the HAL (2014a) report; they have been based on information provided in the Figure only and are therefore subject to revision.

Table 4.3 - Length of proposed channel realignment

River	Length (km)
Colne Brook	1.26
River Colne	0.7
Duke of Northumberland River	3.65
Longford River	2.74
Horton Brook	0.77
Total	**9.12**

River realignments could provide an opportunity to improve the river environment, as described for Heathrow Airport Extended Northern Runway (Heathrow ENR) above. Although there could be positive outcomes it is likely there would also be negative impacts. Potential changes in gradient, discharge and velocity associated with realigned channels could cause alterations to the baseline flow and sediment regime. This could potentially lead to localised deposition or erosion of a river bank and/or bed. Deposition associated with changed velocities could lead to siltation over the river bed, consequently impacting on aquatic ecology including fish, invertebrates and macrophytes. As a result, this could affect the biological elements of one or more of the WFD water bodies. Changed rates of erosion could also potentially cause impacts such as loss of riparian land, increased sediment delivery and potential release of contaminants into the water column. Changes to channel length caused by diversions, realignments or through purposeful increases of sinuosity, could also potentially impact existing sediment and flow regimes.

Changes to the physical channel structure or the flow regime in a realigned channel could also have a potential to impact water quality and ecology both upstream and downstream of the directly affected reach.
If any of the river realignments led to an increase in the channel length, there could be subsequent impacts on the physical processes within the river, primarily by reducing the slope. There could also be potential impacts if realignment decreased the channel length. There is the potential that a realignment could have consequential impacts (both positive and negative) on the biological, physico-chemical and hydromorphological elements of the WFD status of the water bodies.

HAL would also need to consider upstream and downstream receptors (particularly tributaries) of these diverted watercourses as there could be secondary impacts (e.g. altered sediment transfers) from the proposed realignments.

The realignments would be unlikely to have any potential impact on the current WFD statuses or prevent the water bodies from achieving Good status, as long as the channel was designed appropriately. However, those water bodies proposed to be realigned within culverts under the runway could have potentially adverse residual impacts. These are detailed further below in the culverting section, but could potentially cause a deterioration in the water body status without mitigation.

4.3.3 Culverting

There is currently no information on culvert lengths which could potentially impact the flow and sediment regimes. The following (Table 4.4) are approximate culvert lengths that have been taken from Appendix 25 of the HAL (2014a) report; they have been based on the site boundary provided in the Figure and are therefore

subject to revision. They are the likely maximum length of culvert that could be required.

Table 4.4 - Length of proposed culvert

River	Length (km)
Wraysbury River	0.79
River Colne	0.79
Duke of Northumberland River	0.73
Longford River	0.73
Total	**3.04**

Culverting has the potential to significantly interfere with several aspects of the river environment including ecology, morphology, water quality and flooding. The Environment Agency and its predecessors have published a number of guidance documents on culverting and in practice typically object to culverting on environmental grounds. In 1999 they produced a policy on culverting (see Environment Agency, 1999).

Without mitigation, culverting of a channel could replace existing natural features (e.g. pool/riffle sequences, depositional and erosional features) with artificial materials. Culverting could also potentially interfere with continuity of upstream and downstream processes in water bodies, by creating or exacerbating bank/bed erosion, changing the sediment regime or by inducing deposition due to changed velocities and flow patterns. Culverting could potentially lead to narrowing of a natural channel and disruption to an existing channel gradient and sediment conveyance (NRA, 1997; EA, 2002). Shading could also eliminate aquatic plants that might otherwise be important in determining morphological patterns of deposition through growth and die back.

Culverting sections of watercourses at Heathrow could also disconnect the exchanges of water between channels and their floodplains, as well as disrupting connectivity with groundwater. This could have consequential impacts on floodwater storage, drainage, water quality and ecology. Culverts would typically cause loss of riparian corridor, and changed water chemistry through decreasing water turbulence, leading to reduced water oxygenation.

The culverting of three WFD water bodies (comprising four channels) has the potential to have quite a significant impact on the water environment. Culverts could reduce the biological, physico-chemical and the hydromorphological quality elements if not mitigated appropriately. This could subsequently, without considering mitigation, cause a deterioration in one or more of the three water body statuses or prevent each from achieving Good status in the future.

Within two culverts, HAL propose to combine separate water bodies into one. Such an approach would potentially be regarded as detrimental by the Regulators. Arguments for retaining separate channels were well rehearsed by the EA at the Heathrow Terminal 5 Public Enquiry for the Longford and Duke of Northumberland's Rivers (known as the Twin Rivers). From a WFD and general regulatory perspective, combining two water bodies/watercourses would reduce total channel length significantly (and therefore the available habitat). Also, the combined lengths would fundamentally alter the channel morphology including sediment processes with concurrent ecological implications.

4.3.4 Channel Modifications

The HAL proposals provide no specific information on the likely modifications to the Colne Brook and Horton Brook (both WFD water bodies). If the modifications required introduction of hard-engineering techniques, such as concreted banks, this could have the potential to impact WFD statuses of the water bodies. The nature and design of the modifications would enable a better assessment of their likely impacts.

The detailed design of both the modifications to the two WFD water bodies and those to rework the Poyle Channel would need to take into consideration geomorphological and ecological considerations to reduce potential for ongoing maintenance through sediment accumulation or erosion.

The approximate lengths of modified channels listed in Table 4.5 have been taken from Appendix 25 in the HAL (2014a) report. These measurements have been based on information provided in the Figure only and are therefore subject to revision.

Table 4.5 - Proposed lengths of modified channels

River	Length (km)
Colne Brook	0.86
Horton Brook (to accommodate Colne Brook Spur)	0.76
Poyle Channel (to accommodate Colne Brook Spur)	0.86
Total	**2.48**

4.3.5 Water Quality

Increases in the volume of fuel and oils stored, conveyed and used on the site, could all lead to enhanced risk of an impact to the water environment. Fuel and oil storage would not be limited to aviation fuel but would also include heating oil for buildings, stand-by generator fuel and fuel for site vehicles. An increase in storage and use could lead to an increase in the likelihood that a release of contaminants (pollution incident) could occur even with precautionary measures in place. An increase in volume stored could also potentially increase the magnitude of the impact if a release did take place.

Operations including aircraft washing (cleaning agents and cadmium from aircraft), aircraft stand wash-down and aircraft maintenance could all potentially increase the volume of effluent generated. This could lead to an increase in the contaminant loading on interception, storage and attenuation/treatment facilities and increase the potential risk to the receiving water environment.

An increase in the use of de-icing chemicals on aircraft, runways, aprons and taxiways could all increase the risk to the water environment.

A potential positive impact could be a decrease in pesticides, herbicides and other pollutants, due to the replacement/ covering of open ground with hard impervious surfaces. However an increase in the spatial extent of paved surfaces could potentially have several impacts on water quality and the affected WFD water bodies in the absence of appropriate mitigation. The impervious areas could result in an increase in surface water runoff. This could alter the flow and sediment dynamics

in receiving watercourses (including WFD water bodies). Also changes to the volume and rate of surface water runoff could potentially increase the likelihood of pollutants/sediments being mobilised and transported. An increase in the volume and transport rates of these pollutants/sediments could impact upon the efficiency of existing contaminant interception, storage and attenuation facilities.

Currently two of the WFD water bodies (rivers and groundwater) in the Heathrow NWR Study Area are classified as having a 'Failing' chemical status, so a potential increase in pollutants could have a more magnified impact on these water bodies.

The principal issues with respect to water quality are associated with an increase in the storage and use of hazardous materials (especially fuels and de-icer) during operations. Appropriate management procedures and protocols as well as physical interception, storage and treatment of contaminated water prior to discharge to the water environment, would be required. Additionally, it is possible that during construction, contaminants associated with existing sources of hazards, such as historic and current landfills, could be mobilised leading to adverse impacts. There are two active landfills and 16 historic landfills within the footprint of the site that could potentially impact the water environment if disturbed during construction and operation activities (Jacobs, 2014e).

4.3.6 Weir Structures

It has been identified that weirs could be required as part of the works to realign the watercourses. However, no specific information is available on which watercourses/water bodies the weirs would be located on or the number or size of the structures.

The implementation of weir structures in a channel can have a number of potential impacts, namely the removal of the natural channel cross-section, disruption of longitudinal and lateral connectivity of the river and creation of a barrier to sediment and flow processes. If weir structures disrupt the transfer of sediment from upstream to downstream, the longitudinal connectivity of a river could be interrupted. Without mitigation this could lead to an increased area of sedimentation and in turn potentially affect channel flow.

Increased channel depth and decreased flow velocity upstream of a weir could also potentially lead to a number of negative impacts including loss of marginal vegetation, raised groundwater levels, potential for algal blooms and siltation (Rickard et al, 2003).

Implementing a weir on any of the WFD water bodies in the Study area has the potential to cause a deterioration in the overall Ecological Status if not mitigated sufficiently. The cumulative impact of a number of weirs on one water body would have a greater impact than if a singular structure was to be implemented.

4.4 Assessment of Potential Mitigation

Appendix F compares generic mitigation measures recommended within this section and those detailed by the promoter. The following provides a summary of generic mitigation measures. Any gaps that have been identified in the proposals provided by HAL are also detailed.

4.4.1 Channel Creation Mitigation

There are a number of mitigation measures and best practices that could be potentially implemented to reduce the generic impacts that have been detailed above. The following are some of the key measures that could be implemented through the design, construction and operational phases of channel creation:

- Design should incorporate variations in flow, depth and width to provide a variety of habitats;
- Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling;
- Realigned channels should be similar in length, width, depth and gradient to the old (original) channel (if appropriate to the flow and sediment regimes);
- Design should incorporate naturalised bed material (which could be characteristic of natural reaches of the same watercourse or neighbouring watercourses);
- Banks should be vegetated with native species (to promote stability);
- Channel design should be such to naturally convey the full range of flows from high to low;
- Possible storage and transfer of original/natural substrate from a redundant channel to a realigned channel should be considered;
- New river lengths, widths, depths and gradients should not compromise flow conveyance in adjoining downstream or upstream reaches; and,
- Design should consider location of areas of contaminated land. Mitigation could include lining of the channel.

If the mitigation measures were to be incorporated into the design and operation of the Colne Brook Spur, it is unlikely that there would be any residual impacts on the created watercourse. It would also be unlikely that there is any impact on the connected WFD water bodies (including their current statuses).

4.4.2 River Realignment

There are a number of mitigation measures and best practices that could be potentially implemented to reduce the generic impacts that have been detailed above.

- Design should incorporate variations in flow, depth and width to provide a variety of habitats;
- Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling;
- Realigned channels should be similar in length, width, depth and gradient to the old (original) channel (if appropriate to the flow and sediment regimes);
- Design should incorporate naturalised bed material (which could be characteristic of natural reaches of the same watercourse or neighbouring watercourses);
- Banks should be vegetated with native species (to promote stability);
- Channel design should be such to naturally convey the full range of flows from high to low;
- Possible storage and transfer of original/natural substrate from a redundant channel to a realigned channel should be considered;
- New river lengths, widths, depths and gradients should not compromise flow conveyance in adjoining upstream or downstream reaches; and,

- Design should consider location of areas of contaminated land. Mitigation could include lining of the channel.

In considering the mitigation detailed above, the WFD water bodies that are proposed to be realigned around the development would be unlikely to have any potential residual impacts affecting the current WFD statuses or preventing each water body from achieving Good status. However, those water bodies proposed to be realigned within culverts under the runway could have potentially adverse residual impacts. Further mitigation for the culverting of the water bodies would need to be considered, these are detailed further below in the culverting section.

4.4.3 Culverting

There are a number of best practice guidelines available detailing key design criteria for culverts, these include: Environment Agency Culvert Guidelines (see Appendix B), Environment Agency Policy Regarding Culverts (Environment Agency, 1999) and CIRIA Culvert Design and Operation Guide (CIRIA, 2010). The following are some of the key principles detailed in these documents:

- Design should consider the passage of both water and sediment for a range of flows;
- Design should consider the potential for partial or complete blockage of the culvert by debris or sediment during high flow events;
- Culvert gradient should be matched to the gradient of an existing stream to avoid erosion at the head or tail of the culvert;
- Reduction of river length by shortening the river planform should be avoided
- Keeping length of a culvert to a minimum;
- Depressing the invert of a culvert to allow for the formation of a natural bed. This could potentially be filled using excavated (and stored) material from the channel being replaced;
- A culvert of similar cross-sectional size should be used;
- Roughness of culvert inverts should be increased to help reduce the velocity of the water; and,
- There should be consideration of potential use of lighting options (dependent on surroundings and available resources).

Through implementing mitigation measures within the design of culverts, it is still possible that there could be significant residual impacts on the three WFD water bodies and their current statuses or ability of each to achieve Good status. Consideration should be given to mitigation measures requiring compensation for the loss of habitat and natural channel cross-section. This could include like-for-like replacement of habitat within the same water body either upstream or downstream.

4.4.4 Water Quality

There are a number of mitigation measures and best practice guidelines relevant to reducing any potential impacts on water quality. These are as follows:

Construction

- Development and implementation of a Construction Environmental Management Plan (CEMP) including:
  - Procedures to respond to any environmental incidents
  - Pollution prevention and material storage handling measures to be implemented

  - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location.
  - Groundwater and surface water monitoring requirements to be carried out before and during construction and during operation.
- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.
- Storage of excavated materials would be minimised and any temporary storage would located away from surface watercourses and areas with permeable soils.
- Any contaminated water from excavation or dewatering activities would be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There would be no direct discharge of contaminated water to surface watercourses.

Operation

- Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing takes place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase.
- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.

Mitigation to address potential water quality impacts are addressed in the proposals. The mitigation measures proposed include runoff attenuation, SuDS and interceptors to provide storage for major spills.

Mitigation measures identified are generic; further assessment of potential contaminant sources, contaminant migration pathways and receptors would be required to ensure inclusion of appropriate and specific mitigation (both management protocols and engineered systems) in the construction and operational phases.

4.4.5 Weir Structures

The following should be considered when designing and implementing weir structures into watercourses. Where possible the use of weirs should be avoided and alternatives implemented, such as smaller check weirs, made from natural boulders:

- Installation of fish passes and/or diversion channels to bypass the main weir structure;
- Careful design of weir layout;
- Headwalls and wing walls to be set within the line of the bank and married into the surroundings;
- Use of soft engineering (i.e. willow and reed pilling or imported natural stone) rather than hard engineering solutions. This should minimise the risk of downstream erosion;
- Careful selection of construction material. Soft engineering techniques would be preferred to lessen the impact on hydromorphological quality;
- Planting of weir sides with native plants for channel stability;

- Seeking latest advice on weir design and mitigation measures from the Environment Agency and Natural England; and,
- Using alternative/compensation ecological mitigation measures (e.g. nesting boxes, backwaters, bankside planting, otter ramps).

In taking into consideration the mitigation measures detailed above, the potential impacts on a watercourse/water body could be reduced. If a weir structure were to be implemented on a WFD water body, mitigation measures should be designed to mitigate for some of the impacts and potentially prevent any deterioration in water body status. If more than one weir is implemented on a WFD water body, the cumulative impact would potentially have a greater impact, in particular a deterioration in water body status or the potential for a water body to not meet Good status in the future.

4.5 Promoter Submission – Potential Impacts and Mitigation

A summary of proposed works and mitigation measures related to WFD water bodies are set out in Appendix H.

4.5.1 Creation of the River Colne Brook Spur

Potential Impacts

HAL propose to create a new channel running south-west from the Colne Brook at Thorney (north of Junction 15 on the M25), called the Colne Brook Spur. The proposed channel planform utilises part of the existing Horton Brook channel for approximately 400m, before turning to the south-east and flowing into the Colne Brook south of Colnbrook. The channel creation would be likely to add significant length compared with the rivers proposed to be replaced within the vicinity of Heathrow Airport.

Creation of the River Colne Spur could also potentially lead to water quality impacts as a consequence of excavations through contaminated land as described in the HAL submission (AMEC, 2014).

Potential Mitigation

The following are the key mitigation measures and best practices detailed in the HAL proposals for the creation of the River Colne Spur:

- New channels designed to maintain connectivity of flow in all rivers;
- Designed to ensure no net change to downstream flow;
- Bed of new channel to be lined with impermeable material wherever it is necessary to prevent contamination entering the river;
- Best practice during channel design;
- Channel designed with natural banks and bed materials wherever possible;
- Channel would have sufficient space and flexibility for natural evolution of the channel structure; and,
- Transfer of cobbles and boulders from original channel.

The mitigation measures detailed by HAL for the creation of the Colne Spur encompass the majority of the mitigation detailed in Section 4.4.1 for river realignment. This would include transfer of original channel bed material and best practice designs. There is no specific mention in the proposals of ensuring similar

channel gradient and length to the existing channel. This should be a primary consideration when creating a new channel.

4.5.2 Channel Realignment

Potential Impacts

HAL proposes to realign several water bodies to direct them around the development or to culverts running underneath the runway. The following major watercourses (excluding small drains, streams and connections) would be impacted due to realignment:

- River Colne (GB106039023090 - Colne and GUC (from confluence with Chess to Ash));
- Wraysbury River (GB106039023090 - Colne and GUC (from confluence with Chess to Ash));
- Duke of Northumberland River (GB106039023480 - Ash and Stanwell Brook);
- Longford River (GB106039023450 - Port Land Brook); and,
- Horton Brook (GB106039023040).

Potential impacts associated with channel realignment are detailed in Section 4.3.2. Without mitigation similar water quality impacts to those detailed in the channel creation section (Section 4.4.1) could arise from the realignment of the five watercourses, particularly if the channel passed through contaminated land.

HAL states that the diversion of the Horton Brook at Colnbrook to accommodate the Colne Brook Spur would be carefully designed to provide the potential for localised improvements to aquatic and riparian habitat compared to the baseline.

Potential Mitigation

The following are the key mitigation measures detailed in the HAL proposals for the realignment of several water bodies within the development:

- Channel diversion design to utilise best practice to maximise habitat opportunities;
- Channels designed to provide high quality aquatic and riparian habitat;
- Connectivity maintained between all river channels in the Colne valley;
- Diverted channels designed as natural meandering channels, including features such as pools, riffles and natural banks and bed; and,
- Transfer of cobbles and boulders from current river channels.

Mitigation measures detailed by HAL encompass the majority of the basic generic mitigation detailed in Section 4.4.2. There is no specific detail given to ensuring similar channel gradients and length on the new channels or appropriate mitigation measures that could be used if this could not be achieved.

4.5.3 Culverting

Potential Impacts

HAL proposes to divert three WFD water bodies under the new runway through two large culverts. The River Colne and the Wraysbury River (GB106039023090 - Colne and GUC (from confluence with Chess to Ash)) would be combined in one culvert

and the Duke of Northumberland River (GB106039023480 - Ash and Stanwell Brook) and Longford River (GB106039023450 - Port Land Brook) combined in another culvert to the east.

The promoter states combining the Wraysbury River and River Colne and the Longford River and Duke of Northumberland's River and culverting the channels under the runway would result in loss of habitat.

Potential Mitigation

The HAL proposals suggest that all culvert design would follow the Environment Agency culverting guidelines (see Appendix B) and that consultation with the Environment Agency would be undertaken regarding the culvert design. The following are the other key considerations and mitigation measures detailed in the proposal:

- Appropriate depths and velocities of flow would be ensured, avoiding steps and perched sections;
- A two-stage channel would be implemented;
- Consideration would be given to potential use of lighting options for ecological purposes;
- Water quality upstream and downstream of the culvert would be monitored regularly;
- Culverts would be designed to facilitate fish passage; and,
- Compensation would be recommended such as the creation of a new natural channel with diverse aquatic and riparian habitat.

The HAL proposal provides details on following the Environment Agency culverting guidelines (provided in Appendix B) to inform a suitable culvert design. It should also be noted that there are other guidelines available including the CIRIA Culvert Design and Operation Guide (CIRIA, 2010) that should be followed. The mitigation measures detailed in the proposal and the use of these guidelines should provide a suitable culvert design.

4.5.4 Channel Modifications

Potential Impacts

HAL proposes to modify a section of the Colne Brook at Thorney and a section of Horton Brook at Colnbrook to accommodate part of the new River Colne Spur. It is not stated by the promoter what precisely the modifications would involve. Potential impacts would need to be assessed following the design of the modifications.

HAL also proposes to rework the Poyle Channel to create a smaller, sinuous channel (within the existing channel) suited to a reduced volume of flow, that would be caused by the creation of the new River Colne Spur.

Potential Mitigation

There are no specific details provided by HAL of any requirement for mitigation of any channel modification.

4.5.5 Water Quality

Potential Impacts

The Water Quality and Hydro-ecology Assessment (AMEC, 2014) acknowledges that without mitigation, construction activities would have potential to cause pollution to surface and groundwater through mobilisation of sediment or fuel spills. Construction could also require excavation into the gravel aquifer (within the Colne Valley) as well as piling. The report acknowledges that there are areas of made ground[3] in the vicinity of the site, which could also be disturbed during construction and result in the mobilisation of contaminants.

The report identifies that airport operations generally involve considerable use of fuels and de-icers, and that without mitigation runoff containing spills or residues of fuel and de-icer could potentially enter surface or groundwater.

Table 4.3 within The Water Quality and Hydro-ecology Assessment (AMEC, 2014) provides a summary of effects on each of the identified receptors following mitigation including the impact on water quality.

In Section 5.4 of the report (AMEC, 2014) it is reiterated that one of the key elements of a natural environment mitigation strategy would be to ensure that the development had no impact on the surface water and groundwater quality through appropriate channel design, construction practices or airport operation. The report then indicates that a robust Sustainable Drainage Strategy would be fully developed and any existing airport procedures revised and updated to address any additional risks from new infrastructure.

Potential Mitigation

Construction

- A CEMP would be developed incorporating Pollution Prevention Guidance and Construction Practice guidance.
- Surface water quality monitoring including recording of both chemical and biological parameters would be undertaken in key risk areas including during the creation of the River Colne Spur channel and other construction areas in close proximity to surface watercourses. This would be continued into operation.
- Installation of boreholes to monitor/sample groundwater quality during construction and operation
- No storage of excavated materials on permeable surfaces. Excavated materials would not be left exposed on the ground surface. This would reduce the likelihood for migration of contaminations to groundwater or surface water.
- Excavated material from different water horizons, geological formations, or of distinctly different quality, should be separated to prevent the potential for cross-contamination.
- Material to be sampled and treated (if necessary) before using as backfill.
- Material unable to be treated would be disposed of off-site in line with legislative requirements.

[3] Made ground is the term used to describe deposition of soil material (by man) of unknown composition. Soil is typically 'tipped' rather than placed by engineering methods and could contain potential contaminants.

- Good practice would be followed during borehole drilling and development and other site activities near boreholes into the chalk aquifer.
- Good practice would be followed during drilling and the storage of fuel. An emergency response plan would be developed and kept up to date to enable any pollution incidents or extreme weather events to be responded to effectively.
- During dewatering operations (likely during construction of basement structures) impermeable structures such as coffer dams would be used to minimise the extent of impact of dewatering on the surrounding groundwater body.
- Suspended solids or oil generated on site through dewatering or other construction activities would be separated prior to discharge.
- Maintenance of impermeable surface water features to prevent deterioration.

Operation

- Implementation of a Sustainable Drainage Strategy which would include:
  - Dedicated areas for de-icing aircraft and a glycol recovery procedure to reduce the concentration of glycol within surface water runoff;
  - Separate attenuation storage tanks for 'clean' and 'first flush' surface water runoff; and,
  - An engineered wetland designed to treat excess glycol.
- Permits for any discharges of treated runoff that are required would be agreed with the EA. There would be no discharges to groundwater due to the risk of mobilising existing contamination.
- Development of a fertiliser and pesticide application strategy to reduce the potential for nitrate leaching.
- Possible addition of a new Sewage Treatment Works, with some of the treated water to be re-used for non-potable purposes within the Airport.
- The bed of the new channel of the River Colne Spur would be lined with impermeable material (e.g. clay) to prevent contamination from the underlying contaminated land entering the river.

The following are detailed within the HAL proposal as mitigation measures to address the impacts from increased impermeable surfaces associated with the development:

- Re-use of surface water would be maximised. Rainwater would be harvested from building roofs, treated water from the wetland and soft water from the glycol recovery process would be re-used. This would reduce the volume of water being discharged to watercourses;
- Excess water would be discharged to watercourses at greenfield rates;
- A perimeter drain around the edge of the impermeable areas of the site would be installed to capture excess surface runoff during storm events;
- Oversized pipes would capture water from the perimeter drain providing capacity up to the 1 in 100 flood event (plus climate change); and,
- Surface water would be directed to two centrally located underground storage tanks, also with storage up to the 1 in 100 year flood event.

4.5.6 Weir Structures

Potential Impacts

The proposals from HAL suggest that some weir structures could be implemented as part of the proposal, but no specific information is given on the potential locations or sizes of these structures.

Potential Mitigation

As the HAL proposal includes little information on the requirement of weirs as part of the development, the potential mitigation for these structures is also minimal. The following are the key measures detailed in the proposals:

- Use of appropriate fish passes; and,
- Fish passes would be designed to accommodate medium swimming strength coarse fish.

The mitigation measures provided by HAL for the implementation of a weir in a watercourse/water body primarily focus on fish passage. Although this is a primary concern, mitigation measures could also include the installation of a diversion channel to maintain longitudinal connectivity, soft engineering rather than hard engineering solutions and the weir layout. Liaison with the Environment Agency and Natural England to involve and seek their advice is also recommended.

4.6 Heathrow Airport Northwest Runway Residual Risks - Conclusions

Based on the assumption that application of best practices in design and construction would be used along with suitable mitigation, HAL state that no adverse residual risks to water quality would arise from the airport expansion. It is stated that some local impacts to flow would occur from channel modification and addition of the Colne Brook Spur; and the loss of habitat would be a residual risk from combining and culverting four channels. It is acknowledged that impacts would arise from culverting the existing WFD water bodies. However, HAL state that the implementation of a mitigation strategy would maximise habitat opportunities on the whole and prevent any impact to water quality.

Whilst it is generally recognised that impacts arising from airport construction and operation would to varying degrees be mitigated, potentially significant adverse residual impacts could remain for the development proposals. From previous experience of airport developments and other developments in general these residual impacts could include:

- Permanent changes to channel alignments or creation of new channels (either increasing or decreasing slopes);
- Permanent culverting of watercourses/water bodies;
- Permanent structures (such as weirs); and,
- Contaminated runoff impacting on WFD physico-chemical status.

There are also potential residual impacts on water quality arising in operation despite mitigation, such as accidental spillage or failure of equipment and consequential pollution of downstream receiving waters. There is also some potential risk from liners to channels through contaminated land (or landfills) subsequently becoming inadvertently breached.

The development has the potential to impact on the water environment, particularly without appropriate mitigation in place. Even with mitigation there would most likely be considerable residual impacts that would be of significant concern to Regulators such as the Environment Agency. This issue is recognised by HAL and is explored more fully in this assessment.

It is estimated that approximately 12.25kms of existing watercourse would be replaced with diverted/realigned channels as a result of this proposal. Diversion of approximately 1km of the Colne Brook around the western end of a new runway, diversions of parts of the Duke of Northumberland's River and River Colne to the south of the new runway and creation of a new channel (the 'River Colne Spur') would not only present technical challenges, but would probably have residual adverse effects on the hydromorphology/geomorphology due to the changed gradients and other associated uncertainties.

Culverting the Longford River, the Duke of Northumberland's River, River Colne and Wraysbury River beneath the proposed runway would probably have significant adverse residual impacts. There is considerable scientific literature showing that certain impacts of culverts are largely unmitigable. A provisional estimate shows that approximately 3km of currently open channels would be culverted by the proposals. This would probably be unprecedented in the UK in modern times. The River Bollin (a single channel) was culverted in the 1990's over a distance of about 0.25km to accommodate a second runway at Manchester. The proposal to combine channels would be adverse particularly from a loss of water body/watercourse length.

The water bodies in the Heathrow study area are sensitive and extensive diversions/culverting/combining channels would run counter to the considerable work put in by the Environment Agency and its predecessors to provide environmentally-friendly flood schemes (as part of the Lower Colne Catchment flood scheme) and also in successfully rebutting culverting/syphoning proposals of the Longford and Duke of Northumberland's rivers at Heathrow Terminal 5 (again in the 1990's). Several of the watercourses now have the added protection (as water bodies) from the European Water Framework Directive. Any deterioration of ecological status (which would undoubtedly arise from culverting) would potentially be opposed by Regulators. In view of this, the development would probably need to progress through an Article 4.7 (of the WFD) route and a case proven that any environmental damage is outweighed by a greater public need (for an airport development).

There could also be residual water quality impacts arising from polluted runoff, although HAL state that they believe that these impacts are mitigable. The Jacobs' assessment recognises that it is often recognised (for example) that despite mitigation at airports, contaminants such as de-icers do reach receiving watercourses at certain times. If this were the case there could most likely be an adverse residual effect on WFD physico-chemical status despite mitigation commitments.

5 Water Quality Impacts - Heathrow Airport Extended Northern Runway

This section presents and assesses the Heathrow Airport Extended Northern Runway (ENR) submission, providing the following information:

- Outline of proposed works;
- Summary of baseline conditions in 2014 and projected to 2050 without a scheme in place;
- Jacobs' assessment of the potential impacts of the promoter's scheme on water quality and WFD water body status including river realignment and culverting;
- Assessment of potential options available to mitigate any impacts;
- Commentary on the proposers' submission;
- Assessment of residual risks.

5.1 Proposed Works

This scheme proposal is for a runway extension of the existing Heathrow Airport northern runway. The embankment for the proposed westerly extension of the north runway, taxiways and apron would impact on two key river channels within the Colne Valley – the River Colne and the Colne Brook. The promoters (HH) also propose to make some sections of the Wraysbury River, the Poyle Channel, the Duke of Northumberland's River and the Longford River obsolete. An addition of 400ha of impermeable surfaces would be created by the Heathrow ENR, with a consequent increase (if unmitigated) of surface water runoff.

The development would specifically involve:

- Diverting the Colne Brook and the Poyle Channel around the west end of the extended north runway;
- Culverting the Longford River, the Duke of Northumberland's River, the River Colne and the Wraysbury River underneath the proposed runway; and,
- The addition of 400ha of impermeable surfaces.

Based on information from Jacobs (2014b) (Figure B1988000-PH2-1.3-SK003 Version 1.0), it is estimated that the following approximate lengths of watercourses would be replaced with diverted/realigned channels due the proposed airport development (Table 5.1).

Table 5.1 - Approximate lengths of original channels replaced/diverted due to scheme development

River	Length (km)
Colne Brook	1.01
Wraysbury River	2.32
River Colne	2.17
Duke of Northumberland's River	2.53
Longford River	2.37
Poyle Channel	2.2
Total	**12.6**

The Heathrow ENR development would also incorporate a series of roads and road improvements to provide better access to the site.

5.2 Summary of Baseline Conditions

The Heathrow ENR Study Area (Figure 5.1) is located within the Thames River Basin District (RBD) and lies within the Colne, London (Maidenhead to Sunbury) and London Management Catchments. The geology within the location of Heathrow Airport comprises London Clay Formation bedrock and superficial deposits dominated largely by alluvium[4] and sand/gravel (BGS, 2014).

Figure 5.1 - Location and current status of WFD water bodies within the Heathrow ENR Study Area

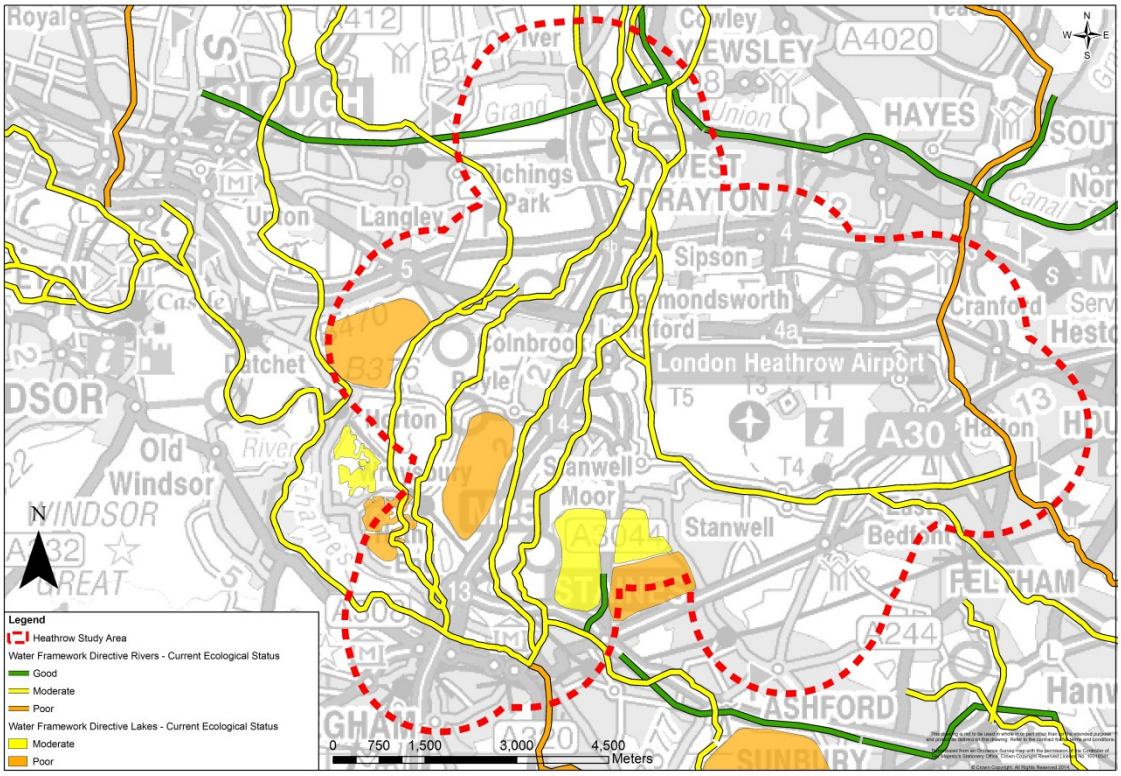

Table 5.2 details the Water Framework Directive (WFD) water bodies present within the Heathrow ENR Study Area (Environment Agency, 2009b). They comprise 14 watercourses, six lakes/reservoirs and one groundwater body. The majority of the water bodies are classified as Artificial/Heavily Modified Water Bodies (A/HMWB) and are not expected to improve in ecological status by 2015.

[4] Alluvium – Unconsolidated sediments deposited by rivers

Table 5.2 - Water Framework Directive classifications of water bodies within the Heathrow ENR Study Area (see Appendix G for a detailed breakdown of the water bodies)

Type	Number	Current Overall Ecological Quality	Hydromorphological Status
Watercourses	1	Good Status	Not Designated
	4	Good Potential	Heavily Modified Water Bodies
	6	Moderate Potential	Heavily Modified Water Bodies
	1	Moderate Status	Not Designated
	2	Poor Potential	Heavily Modified Water Bodies
Lakes/ Reservoirs	2	Moderate Potential	Artificial
	4	Poor Potential	Artificial
Groundwater	1	Good Quantitative Quality	N/A

All of the lake water bodies within the Study Area are detailed as being artificial and deep with high alkalinity. Five of the six lake water bodies are reservoirs providing sources of water supply for London, and one is a gravel pit located in Wraysbury.

The overarching aim of the WFD is to achieve at least Good Ecological Status/Potential in all water bodies by 2027. However, it is acknowledged in all River Basin Management Plans that this is an ambitious and significant challenge. According to the Thames River Basin Management Plan the greatest pressure on the Colne and London (Maidenhead to Sunbury) Management Catchments, potentially preventing water bodies from achieving Good Status, is over abstraction and pollution (both agricultural and urban) (Environment Agency, 2009a).

The predicted 15% increase in passengers from 2025 to 2050 at Heathrow Airport, along with an increase in population in the vicinity of the airport, is likely to put increasing pressure on the water environment. This pressure could affect the biological, physico-chemical and hydromorphological elements assessed under the WFD, which could prevent these water bodies from achieving Good Ecological Status by 2027.

The Thames River Basin Management Plan states that "*over the period to 2027, the pressures on the environment would change, particularly because of climate change. It is not known how the water environment would respond to this*" (Environment Agency, 2009a). Given the uncertainty and changeability of projected climate scenarios and associated impacts on the water environment, any adaptation actions or mitigation measures should be resilient to a range of plausible climate change scenarios, rather than led by a single scenario (WWF and Natural England, 2010).

5.3 Assessment of Potential Impacts

5.3.1 River Realignment

HH proposes to divert the Colne Brook and Poyle Channel around the western extent of the new runway. The Colne Brook is a water body (designated under the Water Framework Directive) and as such the river realignment would need to ensure that there is no deterioration caused to the overall Ecological Status of the water body or that it is prevented from achieving Good status. The Poyle Channel is a

tributary to a WFD water body and as a result it is important to recognise that impacts could arise from diversion of the channel.

At present there are no detailed designs available for the realignments. The following shown in Table 5.3, however, are approximate lengths that have been taken from Jacobs (2014b) (Figure B1988000-PH2-1.3-SK003 Version 1.0). These measurements have been based on information provided in the Figure only and are therefore subject to revision.

Table 5.3 - Length of proposed channel realignment

River	Length (km)
Colne Brook	1.57
Poyle Channel	3.37
Total	**4.94**

River realignment could provide an opportunity to mitigate and potentially improve, enhance or restore natural variability of flow, sediment dynamics and habitats in river systems if properly designed to achieve this.

Although there could be positive outcomes it is likely there would also be negative impacts. Potential changes in gradient, discharge and velocity associated with the realigned channels could cause alterations to the current flow and sediment regimes. This could potentially lead to localised deposition or erosion of a river bank and/or bed. Deposition associated with changed velocities could lead to siltation above the hard river bed, consequently impacting on aquatic ecology including fish, invertebrates and macrophytes. As a result, this could affect the biological elements of one or more WFD water bodies. Changed rates of erosion could also potentially lead to impacts such as loss of riparian land, increased sediment delivery and potential release of contaminants into the water bodies. Changes to channel length caused by diversions, realignments or through purposeful increases of sinuosity, could also potentially impact existing sediment and flow regimes within the affected channels.

Although it is assumed that channel diversions would be designed to be self-maintaining as far as possible, a lack of full understanding of the uncertainties concerning channel dynamics/processes at the design phase could result in disruption to the existing channel equilibrium and cause channel instability. This could then lead to the need for future intervention to cope with adjustment, such as additional bank protection measures to protect against loss of land (National Rivers Authority (NRA), 1997; EA, 2002).

Changes to the physical channel structure or flow regime in a diverted channel could also have potential to impact water quality and ecology both upstream and downstream of the directly affected reach.

Box 5.1 - Lessons Learned: River Colne Catchment – Environmental Enhancement

A study of the River Colne from Rickmansworth to its confluence with the River Thames at Staines (known as the Lower Colne Study) was commissioned by the Environment Agency and its predecessors (Thames Water and NRA) in the 1980s to examine the flood risk and flood risk management opportunities (Gardiner et al., 1987; Thames Water, 1988). This includes the various distributaries in the Heathrow Area including the Colne, Colne Brook and Wraysbury River. This study was followed by detailed design and construction in the 1990s. This was a unique study because, through catchment modelling, it was able to determine the most environmentally sensitive options for flood management. Rather than major widening and deepening of the Lower Colne and its distributaries (as might have been traditionally recommended) and the use of hard engineering such as concrete flumes/ culverts, in excess of 60 individual works were proposed (and built) within the floodplain. These included a combination of the following environmentally-acceptable (at that time) options:

- Flow diversions from one distributary to another;
- The use of existing lakes and gravel pits for flow attenuation;
- Modification or replacement of flow control structures (with the installation of fish and eel passes where needed); and
- Throttles on flow and flood diversion channels.

In the few situations where harder engineering was unavoidable then environmental mitigation and/or restoration was undertaken. Examples include the work on the Wraysbury River at Heathrow using natural techniques such as a low flow slot and import of suitable substrate (etc.) (see description in Brookes and Shields, 1996; Kondolf, 1996).

Both river realignments at Heathrow ENR would lead to a direct increase in the channel length, which could impact on the physical processes within the river by decreasing the slope. This could lead to changes in the flow regime within the realigned reach and beyond. It is widely recognised (from published literature such as Brookes, 1988) that a reduced slope could potentially decrease velocities and associated discharges, leading to in-channel deposition of sediments. As mentioned above, this could have consequential impacts on the ecology, water quality and channel morphology.

Careful consideration should be given to the potential changes in gradient, discharge and velocities associated with an increase in the length of the river; and these would be expected to be clearly shown in any further design by the promoter. The promoter would also need to consider upstream and downstream receptors (particularly tributaries) of these diverted watercourses as there could be secondary impacts (e.g. altered sediment transfers) from the proposed realignments. The realignment of the Colne Brook, without careful channel design/mitigation, could potentially lead to a deterioration in the WFD status of the water body.

5.3.2 Culverting

Culverting has the potential to significantly interfere with several aspects of the river environment including ecology, morphology, water quality and flooding. The Environment Agency and its predecessors have published a number of guidance documents on culverting and in practice typically object to culverting on environmental grounds. In 1999 they produced a policy regarding culverting (see Environment Agency, 1999).

Unmitigated culverting of a channel could replace existing natural features (e.g. pool/riffle sequences, depositional and erosional features) with artificial materials and surfaces. Culverting could also potentially interfere with continuity of upstream and downstream processes in water bodies, by creating or exacerbating bank/bed erosion, changing the sediment regime or by inducing deposition due to changed velocities and flow patterns. Culverting could potentially lead to narrowing of a natural channel and disruption to an existing channel gradient and sediment conveyance (NRA, 1997; EA, 2002). Another consequence is that the shading caused by a culvert would restrict the growth of aquatic plants which in turn are an important component (through growth and die-back) of flow patterns and morphological processes by trapping of fine sediments (especially in chalk fed streams).

Culverting sections of watercourses at Heathrow ENR could also disconnect the exchanges of water between channels and their floodplains, as well as disrupting connectivity with groundwater. This could have consequential impacts on floodwater storage, drainage, water quality and ecology. Culverts would typically cause loss of riparian corridor, and changed water chemistry through decreasing water turbulence, leading to reduced water oxygenation.

Box 5.2 - Lessons Learned: Heathrow Terminal 5 – Environmental Mitigation

The Twin Rivers Diversion was a key issue debated at the five-year long Heathrow Terminal 5 (T5) Public Inquiry during 1996 (Department of Transport, 1996). This was a critical issue that needed to be addressed before T5 could be given approval and then built. Options, other than a diversion, were debated before and during the Public Inquiry. This included syphons placed under T5 (which were also regarded to pose a direct security threat) and a diversion involving culverting (partly because of the fear of bird strike arising from an open watercourse). The evidence and transcripts of the Public Inquiry record the debate for and against the various options. As a result of Evidence given, a preferred solution (promoted by the Environment Agency) involving the diversion of the two rivers around the western perimeter of the airport but as open channels, was chosen. This involved the construction of two 3km long rivers to accommodate the diversions of the Duke of Northumberland's River and the Longford River (both part of the Lower Colne River System).

Detailed design was undertaken in 2002 and the works completed by 2004. For the rivers, it was necessary to satisfy hydraulic requirements as well as to maximise environmental benefits. As far as possible, the new channels are formed by naturalised, trapezoidal banks with concrete walls only where space was limited. Pre-planted coir rolls and hazel hurdles provided habitat along the naturalised banks. In-channel enhancements maximised the ecological value, placed so as to create a meandering flow pattern. Habitat was provided for fish and macro-invertebrates, whilst gravels were also placed. A bird strike risk assessment undertaken by the Environment Agency showed that the risk of bird strike was minimal because the rivers only represent a narrow corridor rather than a large open water body, which has a higher potential for attracting migrating birds in the absence of the usual bird mitigation carried out at airports.

The project subsequently won a CEEQUAL award for construction (see CEEQUAL, 2013).

From the proposal it has been identified that the following WFD water bodies would be culverted: River Colne, Wraysbury River, Longford River and The Duke of Northumberland's River. The following measurements shown in Table 5.4 are approximate lengths that have been taken from Jacobs (2014b) (Figure B1988000-PH2-1.3-SK003 Version 1.0); they have been based on information provided in the

Figure only and are therefore subject to revision. They are the likely maximum lengths that could be required to facilitate development:

Table 5.4 - Length of proposed culverts

River	Length (km)
Wraysbury River	2.5
River Colne	2.39
Duke of Northumberland River	3.71
Longford River	3.56
Total	**12.16**

The Wraysbury River and Longford River would both be likely to be impacted by an increase of slope (through a decrease of channel length). Increased flow velocities and reduced hydraulic roughness due to concrete would have an added effect. Without mitigation these physical changes could potentially lead to increased erosion and/or sediment entrainment, particularly at the downstream extent of each culvert. Mitigation could include a hard engineered bed which in itself would have a potential negative impact on morphology and ecology. An increase in length on the Duke of Northumberland's River would have a corresponding impact by decreasing the channel slope. This could impact the flow regime and potentially decrease sedimentation rates locally. Decreased flow velocities could also impact on water quality through decreased oxygenation.

HH have also considered combining two channels (River Colne and Wraysbury River; Longford River and Duke of Northumberland's River) upstream of the culverts and splitting the flow downstream. Such an approach would potentially be regarded as detrimental by the Regulators. Arguments for retaining separate channels were well rehearsed by the Environment Agency at the Heathrow Terminal 5 Public Enquiry for the Longford and Duke of Northumberland's Rivers (known as the Twin Rivers). From a WFD and general regulatory perspective, combining two water bodies/watercourses would reduce total channel length significantly (and therefore the available habitat). Also, the combined lengths would fundamentally alter the channel morphology including sediment processes with concurrent ecological implications.

The culverting of three WFD water bodies could have the potential to impact on the water environment. Culverts could reduce the biological, physico-chemical and the hydromorphological quality elements if not mitigated appropriately. As a result, without mitigation, the culverting of the three WFD water bodies has the potential to either cause a deterioration in the water body status or prevent it from achieving Good status. There could be adverse residual impacts that cannot be mitigated.

5.3.3 Outfalls and Discharges

Currently, the Heathrow ENR proposal provides no exact locations or numbers of outfalls as part of the scheme; these are likely to be confirmed in the detailed design.

Implementation of permanent outfall structures within a watercourse has the potential to locally alter the channel cross-section as well as the flow dynamics within a channel. Outfall headwalls would be likely to have localised impacts by

removing a small section of natural bank and riparian vegetation, replacing this with artificial materials such as concrete and brick. A small section of channel bed could potentially be impacted depending on the detailed design of an outfall structure. A headwall could also have a localised impact on lateral connectivity of a watercourse with its floodplain and could potentially lead to erosion upstream and downstream of the structure.

Discharges from new outfalls into the watercourses could alter water quality and the flow dynamics (hydromorphology) within the channel. Flow directed by a set angle of an outfall could potentially cause localised erosion of the opposite bank and bed.

It is unlikely that the implementation of a single outfall on a WFD water body would cause deterioration in the water body status or prevent it from achieving Good status. If more than one outfall were implemented on any one watercourse/water body, the potential impacts could become greater on the water environment. For example, there would be a longer section of bank modification, in turn impacting on the riparian corridor. For the WFD water bodies this could mean that a greater percentage of the overall water body length is impacted, potentially altering the overall water body status, without taking mitigation into consideration.

5.3.4 Water Quality

The proposed development at Heathrow ENR, including the construction of an additional runway, could generally increase the risk presented to the water environment (surface water and groundwater) as a result of an increase in the storage and use of potentially hazardous materials and an increase in pathways to sensitive receptors. This includes any surface waters surrounding the site where there could be the potential for runoff to discharge to or where outfall structures could be located. It also includes the Lower Thames Gravels WFD groundwater body. For the WFD water bodies (both surface water and groundwater) this could potentially impact upon the physico-chemical elements and chemical status.

Increases in the volume of fuel and oils stored, conveyed and used on the site, could all lead to enhanced risk of an impact to the water environment. Fuel and oil storage would not be limited to aviation fuel but would also include heating oil for buildings, stand-by generator fuel and fuel for site vehicles. An increase in storage and use could lead to an increase in the likelihood that a release of contaminants (pollution incident) could occur even with precautionary measures in place. An increase in volume stored could also potentially increase the magnitude of the impact if a release did take place.

Operations including aircraft washing (cleaning agents and cadmium from aircraft), aircraft stand wash-down and aircraft maintenance could all potentially increase the volume of effluent generated. This could lead to an increase in the contaminant loading on interception, storage and attenuation/treatment facilities and increase the potential risk to the receiving water environment.

Also an increase in the use of de-icing chemicals on aircraft, runways, aprons and taxiways could all increase the risk to the water environment.

A potential positive impact could be a decrease in pesticides, herbicides and other pollutants, due to the replacement/covering of open ground with hard impervious surfaces. However an increase in the spatial extent of paved surfaces could potentially have several impacts on water quality and the downstream receiving WFD water bodies without appropriate mitigation. The impervious areas could result

in an increase in surface water runoff with subsequent erosion. Changes to the volume and rate of surface water runoff could potentially increase the likelihood of pollutants/sediments being mobilised and transported. An increase in the volume and transport rates of these pollutants/sediments could impact upon the efficiency of existing contaminant interception, storage and attenuation facilities.

Currently two of the WFD water bodies in the Heathrow ENR Study Area are classified as having a 'Failing' chemical status, so a potential increase in pollutants could have a more magnified impact on these water bodies. A reduction in the physico-chemical elements, without considering appropriate mitigation, could potentially lead to impacts on the overall status of these water bodies.

The principal issues with respect to water quality are associated with an increase in the storage and use of hazardous materials (especially fuels and de-icer) during operations. Appropriate management procedures and protocols as well as physical interception, storage and treatment of contaminated water prior to discharge to the water environment, would be required. Additionally, it is possible that during construction, contaminants associated with existing sources of hazards, such as historic and current landfills, could be mobilised, leading to adverse impacts. The promoter has provided little information with regards to current contaminant sources as noted in Jacobs (2014e). However the report indicates that, based on publicly available information, the scheme will be impacted by numerous historic landfills and several historic industrial activities. During construction and operational activities contaminants from these sources could impact the water environment unless specific measures are taken.

5.4 Assessment of Potential Mitigation

Appendix H compares the generic mitigation measures recommended within this section and those detailed by the promoter. The following provides a summary of the generic mitigation measures. Any gaps that have been identified in the proposals provided by Heathrow Hub are also summarised.

5.4.1 River Realignment Mitigation

There are a number of mitigation measures and best practices that could be potentially implemented to reduce the impacts that have been detailed above. The following are some of the key measures that could be implemented (and have been implemented as appropriate on other most recent airport developments) through the design, construction and operation phases of channel realignment:

- Design should incorporate variations in flow, depth and width to provide a variety of habitats;
- Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling;
- Realigned channels should be similar in length, width, depth and gradient to the old (original) channel (if appropriate to the flow and sediment regimes);
- Design should incorporate naturalised bed material (which could be characteristic of natural reaches of the same watercourse or neighbouring watercourses);
- Banks should be vegetated with native species (to promote stability);
- Channel design should be such as to naturally convey the full range of flows from high to low;
- Possible storage and transfer of original/natural substrate from a redundant channel to a diverted channel should be considered;

- New river lengths, widths, depths and gradients should not compromise flow conveyance in adjoining upstream or downstream reaches; and,
- Design should consider location of areas of contaminated land. Mitigation could include lining of the channel.

Through implementing mitigation measures within the design and operation of the river diversions, there is unlikely to be an impact on the statuses of the two WFD water bodies.

5.4.2 Culverting Mitigation

There are a number of best practice guidelines available detailing key design criteria for culverts, these include: Environment Agency Culvert Guidelines (see Appendix B), Environment Agency Policy Regarding Culverts (Environment Agency, 1999) and the Construction Industry Research and Information Association (CIRIA) Culvert Design and Operation Guide (CIRIA, 2010). The following are some of the key principles detailed in these documents:

- Design should consider the passage of both water and sediment for a range of flows;
- Design should consider the potential for partial or complete blockage of the culvert by debris or sediment during high flow events;
- Culvert gradient should be matched to the gradient of the existing stream to avoid erosion at the head or tail of the culvert;
- Reduction of river length by shortening the river planform[5] should be avoided.
- Keeping length of culvert to a minimum;
- Invert of the culvert should be depressed to allow for the formation of a natural bed. This could filled potentially using excavated (and stored) material from the channel being replaced;
- A culvert of similar cross-sectional size should be used;
- Roughness of culvert inverts should be increased to help reduce the velocity of the water; and,
- There should be consideration of potential use of lighting options (dependent on surroundings and available resources).

Consideration should be given to mitigation measures that could be required to compensate for the loss of habitat and natural channel cross-section. This could include like-for-like replacement of habitat within the same water body either upstream or downstream.

Even with the implementation of mitigation measures within the design and operation of the culverts, it is still possible that there could be residual impacts on one or more of the three WFD water bodies that could not be mitigated. This would potentially impact on their current statuses and/or ability to achieve Good status.

5.4.3 Outfalls and Discharges Mitigation

The following are some of the key best practices and mitigation measures that could be implemented in outfall design, to ensure that at the operation phase the outfalls have a minimal impact on the surrounding environment:

- The outfall should be directed in a downstream direction to minimise impacts to flow patterns;
- The outfall should be directed away from earth river banks to minimise any potential risk of erosion; and,
- The size/extent of an outfall should be minimised wherever possible to reduce the extent of potential impact on the banks.

Taking into consideration mitigation, it is unlikely that the implementation of a single outfall structure on a WFD water body would cause a deterioration in the water body status or ability of the water body to achieve Good status. However, if several outfall structures were to be proposed, this could incrementally have an adverse impact on current statuses.

5.4.4 Water Quality Mitigation

There are a number of mitigation measures and best practice guidelines relevant to reducing any potential impacts on water quality, these are as follows:

Construction

- Development and implementation of a Construction Environmental Management Plan (CEMP) including:
  - Procedures to respond to any environmental incidents.
  - Pollution prevention and material storage handling measures to be implemented during the construction period.
  - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location
  - Groundwater and surface water monitoring requirements to be carried out before and during construction and in the operational phase.
- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.
- Storage of excavated materials should be minimised and any temporary storage would located away from surface watercourses and areas with permeable soils.
- Any contaminated water from excavation or dewatering activities should be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There should be no direct discharge of contaminated water to surface watercourses.

Operation

- Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing takes place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase.

- Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.

Mitigation to address potential water quality impacts is covered in the proposal documents. The mitigation measures include appropriate storage of hazardous materials, runoff attenuation, Sustainable Drainage Systems (SuDS) and interceptors to provide storage for major spills.

It is likely that mitigation measures could be implemented to manage water quality to ensure an appropriate discharge from the site.

5.5 Promoter Submission – Potential Impacts and Mitigation

A summary of proposed works and mitigation measures related to WFD water bodies are set out in Appendix H.

5.5.1 Diversion of the Colne Brook and Poyle Channel

Potential Impacts

HH propose to divert the Colne Brook and Poyle Channel around the western extent of the new runway. The Poyle Channel is a tributary to a WFD water body; although it would not be under the same pressure as the Colne Brook to meet certain chemical, physico-chemical and morphological standards as detailed in the Thames RBMP, it is still important to recognise that impacts could arise from diverting the channel.

The proposed diversion would increase the length of the Colne Brook within the Study Area (which is an EU designated WFD water body) by 400m (from 1000m to 1400m) according to the proposal provided. It is not currently stated by HH as to whether the channel diversion would be designed as an artificial (concrete) channel or as a 'naturalised'/restored channel, the latter of which would be preferable. If the diversion was to be designed with a sinuous planform the length could be increased further (and the slope reduced accordingly) which would exacerbate the types of impacts already described above (Section 3.3.1).

The diverted Poyle Channel would have an increased length from 1400m to 1500m, with a corresponding proportional slope reduction. Although this increase is not as significant as that proposed for the Colne Brook, it is still possible that (without mitigation) impacts could still arise within the Poyle Channel.

It is also noted that the promoter's document states that the channel diversions mentioned above would partly cut across contaminated land and areas of landfill. Without appropriate mitigation measures this could pose a serious risk to water quality within a diverted channel.

HH state that impacts could also include localised changes to topography and hydrology. The realignment of the Colne Brook and the Poyle Channel could also impact on the biological, chemical/physico-chemical and hydromorphological elements of the watercourse.

Potential Mitigation

The following are the key mitigation measures detailed in the Heathrow ENR proposals for the diversion of the Colne Brook and Poyle Channel:

- Natural materials would be used for the bed and banks wherever possible;
- Channels would be designed with a variety of widths and depths;
- A two-stage channel would be incorporated;
- A meandering channel would be implemented wherever possible;
- In-channel flow deflectors would be used to vary the velocities and flow direction;
- Gradient and planform of the realigned channel would be made similar to the current channel so as not to increase scour and induce turbidity and sediment problems; and,
- Make a significant contribution to implementation of measures identified in the Thames River Basin Management Plan (RBMP) to deliver and support GES/GEP and minimise likelihood of status deterioration.

The mitigation measures detailed by HH encompass the majority of the mitigation described as good practice in Section 5.4.1. This includes the use of natural materials, a channel designed to incorporate variations in flow, depth and width and consideration of the gradient and planform of the diverted channel. However, within the Proposal there is no specific mention of the use of similar bed material to the original channel. The design should also consider areas of contaminated land, with mitigation including measures such as effective lining of the channel.

5.5.2 Culverting

Potential Impacts

HH proposes to culvert three WFD water bodies (comprising four channels) within the Heathrow area. Table 5.5 lists the water bodies that would be affected, along with their approximate current length and length anticipated after culverting (based on the promoter's information).

Table 5.5 - Water body lengths before and after culverting (URS, 2014)

Water Body and WFD ID	Current Reach Length (km)	Length Following Culverting (km)
River Colne (GB106039023090 - Colne and GUC (from confluence with Chess to Ash))	1.5	1.5
Wraysbury River (GB106039023090 - Colne and GUC (from confluence with Chess to Ash))	2.55	2.46
Duke of Northumberland River (GB106039023480 - Ash and Stanwell Brook)	1.6	1.8
Longford River (GB106039023450 - Port Land Brook)	1.5	1.3

Potential impacts associated with culverting are detailed in Section 5.3.1. From Table 5.5 it is evident that the River Colne would remain the same length after culverting; however, the Wraysbury River and Longford River would decrease by

90m and 200m respectively. The Duke of Northumberland's River would increase by 200m.

Potential Mitigation

The Heathrow ENR proposal documents suggest that all culvert design would follow the Environment Agency culverting guidelines (see Appendix B) and the following key considerations and mitigation measures:

- Consideration would be given to potential use of lighting options for ecological purposes;
- Natural substrate would be included in the channel bed and (where practical) the banks;
- Design of bed topography would be such that it encouraged diversity and formation of quiescent zones for resting fish and eels;
- Insertion of stub groynes or flow deflectors would be undertaken for flow diversity;
- Avoidance of bends would prevent blockages and blind spots; and,
- Regular maintenance would be undertaken using best practice approaches.

The primary consideration for mitigating the culverting of a water body is the use of best practice guidelines in the design and operation of the culverts. Heathrow ENR should also note that there are other culverting guidelines available which may be used to inform best practice and design, including the CIRIA Culvert Design and Operation Guide (CIRIA, 2010).

5.5.3 Outfalls and Discharges

Potential Impacts

The proposals from HH have provided no exact information on the location and extent of outfalls and discharges as part of the proposed works. These are likely to be finalised as part of any detailed design. Water quality issues from the discharges are assessed in Section 5.3.4.

Potential Mitigation

The mitigation measures detailed in the HH proposal documents for outfalls and discharges are quite generic as no specific locations have been suggested, these include the following:

- Discharge locations would be agreed with the consent holder and Environment Agency as necessary; and,
- Discharge from clean attenuation pond/tank would be released at the 'allowable' rate.

The mitigation measures detailed in the HH proposal primarily focuses on the location and quality of discharge issuing from an outfall. Consideration should also be given to the direction of flow (i.e. outfall angled downstream to avoid erosion of the adjacent or opposite bank) and to minimise the size/extent of an outfall structure.

5.5.4 Water Quality

Potential Impacts

The HH assessment (URS, 2014) provides a large amount of detail on the environmental setting of the site, paying particular attention to the potential pollution impact to surface water and groundwater receptors. Their assessment considers both construction and operational impacts and includes details of potential impacts arising from activities such as dewatering, possible disturbance of historic landfill and potential input of poor quality surface and groundwater during operation.

The HH assessment acknowledges that there could be an increased risk of pollutants conveyed to surface water or groundwater due to an additional 400ha of impermeable surfaces and an increase in use of de-icing and anti-icing compounds. The potential for fuel contamination of watercourses and groundwater due to the storage of fuels and or chemicals is also acknowledged.

Potential Mitigation

The following are detailed within the HH proposals as mitigation measures to address the potential water quality impacts from the development:

Construction

- Pollution Prevention Guidance (issued by the Environment Agency) would be adhered to;
- Development and implementation of CEMP;
- Surface water runoff from dewatering activities would be discharged to sewers or local watercourses, with the water achieving the standards required by the sewerage undertaker;
- SuDS would be used to treat and attenuate runoff to greenfield rates; and,
- Creation of new pollution pathways to groundwater would be avoided.

Operation

<u>Surface water quality</u>

- Surface runoff from paved areas (which is likely be contaminated) would receive at least two levels of treatment:
  - Surface water from adopted highways would be intercepted by source control features such as filter drains which provide a primary level of treatment. Retention ponds or detention basins to be designed to provide secondary level treatment.
  - Surface runoff from the extended runway and apron would be intercepted by linear drainage channels before being directed into a network of collector pipes, diverting flows to a petrol/oil interceptor. The discharge from the interceptor would be directed via an online Total Organic Carbon detector to either clean attenuation tanks or polluted water holding tanks. Clean water would be discharged and polluted water treated.
- The interceptor would also provide storage for any major spills;
- Runoff would be directed from the petrol interceptor via an online Total Organic Carbon (TOC) quality monitoring to detect the presence of de-icers. Runoff contaminated with de-icers would be diverted to treatment whereas non-contaminated water would be discharged to the normal attenuation storage;
- Polluted runoff would be attenuated within a polluted water holding tank and released for treatment at a rate agreed with the treatment plant operator;

- Where TOC was below the agreed trigger level it would be directed to a clean attenuation pond or tank and released to a watercourse;
- Runoff from external areas (e.g. highways) would internally be intercepted by source control features (e.g. porous paving); and,
- Attenuated runoff would be directed via site control features (i.e. retention ponds and detention basins).

Groundwater quality

- Storage areas for fuels and chemicals should be located away from SuDS and highly permeable soils;
- SuDS should incorporate pollution prevention into its design;
- Infiltration systems should not be located where contamination was already present;
- Routine maintenance of drainage systems; and,
- Implementing a regime of post-construction monitoring of groundwater levels including the use of appropriate trigger levels and appropriate actions.

Attenuation storage and long term storage would be provided to mitigate impacts from the increase in the peak runoff and the total volume of runoff due to the increase in impermeable surface area.

Long term storage

- Long term storage would be provided to delay the additional surface water volume from being discharged to watercourses, by infiltration, rainwater harvesting or by restricting the discharge rate to 2 litres per second per hectare (l/s/ha); and,
- Surface water runoff from roofs, including those of new buildings (generally uncontaminated) would be intercepted and directed to rainwater harvesting systems for potable water reuse.

Attenuation storage

Attenuation storage (using suitable SuDS features) would be provided at rates equivalent to the existing greenfield runoff rates. Discharge would be conveyed to receiving watercourses to mimic existing conditions. Attenuation storage would be provided to both the airport and highway corridor.

5.6 Heathrow Airport Extended Northern Runway Residual Risks - Conclusions

HH states that it is unlikely that all impacts could be avoided. The promoter recognises that culverting and diverting channels could impact on the downstream sections of the watercourses and water quality. It also states that the reduction in vegetation would impact on the amount of sediment entering the water column through reducing particle and pollutant attenuation.

The promoter states that mitigation measures and best practices would reduce any residual impact on the water environment to low. Alternative options are explored within the promoter's reports to determine this outcome; however, mitigation has not been thoroughly explored and therefore further study and information would better inform the residual impact given by the promoter.

Whilst it is generally recognised that impacts arising from airport construction and operation would to varying degrees be mitigated, potentially significant residual impacts could remain for the development proposals. From previous experience of

airport developments and other developments in general these residual impacts could include:

- Permanent changes to channel alignments or creation of new channels or diversions (either increasing or decreasing slopes);
- Permanent culverting of watercourses/water bodies;
- Permanent structures (such as outfalls); and,
- Contaminated runoff impacting on WFD physico-chemical status.

There are also potential residual impacts on water quality arising in operation despite mitigation, such as accidental spillage or failure of equipment and consequential pollution of downstream receiving waters. There would also be some potential risk from liners to channels through contaminated land (or landfills) subsequently becoming inadvertently breached.

The development has the potential to impact on the water environment, particularly without appropriate mitigation in place. Even with mitigation there would most likely be considerable residual impacts that would be of significant concern to Regulators such as the Environment Agency. This issue is recognised by the promoter of Heathrow Hub and explored more fully in this assessment.

It is estimated that more than 12kms of river channel would potentially be replaced with diverted/realigned channels as a consequence of the proposal. Diversions of the Colne Brook and Poyle Channel (over circa 5km) around the west end of an extended north runway would not only present technical challenges but would probably have residual adverse effects on the hydromorphology/geomorphology due to the changed gradients and other associated uncertainties. The option of combining the River Colne and Wraysbury River into a single culvert and the Duke of Northumberland's and Longford Rivers into a single culvert would probably have the greatest adverse residual impacts. There is considerable scientific literature showing that certain impacts of culverts are largely unmitigable. An initial estimate of the proposal indicates that there could be in excess of 12 kilometres of additional culvert. This would probably be unprecedented in the UK in modern times. The River Bollin (a single channel) was culverted in the 1990's over a distance of about 0.25km to accommodate a second runway at Manchester.

The water bodies in the Heathrow study area are sensitive and extensive diversions/culverting would run counter to the considerable work put in by the Environment Agency and its predecessors to provide environmentally-friendly flood schemes (as part of the Lower Colne Catchment flood scheme) and also in successfully rebutting culverting/syphoning proposals on the Longford and Duke of Northumberland's rivers at Heathrow Terminal 5 (again in the 1990's).

Several of the watercourses now have the added protection (as water bodies) from the European Water Framework Directive. Any deterioration of ecological status (which could arise from culverting) would potentially be opposed by Regulators. In view of this the development would probably need to progress through an Article 4.7 (of the WFD) route and a case proven that any environmental damage is outweighed by a greater public need (for an airport development). There could also be residual water quality impacts arising from polluted runoff. It is widely recognised (for example) that despite mitigation, contaminants such as de-icers do reach receiving watercourses at certain times. If this were to be the case then there would most likely be an adverse residual effect on WFD physico-chemical status.

This study has not included detailed assessment of cumulative and secondary impacts, including pressures on the water environment arising from increased traffic on existing transport networks or new developments.

6 Water Quantity Assessment Methodology

This section covers:

- Scope of the water quantity assessment in relation to the Airports Commission Appraisal Framework
- Outline of the methodology applied to the assessment covering inputs and approach to the assessment and how the baseline information has been used
- Assumptions and limitations associated with Jacobs' assessment

6.1 Context and scope

Chapters 6 to 9 provide an assessment of how three airport schemes meet the Airports Commission's objective to use water resources efficiently. The three schemes assessed are; Gatwick 2R, Heathrow NWR and Heathrow ENR. Each scheme is assessed as detailed in the Airports Commission: Appraisal Framework (April 2014) to ensure that:

1) The impacts on water resources in terms of the availability, reliability, rarity and substitutability, are fully considered; and
2) Measures are proposed to mitigate any detrimental impact on water resources.

The information used to assess the water resource implications of each airport scheme has been extracted from the promoters' submission documents and from each promoter's response to clarifications. Documents referred to are listed below:

- A Second Runway for Gatwick: Updated Scheme Design – Appendix A12: Water and Flood Risk (April 2014)
- Heathrow Airport Limited (2014b) Taking Britain Further: Heathrow's plan for connecting the UK to growth. Volume 1
- Heathrow's North West Runway – Resource Use Assessment. Appendix to 5.8 A Resource Efficient Heathrow. Taking Britain Further: Volume 1 Technical Submission 10
- Heathrow Expansion: Stage 2 Submission – Attachment 5-1 (14 May 2014) (Environment Technical Notes) (Section 2 only: Water and Flood Risk)
- Heathrow Expansion: Stage 2 Submission (14 May 2014) (Updated Design Scheme)
- Jacobs (2014a) Department for Transport Airports Commission Environmental Support: Water and Flood Risk Baseline

6.2 Methodology

Chapter 7 of this report analyses the assessment of water consumption undertaken by the scheme promoters. These assessments have been made at a high level due to the nature of the uncertainty in the final design and passenger forecasts.

Each scheme is assessed against the baseline case as described in Jacobs Baseline Report (2014a). The baseline case includes an assessment of the forecast demand from an increase in passenger numbers and the change in climate anticipated between the years 2025/26 and 2085/86 but assuming no additional runway at Gatwick or Heathrow Airports. The baseline was revised to also cover 2050 in this assessment to allow comparison with the promoters' submissions. In

assessing each scheme, the same information that was used to develop the baseline case is used. This includes, but is not limited to:

- Water and Flood Risk Baseline Report (Jacobs, 2014a) including information collated from River Basin Management Plans (RBMP), Catchment Abstraction Management Strategies (CAMS) and Water Company Water Resource Management Plans (WRMPs);
- Airports Commission Assessment of Need Carbon capped (Airports Commission, 2014) (passenger numbers); and
- Airport Sustainability Reports.

Further information on the assessment methodology is provided in Appendix I.

6.3 Assumptions and Limitations

This review of the submissions is based on a comparison with the Water and Flood Risk Baseline Report (2014a) and our assessment of the impacts on water resources resulting from the proposed schemes. We have used this as a basis for commenting on the submissions. In defining the Baseline, Jacobs made a number of assumptions. The assumptions made and their limitations are summarised below:

- The assessment of the high level baseline water resource position was determined at a high level by the review of publicly available documents listed in section 1.2 above;
- The baseline scenario for 2025/26 and 2050 is based on continued, but constrained, growth in the absence of any major additional infrastructure;
- Per passenger water consumption rates have remained constant from those reported in 2012 for Gatwick Airport and in 2013 for Heathrow Airport;
- Where data exists, climate change impacts taken from the WRMP forecast for non-household demand increases have been applied to the baseline passenger consumption rates and total demands;
- Passenger forecasts from the Airports Commission Assessment of Need (AoN) Carbon Capped are considered to be accurate and appropriate for the assessment;
- The analysis has been undertaken using AoN Carbon Capped demand forecast ATMs and passenger numbers. Other scenarios have been prepared that do not cap carbon within the aviation sector (i.e. carbon traded with other sectors to allow for no net CO2 increase against target, but without a constraint of 37.5Mt on the aviation sector), and as a result see a variance of ATMs and passenger numbers. Such variance will have a consequential impact (all else being equal) to any environmental effect directly proportional to ATMs or passenger numbers. For Gatwick 2R, the difference between AoN Carbon Capped and carbon traded scenarios ATMs is between circa +7% in 2030 rising to up to +20% in 2050. The variance between passenger numbers is an increase of between circa +9% in 2030 rising to up to circa +38% in 2050. For Heathrow NWR, the difference between AoN Carbon Capped and carbon traded scenarios ATMs is between circa +5% in 2030 with no significant difference in ATMs in 2050. The variance between passenger numbers is between slightly more than +6% in 2030 and up to +10% in 2050. For Heathrow ENR, the difference between AoN Carbon Capped and carbon traded scenarios ATMs is between circa +5% in 2030 with no significant difference in ATMs in 2050.

The variance between passenger numbers is between slightly less than +6% in 2030 and up to +10% in 2050. Impacts on water quantity driven by these ATMs or passenger numbers are sensitive to any such variance.

- Gatwick Airport uses potable water to meet all demands; water is supplied via piped mains water from Sutton and East Surrey Water (SESW); and
- Heathrow Airport is primarily supplied by a potable mains supply provided by Affinity Water (81%), on site boreholes (19%) and a limited contribution from rainwater harvesting schemes.

Each submission is unique in its approach and the level of detail provided varies between the short-listed schemes. All submissions are treated equally. Where information is not presented it was sought as a clarification request. Assumptions and limitations identified with the promoters' submissions have been summarised after each section.

7 Water Quantity Impacts – Gatwick Airport Second Runway

This section assesses the Gatwick Airport Second Runway (2R) scheme, providing the following information:

- Summary of baseline water demands for 2012/2013 and 2025/26 and projected to 2050 without a scheme in place;
- Jacobs assessment of impacts on water quantity including potential passenger consumption increases with scheme compared to baseline;
- Potential for mitigation of impacts including potential water efficiency approaches;
- Comments on the proposers' submissions.

Section 7.1 below provides an overview of the current and anticipated (for 2025 to 2050) baseline conditions at Gatwick 2R as defined by Jacobs. Further details of the baseline are reported in Jacobs Water and Flood Risk Baseline report (2014a). Section 7.2 provides an assessment by Jacobs on potential demand reduction measures. Section 0 reviews the scheme promoter's assessment of how the proposed scheme may affect water resources, followed, in Section 7.4 on how any impacts on water resources will be mitigated by GAL. Section 7.5 makes comment on the promoter's submission, including its limitations and assumptions.

7.1 Baseline (No Scheme) Demand

Gatwick Airport currently receives 100% of its potable water supply from Sutton and East Surrey Water (SESW). SESW report that Gatwick Airport is currently principally supplied from Bough Beech Reservoir; however, they are finalising resilience measures to allow Gatwick Airport to be supplied with water from an alternative water treatment works.

A baseline scenario for growth at Gatwick Airport without the proposed scheme has been developed (Jacobs, 2014a) to allow an assessment of the future impacts of development on water quantity to be made. The baseline uses readily available information from reports in the public domain and is discussed in more detail in the Jacobs Water and Flood Risk Baseline Report (2014a). Baseline figures are presented in Table 7.1 as derived by Jacobs and GAL.

Table 7.1 - Baseline Annual Water Consumption for Gatwick Airport

	2010	2012	2025		2050	
Metric	**Actual[6]**		**Jacobs Baseline (Airports Commission[11] forecast passenger nos)**	**Baseline (GAL[7] forecast passenger nos)**	**Jacobs Baseline (Airports Commission[11] forecast passenger nos)**	**Baseline (GAL[7] forecast passenger nos)**
Passenger Nos. (millions)	31.3	34.2	39.5	45.0	46.6	45.0
Water Consumption per passenger (m^3)	0.0310	0.0210	0.0212*	0.0212	0.0213**	0.0213
Total Consumption (Mm^3 per annum)	0.97	0.72	0.84	0.95	0.99	0.96

* Based on 2012 figure and a 0.69% uplift for predicted increase in household demand by SESW.
** Based on 2025 figure and includes a 1.42% uplift for climate change.

The baseline scenario for 2025 and 2050 is based on continued, but constrained, growth at Gatwick without any major infrastructure construction. The assessment was not extended further to 2085, which is the lifespan of the project, due to the limitations with available forecast figures and the restricted planning horizon reported in the WRMP.

In comparing the Jacobs Water and Flood Risk Baseline Report (2014a) findings with the baseline generated using GAL's passenger forecasts the following is noted:

- The GAL submission forecast passenger numbers are 5.5 million greater than the Jacobs Baseline (Airports Commission derived figures) for 2025, and 1.6 million fewer for 2050;
- In the absence of further information, the Jacobs Baseline water consumption per passenger in 2025 is based on 2012 rates with an increase of 0.69% in line with SESW Company estimates for climate change increases in non-household demand. Following a reduction in water consumption of 31% between 2010 and 2012, far exceeding the GAL target of a 20% reduction by 2020, it has been assumed that no further water efficiency measures will take place before 2025;
- In the absence of further information, the Jacobs Baseline water consumption per passenger in 2050 is based on 2025 with a further increase of 1.42% in line with SESW Company estimates for climate change. For the purposes of this assessment it has been assumed that all water efficiency measures are now in place and limited additional water saving measures can be employed;
- Using the current rate (for 2012) of water consumption, to assess demand based on the Airports Commission forecasts, GAL would require an additional 0.12Mm3 (17%) per annum by 2025 and 0.27Mm^3 (38%) per annum by 2050;

[6] Gatwick Airport Limited (2013). Section 106 Annual Monitoring Report 2012. Available Online at: http://www.gatwickairport.com/PublicationFiles/business_and_community/all_public_publications/corporate_responsibility/S106_2013_Report.pdf [Accessed 15 July 2014]
[7] CH2MHill *prepared for Gatwick Airport Limited* (2014). A Second Runway for Gatwick, Appendix A12 Water and Flood Risk

- Based on the GAL submission estimate of per passenger consumption and forecast passenger numbers, Gatwick would require an additional 0.23Mm³ (32%) per annum by 2025, and an additional 0.24Mm³ (33%) per annum by 2050 when compared with current (2012) demands; and
- Compared to a 2010 baseline, water consumption in 2025 and 2050 based on the GAL estimates of passenger numbers would be broadly similar.

The GAL submission forecasts an increase in annual water consumption between 2012 and 2050 of 0.24 Mm^3 per annum in the absence of major development. This is a notable increase in demand (33%) for a region that is already classified as water stressed.

7.2 Potential Mitigation Measures

From an assessment of water efficiency measures and examples of best practice taken from schemes at other airports (Appendix J), the following demand savings could potentially be achieved at Gatwick.

Rainwater Harvesting
The rainwater harvesting scheme currently in use at Heathrow Terminal 5 (T5) has a potential capture rate of 85% and meets 8% of the non-potable water demand for T5 per annum; approximately 1% of total airport demand. Assuming a similar design and capture rate from a system at Gatwick, there is no reason not to expect it to meet a similar proportion, 10%, of the new terminal non-potable water demand.

Water Efficiency Measures
Low flush or flush stop toilets, aerated taps and waterless urinals have all been incorporated in the design of new terminal buildings, or retrofitted to existing facilities with the aim of reducing water demand. Examples of measures used at other airports have been presented in Appendix 0J. The installation of waterless urinals at Heathrow Terminal 3 (T3)[13] has achieved savings of 0.029Mm³ per annum. This is equivalent to 1.3% of the 2013 total airport demand. The existing terminal buildings at Gatwick have already been fitted with water efficiency devices, leading to the 30% reduction in demand between 2010 and 2012. It is not anticipated that any further significant savings could be made, but the new terminal building would make use of these measures to minimise additional demand.

Leakage Reduction
HAL estimated that 15% of water is lost to leakage through their water distribution and processing network. Appendix J0 shows that at Paris Charles De Gaulle Airport, through the use of monitoring software, leakage was reduced to less than 10%, which is considered to indicate a network in good condition. GAL has already made a 20% saving on demand during 2011 from improved infrastructure management and leakage detection and repair. Therefore, further substantial savings are not expected.

Where estimates on demand savings can be made from a review of data from similar schemes, it would indicate that there is the potential for a 10% saving on current levels of potable water demand by 2025 from the use of the above measures.

7.3 Assessment of With Scheme Demand

Demand has been assessed based on the assumption that a second runway is built at Gatwick by 2025 in line with the programme presented by GAL in the submission. The GAL submission provides two figures for each forecast demand scenario, 'Terminal buildings only' and 'Total (terminal buildings and associated commerce)'. The demand forecasts below are for the 'Total' case, because the consumption per passenger for the worst case with scheme scenario (assuming no change from current water use) in 2025 of 0.022m^3 is the most similar to the Jacobs Baseline estimate of water consumption (0.021m^3). It is possible that this leads to an overestimation of water consumption at Gatwick Airport by considering hotels and other facilities beyond the control of GAL.

Three forecast scenarios have been provided by GAL:

- Worst case;
- Scheme with embedded mitigation; and
- Scheme with additional mitigation.

The GAL submission forecast scenario presented for Gatwick Airport in Table 7.2 is for the 'scheme with embedded mitigation'. This includes water efficiency measures included in the proposed design. The scheme with additional mitigation assumes that there is scope to use innovation to achieve greater efficiencies. However, as these measures are either not specified or still under review they will be excluded from further analysis.

These 'with scheme' figures have been presented alongside the Jacobs assessment estimates of water use in Table 7.2

Table 7.2 - Annual Water Consumption for Gatwick Airport, Actual and Forecast

	2012	2025		2050	
Metric	**Actual**	**Jacobs Assessment (AC passenger forecasts with scheme)**	**GAL with scheme**	**Jacobs Assessment (AC passenger forecasts with scheme)**	**GAL with scheme**
Passenger Nos. (millions)	34.2	40.5	73.0	69.4	95.0
Water Consumption per passenger (m^3)	0.0210	0.0191**	0.0160***	0.0192**	0.0120***
Total Consumption (Mm^3 per annum)	0.72	0.77	1.18	1.33	1.14

** Assumed that a realistic saving of 10% could be made to per passenger consumption rates, as outlined in Section 7.2
*** Calculated from total consumption and passenger numbers.

From the data presented in Appendix K, GAL are already reporting the lowest per passenger consumption rates, and those forecast with the scheme are a further 23% lower in 2025 and 43% lower in 2050, as a result of the proposed water efficiency measures, as discussed in Section 7.2.

For the assessment of demand 'with scheme' (Table 7.2) it is noted that with the increase in passenger numbers resulting from the scheme, GAL estimate an increase in overall water consumption of 0.46Mm³ (64%) per annum by 2025, falling to 0.42Mm³ (58%) per annum by 2050 when compared with 2012. Jacobs however, estimate an increase in 2025 of 0.05Mm³ (7%) per annum and 0.61Mm³ (85%) per annum in 2050. The GAL estimate of total 'with scheme' consumption is 0.41Mm³ (53%) per annum greater in 2025 than the Jacobs assessment and lower by 0.19Mm³ per annum (-14%) in 2050. This significant variation between GAL and Jacobs in 2025 can largely be explained by the differences in forecast passenger numbers. GAL has forecast 32.5 million more passengers in 2025 than the Airports Commission and 25.6 million more in 2050. The GAL submission also proposes lower per passenger rates of consumption than the Jacobs assessment; 16% lower in 2025 and 38% lower in 2050.

GAL consulted SESW regarding their forecast demand scenarios of water consumption in 2025, 2040 and 2050 following the completion of the GAL scheme. SESW confirmed that the GAL forecasts were not consistent with the figures included in its WRMP, but that the differences were not significant and could be accommodated within their headroom allowance (uncertainty). SESW also report that their WRMP includes a number of feasible options that are not currently due for implementation by 2040 and state that they are "confident that they will have, or can make, sufficient water available to meet demand from customers, including Gatwick Airport up until 2050".

In their WRMP completed in 2014, SESW provides evidence to support the availability of surplus water (excluding headroom) only up to 2033/34. Without additional SESW figures and assumptions it is not possible to comment on the size of the headroom relative to the increase in demand from the Gatwick 2R scheme. However, if SESW believe they can meet demand this is the strongest indicator of water availability in 2025. The current WRMP only covers the period up to 2039/40 so it is not possible to comment on supply and demand in 2050, or further ahead to 2085.

GAL does not anticipate any detrimental impacts on water resources in the local or regional community or environment.

During construction, water will be needed as a dust suppressant, to clean vehicles and for mixing concrete. The GAL submission states that it is difficult to assess water usage in construction but provides an estimate of 120m^3 per £1million build cost. This water usage will be in addition to estimates provided in Table 7.2 as construction would be programmed to continue past 2025. Any water use relating to the construction of the scheme would make use of the industry standards produced by WRAP[8] on water efficiency in construction, to minimise impact, as referenced in the submission.

The additional demand forecast at Gatwick will be partially offset through the loss of demand from the houses and commercial premises that are lost to the development;

[8] http://www.wrap.org.uk/content/water-efficiency-construction

however, some of these properties will be relocated within the same WRZ resulting in little or no overall change in demand.

The expansion of the airport will not only impact on the water demand from the site, as discussed above. The diversion of watercourses, opening up of culverts and construction of a weir have the potential to effect the hydrological regimes of the watercourses and impact downstream sites and users; of particular importance are the designated sites within this report and the Biodiversity Assessment (Jacobs, 2014c).

There is also going to be a significant increase in impermeable area resulting from the development. The consequence of this in relation to flooding is covered in the Flood Risk Assessment Report (Jacobs, 2014d). However, the increased impermeable surface along with proposals to capture and reuse rainwater and site surface runoff will result in a change to the discharges to neighbouring watercourses, potentially impacting on flow sensitive sites and users downstream.

7.4 Gatwick Airport Second Runway Mitigation Measures

The GAL submission proposes measures to mitigate for the increase in water demand following construction of the scheme including:

- Water recycling through rainwater harvesting. Storage tanks would be built into the new buildings (roof area c.0.13 km^2) and used for non-potable requirements e.g. toilet flushing. GAL estimated that 26% of water for toilet flushing in the new terminal will come from rainwater (Appendix J) and
- A 1% year on year reduction in water use across the whole site to be achieved through the use of low-water-use appliances, improved leakage detection and replacement of life-expired pipework. GAL aims to reduce the per capita consumption to what is currently considered 'best in class'.

The GAL submission also recognises the need to mitigate for increased demand in water during construction. Several low water use techniques or approaches are presented in the submission document. It is not known whether the estimate of water use during construction makes allowance for these techniques.

7.5 Commentary on Promoter's Submission

The GAL submission lacks detail in the origin of many of the figures and therefore requires many assumptions to be made to allow an assessment against the baseline. The following assumptions have been made here to facilitate the assessment:

- The forecast scenarios stated in the promoter's submission are correct;
- Potable water providers (SESW) could meet the additional demand for water both during construction and following completion of the scheme;
- Rainwater harvesting could provide 26% of non-potable water to the new terminal; and
- A 1% reduction in water use each year could be achieved through water efficiency measures.

The following points have been identified from the promoter's submission:

- No estimate was provided of baseline per passenger water consumption for 2025, 2050 or 2085 (i.e. without scheme) therefore the Jacobs baseline values were used to calculate total demand. As a consequence, the comparison of with and without scheme figures have not been derived from the same assumptions, as the with scheme had an estimate of per passenger consumption within the submission;
- Limited details on the methodology and assumptions made for estimating water consumption in 2025 and 2085 with the scheme in place were provided in the submission;
- No detail on the allowance made for climate change;
- Lack of clarity as to which scenario ('Terminal only' or 'Total (terminal buildings and associate commerce)') best fits the actual annual total water consumption reported for Gatwick Airport in their S106 report[7];
- The difference between 'operational mitigation measures' and 'additional mitigation measures' has not specified;
- No details on the derivation of the 'worst case' baseline; and
- Estimates of water demand extend to 2050 and not for the full design life (60 years) to 2085.

7.6 Conclusion

The submission has been reviewed to assess the impacts of the shortlisted airport scheme on water quantity. The submission only considers water consumption up to 2050 and not the lifetime of the scheme, 2085. No detail is provided on the methodology used or the assumptions made in forecasting water consumption with scheme, therefore it has not been possible to assess these fully.

Following construction of the second runway, GAL forecasts a reduction in the water consumption per passenger but a rise in total water consumption. Given GAL's track record for reducing per passenger consumption and evidence from an assessment of the success of other water efficiency measures adopted at other airports, the forecast reduction in per passenger consumption appears reasonable. The difference in the total annual consumption of water in 2025 between the Jacobs assessment and the GAL (with scheme) is estimated to be 0.41Mm³ (53%) per annum more in 2025 and -0.19Mm³ (-14%) per annum less in 2050. Consultation by GAL with the water supplier SESW has confirmed that the increase in demand by 2025, as forecast by GAL, could be accommodated within the headroom of the current WRMP.

Jacobs' assessment and review of the GAL submission documents and subsequent comparison of demand against a Jacobs assessment led to the following conclusions:

- The forecasted increase in demand at Gatwick Airport in the GAL submission can be met by the existing, and forecast, surplus in the SESW supply zone and with the use of water efficiency measures. A lack of detail in the submission document leads to uncertainty in the methodology and assumptions used to determine consumption rates.
- GAL estimate an increase in demand for potable water both during construction and following completion of the scheme;
- GAL proposes to reduce water consumption per passenger through the use of rainwater harvesting in the new terminal, through leakage repair and infrastructure replacement;

- If the scheme is implemented by 2025 it is estimated that an additional 0.46Mm³ (64%) per annum of potable water per year will be needed and by 2050 this reduces to 0.42Mm³ (58%) per annum, when compared with 2012 consumption. These totals are 0.19Mm³ (13%) per annum more and -0.19Mm³ (-14%) per annum less than the Jacobs assessment of demand for 2025 and 2050 respectively;
- SESW have stated that they can meet GAL's forecast increase in water demand both in 2025 and 2050 following the construction of a second runway;
- Estimates of water efficiency measures proposed by GAL are plausible; between 2010 and 2012 Gatwick reduced its total annual water consumption by around 30%; and
- GAL's submission does not consider water consumption throughout the scheme's lifetime to 2085.

8 Water Quantity Impacts – Heathrow Northwest Runway

This section assesses the Heathrow Airport Northwest Runway (NWR) scheme, providing the following information:

- Summary of baseline water demands for 2012/2013 and 2025/26 and projected to 2050 without a scheme in place;
- Jacobs assessment of impacts on water quantity including potential passenger consumption increases with scheme compared to baseline;
- Potential for mitigation of impacts including potential water efficiency approaches;
- Comments on the proposers' submissions.

Section 8.1 below provides an overview of the current and anticipated (for 2026 to 2050) baseline conditions at Heathrow as defined by Jacobs. Further details of the baseline are reported in Jacobs Water and Flood Risk Baseline Report (2014a). Section 8.2 gives an assessment by Jacobs on potential demand reduction measures. Section 8.3 reviews the scheme promoter's assessment of how the proposed scheme may affect water resources, followed, in Section 8.4 on how any impacts on water resources will be mitigated by HAL. Section 8.5 makes comment on the HAL submission, including its limitations and assumptions.

8.1 Baseline (No Scheme) Demand

The initial assessment of water resources presented in Jacobs Water and Flood Risk Baseline Report (2014a) highlighted the high level of water stress that currently exists across the south-east of England and the limited availability for additional abstraction licences to be granted.

The Affinity Water WRMP concluded that there is a water resource deficit in the Water Resource Zone (WRZ4) that supplies Heathrow. Water supply at Heathrow comprises potable mains supply provided by Affinity Water (81%) and on-site boreholes (19%). Since 2011 the onsite boreholes have not been fully exploited, abstracting between 2011 and 2013, 37%, 44% and 46% of total licenced volume[9]. HAL propose to reduce the quantities abstracted from the onsite boreholes and from potable supplies in the future, by improving water efficiency and reuse across the site.

Currently, potable water is used for cleaning aircraft and vehicles. WCs alone are estimated to account for 40% of total water demand at the airport. Rainwater harvesting at Terminal 5 (T5) provides a limited contribution to total airport demand (approximately 1%) of non-potable water and data is not available for a similar and recently commissioned scheme at Terminal 2 (T2). HAL currently use non-potable water for approximately 14% of their total demand, and plan to increase this proportion considerably, however, no target was reported.

[9] Heathrow Airport Limited (2013)
[9] Airports Commission (2014)
[9] Heathrow Airport Limited (2014)

A baseline scenario for growth at Heathrow without the proposed scheme has been developed (Jacobs Water and Flood Risk Baseline Report, 2014a) to allow an assessment of the future impact of development on water resources to be made. The baseline uses readily available information from reports in the public domain and is discussed in more detail in the Jacobs (2014a) report. A baseline has also been produced by HAL. The baseline figures from both sources for water consumption (demand) are presented in Table 8.1.

The baseline scenario for 2026 and 2050 is based on continued, but constrained, growth at Heathrow without any major infrastructure construction. The assessment was not extended further to 2086, which is the lifespan of the project, due to the limitations with available forecast figures and the restricted planning horizon reported in the Affinity Water WRMP.

Table 8.1 - Baseline Annual Water Consumption for Heathrow Airport

	2010	2013	2026		2050	
Metric	**Recorded[10]**		**Jacobs Baseline (Airports Commission[11] forecast passenger nos.)**	**Baseline (HAL[12] forecast passenger nos.)**	**Jacobs Baseline (Airports Commission[11] forecast passenger nos.)**	**Baseline (HAL[12] forecast passenger nos.)**
Passenger nos. (millions)	65.7	72.3	81.4	82.5	93.5	89.9
Water Consumption per passenger (m^3)	0.0339	0.0320	0.0320*	0.0230**	0.0324*	0.0230**
Total Consumption (Mm^3 per annum)	2.22	2.30	2.60	1.90	3.03	2.07

* assumed to remain constant from 2013 to 2026 as no other figures were available, 2050 rate has 1.3% uplift to account for impact of climate change as identified in Affinity WRMP.

** HAL[12] estimated demand at 2040 would be 2.0 Mm^3 per annum. The passenger consumption rate was derived using total consumption and forecast passenger numbers. This estimate of water consumption was then used for both the 2026 and 2050 assessment.

From a comparison of the demand aspects of the two baselines (Table 8.1) the following is noted:

- The forecast passenger numbers used by HAL are 1.1 million greater than the Airports Commission's figures for 2026, and 3.6 million less for 2050;
- The HAL forecast baseline water consumption per passenger for 2026 is almost 30% lower than the most recent available (2013) consumption rate;
- For the Jacobs Baseline the total annual water consumption based on Airports Commission passenger forecasts and current per passenger water consumption, including an allowance of 1.3% for non-household demand

[10] Heathrow Airport Limited (2013) Responsible Heathrow: 2013 Sustainability Performance Summary v1. Online. http://www.heathrowairport.com/static/HeathrowAboutUs/Downloads/PDF/Sustainability/2013_sustainability_summary_report.pdf [Accessed 15/07/2014]

[11] Airports Commission (2014) Demand Forecast. '140901 Pax and ATM Forecast Summary v1.1_CT.xlsx'

[12] Heathrow Airport Limited (2014) Taking Britain Further: Heathrow's plan for connecting the UK to growth. Volume 1. Available Online at: http://www.heathrowairport.com/about-us/company-news-and-information/airports-commission/our-reports [Accessed 15/07/2014]

uplift due to climate change, would increase by 0.3Mm^3 per annum (13%) by 2026 and 0.73Mm^3 per annum (32%) by 2050 from the 2013 level;

- Total annual water consumption based on HAL passenger forecasts and estimates of per passenger consumption, is predicted to decrease by 0.4Mm^3 per annum (-17%) by 2026, and 0.23Mm^3 per annum (-10%) by 2050 compared with current (2013) consumption.

8.2 Potential Mitigation Measures

From an assessment of water efficiency measures and examples of best practice taken from schemes at other airports (Appendix J), the following demand savings could potentially be achieved.

Rainwater Harvesting

The rainwater harvesting scheme currently in use at Heathrow T5 has a potential capture rate of 85% and meets 8% of the non-potable water demand for T5; approximately 1% of total airport demand. Assuming a similar design and capture rate from a new system, with approximately twice the roof area, there is no reason not to expect approximately 2% of additional total airport demand to be met. This is in addition to the existing T2 rainwater harvesting system for which there is currently no usage data.

Water Efficiency Measures

Low flush or flush stop toilets, aerated taps and waterless urinals have all been incorporated in the design of new terminal buildings, or retrofitted to existing facilities with the aim of reducing water demand. Examples of measures used at other airports have been presented in Appendix J. The installation of waterless urinals at Heathrow Terminal 3 (T3)[13] has achieved savings of 0.029Mm^3 per year. This is equivalent to 1.3% of the 2013 total airport demand. T5 and T2 have these efficiency measures incorporated in their design. The new terminal buildings could potentially reduce the demand currently from T1 which will be replaced, potentially saving between 2% and 5% of demand.

Leakage Reduction

HAL estimated that 15% of water is lost to leakage through their water distribution and processing network; this equates to approximately 0.35Mm^3 per year (based on 2013 total consumption). Appendix J0 shows that Gatwick achieved a 20% reduction in demand from addressing leakage in 2011 and at Paris Charles de Gaulle Airport, through the use of monitoring software, leakage was reduced to less than 10%, which is considered to indicate a network in good condition; if HAL achieve a similar level of leakage of 10% they would save 0.115Mm^3 (5%) on 2013 demands.

Wastewater Recycling / Reverse Osmosis

With an increased focus on the cost of water, water stress and integrated water resources management it is likely that water reuse will receive increasing attention

[13] Case study published online by Carillion: http://sustainability2013.carillionplc.com/environment/water.html [Accessed 01/08/2014]

and support. The human health risks associated with emerging contaminants and endocrine disrupting compounds, and public perception issues, mean it is likely water reuse will continue to focus on agricultural, industrial and irrigation schemes, and used for indirect rather than direct potable reuse.

Effluent reuse can either be direct or indirect. Direct effluent reuse is the immediate reuse of effluent for human, agricultural or industrial use without involving intermediate stages (i.e. rivers, groundwater). Direct effluent reuse for potable water through tertiary / advanced treatment processes at wastewater treatment plants is not practiced in Europe and rarely used in the rest of the world due to potential health risks.

For indirect reuse, the effluent is discharged into a water body (i.e. rivers) where it is diluted, before being abstracted further downstream. The water still requires further treatment before being used for potable supply. Indirect effluent reuse is practised in the UK and although limited in extent currently, it is an approach included in a number of water company plans to address predicted supply demand deficits over the next 25 years.

The combined use of a waste water treatment plant and reverse osmosis plant to provide water for potable supply would have high operational and energy/carbon costs associated with their use; generally only making them viable for periods of short term peak demand.

However, given the scale of the airport development, water reuse for meeting a proportion of non-potable demands, rather than potable, is a feasible option for Heathrow Airport. Without undertaking a more detailed assessment, the benefits of such a scheme on reducing current, and forecast demands is not possible to be estimated at this stage.

Where estimates on demand savings can be made from a review of data from similar schemes, it would indicate that there is the potential for a 10 - 15% saving on current potable water demand from the use of the above water efficiency measures as for example, rainwater harvesting could be used to provide an overall saving to potable supply where rainwater can be used instead of potable water.

8.3 Assessment of With Scheme Demand

The Heathrow ENR scheme estimates of water consumption include the proposed mitigation (as detailed in Section 8.4) and assume that construction will be completed in 2026. A comparison between the Jacobs assessment, post-construction passenger numbers and water consumption with the HAL submission is presented in

Table 8.2.

Appendix K presents data from a number of other airports on their passenger water consumption rates. Data from the most recent years where passenger consumption rates are available show a range of between 0.021m³ at Gatwick to 0.074m³ at Dallas Fort Worth. The Jacobs assessment rate of consumption, including potential percentage reduction resulting from efficiency measures, is within the range of consumption rates reported at other airports; the forecast rate of consumption at HAL is 0.0041m³ (20%) lower than the minimum rate.

Table 8.2 - Forecast Annual Water Consumption for Heathrow Airport NWR with Scheme

	2013	2026		2050	
Metric	**Recorded[1]** 0	**Jacobs Assessment (AC passenger forecasts with scheme)**	**HAL[12] with scheme**	**Jacobs Assessment (AC passenger forecasts with scheme)**	**HAL[12] with scheme**
Passenger Nos. (millions)	72.3	91.7	103.6	134.9	134.6
Water Consumption per passenger (m^3)	0.0320	0.0288*	0.0169**	0.0292*	0.0169**
Total Consumption (Mm^3 per annum)	2.30	2.64	1.75	3.94	2.27

* Assumed that a realistic saving of 10% could be made to per passenger consumption rates, as outlined in Section 8.2

** HAL estimated the rate of consumption will be half the 2010 rate once the scheme is at full capacity (also see Table 8.4).

For the assessment of demand 'with scheme' it is noted that despite an increase in passenger numbers resulting from the scheme, HAL estimate a reduction in overall water consumption of 0.55Mm^3 (-24%) per annum by 2026, and 0.03Mm^3 (-1%) per annum by 2050 when compared with 2013. Jacobs however, estimate an increase in 2026 of 0.34Mm^3 (15%) per annum and 1.64Mm^3 (71%) per annum in 2050. The reduction in total consumption 'with scheme' when compared against the Jacobs assessment (with estimates of demand saving) are 0.89Mm^3 (-34%) per annum in 2026 and 1.67Mm^3 (-42%) per annum in 2050 lower. These reductions in demand are based on the implementation of the mitigation measures discussed in Section 8.4. Despite forecasting 11.9 million more passengers in 2025 than Jacobs, HAL are forecasting a per passenger consumption rate that is 41% lower, resulting in a lower overall demand (-34%). For 2050, the passenger forecast and consumption rates are 0.3 million and 42% lower than estimated by Jacobs.

Aside from the expansion of the airport and passenger numbers, water use during the construction phase is likely to have a significant short term impact on water resources. These demands were not discussed in the promoter's submission, but should be considered in this assessment of the overall scheme impact. To minimise water use during construction it is recommended that measures outlined by WRAP[8] on water efficiency in construction are implemented.

The expansion of the airport will not only impact on the water demand from the site, as discussed above. The diversion, culverting and combining of water courses across the site has the potential to effect the hydrological regimes of the water courses and impact downstream sites and users; of particular importance are the designated sites as discussed in this report and the Biodiversity Assessment (Jacobs, 2014c).

There is also going to be a significant increase in impermeable area resulting from the development. The consequence of this in relation to flooding is covered in the Flood Risk Assessment (Jacobs, 2014d). However, the increase in impermeable surface along with proposals to capture and reuse rainwater and site surface water runoff will result in a change to the discharges to neighbouring watercourses, potentially impacting on flow sensitive sites and users downstream.

8.4 Heathrow Airport Northwest Runway Mitigation Measures

A number of measures have been proposed in the HAL submission to reduce the current impact of the airport and the impact of the HAL proposed scheme on water resources. These included:

- Grey-water recycling, particularly;
  - the integration of grey water recovery from de-icer processing; and
  - vehicle washing water recovery (95%) and reuse;
- Increased rainwater harvesting from roofs for non-potable uses (e.g. cleaning aircraft / vehicles, flushing WCs and washrooms). HAL has assumed that rainwater harvesting tanks will be oversized to provide storage for a 1 in 100 year rainfall event, with an allowance for climate change; the duration of this event was not stipulated in the submission;
- Use of highly efficient water fittings in the design of new buildings and retrospectively fitted to older buildings;
- Use of 'Smart Control' to identify usage trends, high use and leakage. Then using these data to prioritise maintenance / investments / savings;
- Increase in leakage detection / prevention;
- New water treatment plants, including an on-site sewage treatment works (STW) and reverse osmosis (RO) plant - working in combination to recycle waste water. This is proposed to provide potable water and to meet all of the airports non-potable water requirements, removing the need to abstract from the on-site sensitive aquifers. The exact quantities available from these processes would be dependent upon their design capacity;
- Increase in water metering across the site;
- Increase in communication / education / awareness / training relating to water use.

HAL report that no discussions have been held between HAL and utility companies regarding future water supply at Heathrow Airport. The HAL submission forecasts a reduction in the reliance on potable water supply from Affinity Water as a result of efficiency measures across the site, both with and without the proposed scheme.

A proportion of the increase in demand could potentially be offset through the reduction in demand from a number of houses and commercial premises that will be compulsorily purchased as part of the development. However, this will only apply if these properties are relocated outside of the WRZ. With demand from these premises and point of relocation currently unknown, no further quantities can be estimated at this stage.

In a high level summary graph of resource use assessment, presented as part of the promoter's submission, water efficient fittings, smart buildings and water management are identified as the areas where the greatest savings are proposed. The construction of the STW and RO plant are also expected to achieve a significant potable water demand reduction and meet the airport's requirement for non-potable water. The waste streams associated with this, concentrated brine for example, would still need to be treated and disposed of.

Based on the details within the HAL submission, Jacobs has used estimates of potential rainfall volumes captured over a range of rainfall durations (Table 8.3) to estimate potential volumes from the rainwater harvesting scheme. Assuming that 85% of the annual average rainfall is captured, the system would collect 80,992m^3, enough to meet 9% of the total 2013 WC flushing demand. It should be noted that in

2010 when data was last recorded for rainwater harvesting use, that the rainwater harvesting system at T5 only supplied a total of 31,183m³.

Table 8.3 - Estimates for Rainwater Harvesting Capacity

New Terminal Buildings - Roof Surface Area (m²)	157,871			
Rainfall Capture Rate (%)*	85			
1 in 100 year Rainfall Event (mm)**	37.93	51.83	100.20	603
Duration	15 minutes	1 hour	1 day	Annual Average
Climate Change (CC) Factor (%)	20	20	20	20
Rainfall plus CC (mm)	45.52	62.20	120.24	N/A
Total Potential Volume (m³)	6,108	8,346	16,135	80,992

* Rainfall capture rate assumed to be same as T5 potential rate.
** 1 in 100 year rainfall derived from the Flood Estimation Handbook (FEH)

Assuming that the storage tanks are designed for a 1 in 100 year 15 minute rainfall event, they would need a capacity of at least 6,108m³. For comparison, Frankfurt Airport currently has 6 x 100m³ storage tanks, whilst Paris Charles De Gaulle has 2 x 35m³ tanks (Appendix J); both schemes are significantly smaller than that proposed by HAL.

HAL are proposing that by 2026, with the scheme at capacity, with all of the efficiency measures in place that they will have halved per passenger consumption from 2010 rates.

HAL have been consulting with the Environment Agency and Natural England with regards to the watercourse diversions and culverting to ensure that any water resources impacts downstream are mitigated.

8.5 Commentary on Promoter's Submission

The HAL submission specifies that the scheme will reduce overall water consumption through the use of numerous mitigation measures even with an increase in passenger numbers.

HAL's submission lacks detail in the origin of many of the figures and therefore assumptions were made by Jacobs based on available data to allow an assessment to be made. These include:

- Total consumption, without the scheme, in 2040 will be 2.0Mm³;
- Several values for passenger water consumption rates with the scheme have been discussed in the submission, Table 8.4. The headline indicator of halving consumption from 2010 rates has been used within the assessment as the other values appear to be extremely low, especially when compared with existing per passenger consumption rates reported at other airports (Appendix K).

Table 8.4 - Variation in Reported Rates of Consumption after Construction

Comment	Year	Passenger Nos (million)	Total Consumption (Mm^3 per annum)	Per Passenger Consumption (m^3)	Source
Recorded values used as Baseline in submission	2010	65.7	2.227	0.0339	Heathrow Airport Limited (2013) Responsible Heathrow: 2013 Sustainability Performance Summary v1
Headline indicator to half passenger consumption with scheme from 2010 rates	2026	130	2.197	**0.0169**	Heathrow Airport Limited (2014b) Taking Britain Further: Heathrow's plan for connecting the UK to growth. Volume 1. Page 338
Water abstraction per passenger reduced by 70% from 2010. Requires all 14 efficiency measures to be incorporated.	2026	130	1.326	0.0102	Appendix to 5.8 – A resource efficient Heathrow: Taking Britain Further, Volume 1 Technical Submission - '10 Heathrow 3RNW - Resource Efficiency.pdf'. Page 5
Absolute decrease of 25.3 litres of water extracted per passenger from 2010. Requires all 14 efficiency measures to be incorporated.	2026	130	1.118	0.0086	Appendix to 5.8 – A resource efficient Heathrow: Taking Britain Further (2014c), Volume 1 Technical Submission - '10 Heathrow 3RNW - Resource Efficiency.pdf'. Page 5

The following points within the HAL submission are noted:

- HAL only forecast demands up to 2040, in their assessment they state this is due to the high levels of uncertainty with longer term forecasts;
- Climate change impacts on passenger water consumption were not specifically included in the discussion on water resources;
- No baseline passenger consumption rates or total consumption values were reported for 2026 or 2050;
- Only a high level summary chart showing the impact on potable water demand from a number of potential demand reduction measures was provided, however, neither the actual savings nor accompanying calculations were provided; and
- Estimates of water demand extend to 2040 and not for the full design life (60 years) to 2086.

Evidence from similar water efficiency schemes adopted at other airports presented in Appendix J indicates that reductions in potable water use could be made with the implementation of the proposed water efficiency measures and by using rainwater harvesting systems. HAL are also proposing a heavy reliance on a new STW and RO plant to reduce demands. However, limited evidence was presented on the effectiveness of each of these schemes and without the calculations and assumptions used by HAL to substantiate their claims the proposed levels of reduction appear to be optimistic.

8.6 Conclusion

Passenger numbers are forecast to increase at Heathrow, with and without the proposed scheme. However, following implementation of the scheme, HAL estimates of overall water consumption when compared to the Jacobs assessment of demand are 0.89Mm³ (-34%) per annum less in 2026 and 1.67Mm³ (-42%) per annum less in 2050 as a result of water efficiency and recycling measures across the site.

Jacobs' assessment and review of the HAL submission documents and subsequent comparison of demand against a baseline derived by Jacobs leads us to conclude that:

- The HAL submission proposes to achieve a significant reduction in demand at Heathrow following the implementation of water efficiency and recycling measures across the site. HAL have forecast a doubling of passenger numbers whilst halving the per passenger consumption rate.
- Through the implementation of a number of water efficiency measures across the airport and by increasing the volume of recycled water used, HAL anticipate that following construction of a third runway demand will reduce from 2013 levels by 24% in 2026 and 1% in 2050. When compared with the Jacobs assessment of demands, which forecast an increase in demand of 15% and 71% in 2026 and 2050 respectively, the HAL demands are 34% and 42% less. These reductions in demand anticipated by HAL are significant and are highly dependent on implementing water and waste water recycling and the wastewater recycling is associated with high capital cost and energy consumption. There are potentially acceptability and health issues with direct use of RO treated wastewater as potable water.
- Uncertainty lies within the calculation of savings to be achieved from water resource efficiency measures. HAL have stated that by 2026, per passenger consumption will have halved from 2010 levels but did not detail exactly how this was to be achieved.
- The HAL submission did not consider water consumption throughout the scheme's lifetime to 2086.

9 Water Quantity Impacts – Heathrow Airport Extended Northern Runway

This section assesses the Heathrow Airport Extended Northern Runway (ENR) scheme, providing the following information:

- Summary of baseline water demands for 2012/2013 and 2025/26 and projected to 2050 without a scheme in place;
- Jacobs assessment of impacts on water quantity including potential passenger consumption increases with scheme compared to baseline;
- Potential for mitigation of impacts including potential water efficiency approaches;
- Comments on the proposers' submissions.

Section 9.1 below provides an overview of the current and anticipated (for 2026 to 2050) baseline conditions at Heathrow ENR as defined by Jacobs. Further details of the baseline are reported in Water and Flood Risk Baseline report (Jacobs, 2014a). Section 9.2 gives an assessment by Jacobs on potential demand reduction measures. Section 9.3 reviews the scheme promoter's assessment of how the proposed scheme may affect water resources, followed, in Section 9.4 on how any impacts on water resources will be mitigated by HH. Section 9.5 makes comment on the HH submission, including its limitations and assumptions.

9.1 Baseline (No Scheme) Demand

The initial assessment of water resources presented in the Jacobs Baseline Report (2014a) highlighted the high level of water stress that currently exists across the south-east of England and the limited availability for additional abstraction licences to be granted.

The Affinity Water WRMP concluded that there is a water resource deficit in the Water Resource Zone (WRZ4) that supplies Heathrow. Water supply at Heathrow comprises potable mains supply provided by Affinity Water (81%) and on-site boreholes (19%). Since 2011 the onsite boreholes have not been fully exploited, abstracting between 2011 and 2013, 37%, 44% and 46% of total licenced volume[9].

A baseline scenario for growth at Heathrow Airport without the proposed Heathrow ENR scheme has been developed (Jacobs, 2014a) to allow an assessment of impacts from the promoter's scheme. The Water and Flood Risk Baseline Report (Jacobs, 2014a) is based on the Airports Commission passenger number forecasts. The baseline data for the Heathrow ENR scheme was developed using readily available information from reports in the public domain. Baseline figures are presented in Table 9.1.

The baseline scenario for 2026 and 2050 is based on continued, but constrained, growth at Heathrow without the construction of the proposed Heathrow ENR scheme. The assessment was not extended further to 2086, the lifespan of the project, due to the limitations with available forecast figures and the restricted planning horizon reported in the WRMP.

Table 9.1 - Baseline Annual Water Consumption for Heathrow ENR

	2010	2013	2026		2050	
Metric	**Recorded[10]**		**Jacobs Baseline (Airports Commission[11] forecast passenger nos.)**	**Baseline (HH[14] forecast passenger nos.)**	**Jacobs Baseline (Airports Commission[11] forecast passenger nos.)**	**Baseline (HH[14] forecast passenger nos.)**
Passenger Nos. (millions)	65.7	72.3	81.4	82.0	93.5	92.0
Water Consumption per passenger (m^3)	0.0339	0.0320	0.0320*	0.0320***	0.0324**	0.0324****
Total Consumption (Mm^3 per annum)	2.22	2.30	2.60	2.62	3.03	2.98

* assumed to remain constant from 2013 as no other figures were available.
** 2050 rate has 1.3% uplift to account for impact of climate change as identified in Affinity WRMP.
*** Jacobs 2026 baseline per passenger consumption rates used in the absence of any values in the HH submission.
**** Jacobs 2050 baseline per passenger consumption rates used in the absence of any values in the HH submission.

For the baseline assessment of demand the following is noted:

- The HH submission passenger forecasts are 0.6 million higher than the Jacobs Baseline figures for 2026, and 1.5 million less for 2050;
- Total water consumption and passenger consumption rates were not included in the HH submission and therefore the Jacobs Baseline passenger consumption rates were used to calculate total demand;
- Total annual water consumption (based on the Airports Commission passenger forecasts) and per passenger water consumption, including an allowance of 1.3% for climate change, would increase by $0.3Mm^3$ (13%) per annum by 2026 and $0.73Mm^3$ (32%) per annum by 2050 from the 2013 level as determined in the Baseline Report (Jacobs, 2014a);
- The HH submission forecasts a total annual water consumption increase of $0.32Mm^3$ (14%) per annum by 2026 and $0.68Mm^3$ (30%) per annum by 2050 from the 2013 level.

9.2 Potential Mitigation Measures

From an assessment of water efficiency measures and examples of best practice taken from schemes at other airports (Appendix J), the following demand savings could potentially be achieved.

Rainwater Harvesting

The rainwater harvesting scheme currently in use at Heathrow Terminal 5 (T5) has a potential capture rate of 85% and meets 8% of the non-potable water demand for T5; equating to approximately 1% of total airport demand. Assuming a similar design and capture rate from a new system, with approximately twice the roof area, there is no reason not to expect approximately 2% of additional total airport demand to be

[14] Runway Innovations Ltd and Heathrow Hub Ltd. (2014).

met. This is in addition to the existing Terminal 2 (T2) rainwater harvesting system for which there is currently no usage data available.

Water Efficiency Measures

Low flush or flush stop toilets, aerated taps and waterless urinals have all been incorporated in the design of new terminal buildings, or retrofitted to existing facilities with the aim of reducing water demand. Examples of measures used at other airports have been presented in Appendix J. The installation of waterless urinals at Heathrow Terminal 3 (T3)[13] has achieved savings of 0.029Mm³ per year. This is equivalent to 1.3% of the 2013 total airport demand. T5 and T2 have these efficiency measures incorporated in their design. The new terminal buildings could potentially reduce the demand currently from T1 which will be replaced, potentially saving between 2% and 5% of demand.

Leakage Reduction

HAL estimated that 15% of water is lost to leakage through their water distribution and processing network; this equates to approximately 0.35Mm³ per year (based on 2013 total consumption). Appendix J shows that Gatwick achieved a 20% reduction in demand from addressing leakage in 2011 and at Paris Charles De Gaulle (CDG) Airport, through the use of monitoring software, leakage was reduced to less than 10%, which is considered to indicate a network in good condition; if Heathrow Hub can achieve a similar level of leakage of 10% they would save 0.115Mm³ (5%) on 2013 demands.

Where estimates on demand savings can be made from a review of data from similar schemes, it would indicate that there is the potential for a 10 - 15% saving on current potable water demand from the use of the above water efficiency measures as, for example, rainwater harvesting could be used to provide an overall saving to potable water supply where rainwater is used instead of potable water.

9.3 Assessment of With Scheme Demand

The increased demand resulting from the additional runway as part of the HH scheme at Heathrow has been assessed on the basis that construction of a new runway will be completed in 2026, as stated in the promoter's submission. The demand assessment and post-construction passenger numbers are shown in Table 9.2. It should be noted that the estimated increase in demand reported in the HH submission is for the airport extension and the associated Heathrow Hub interchange; preventing a direct comparison between the Jacobs and HH forecast demands[15].

[15] Heathrow Hub interchange has been excluded from the footprint and the assessment. The Airports Commission stated in its Interim Report its intention to consider HH's proposed transport hub as a detachable component which could be associated with either of the Heathrow runway options under consideration. Accordingly, the core appraisal case for the Heathrow ENR scheme includes a more traditional surface access package.

Table 9.2 - Forecast Annual Water Consumption for Heathrow Hub

	2013	2026		2050	
Metric	**Recorded** [10]	**Jacobs Assessment (AC passenger forecasts with scheme)**	**HH Assessment (with scheme)**	**Jacobs Assessment (AC passenger forecasts with scheme)**	**HH Assessment (with scheme)**
Passenger Nos. based on AC forecasts (millions)	72.3	91.1	91.1	128.6	128.6
Water Consumption per passenger (m^3)	0.0320	0.0288*	0.0306**	0.0292*	0.0306****
Total Consumption (Mm^3 per annum)	2.30	2.62	2.79***	3.76	3.94*****

* Assumed that a realistic saving of 10% could be made to per passenger consumption rates, as outlined in Section 8.2
** calculated from forecast demand
*** additional demand of 0.491Mm^3 forecast by HH which includes the airport extension and Hub
**** assumed to remain constant from 2026
***** calculated from AC forecast passenger numbers and assumed per passenger consumption rate for 2026

Appendix K presents data from a number of other airports on their passenger consumption rates. Data from the most recent years where passenger consumption rates are available show a range of between 0.021m^3 at Gatwick to 0.074m^3 at Dallas Fort Worth. The Jacobs assessment rate of consumption and calculated HH rate of consumption are both within the range of consumption values reported at other airports.

In the assessment of the 'with scheme' water consumption the following is noted:

- Water consumption per passenger and total water consumption per annum for the airport extension alone were not reported in the Heathrow ENR scheme submission however, a forecast increase in demand of 491,000 m^3 resulting from the airport extension and Heathrow Hub Interchange was provided. From this per passenger rates were calculated.;

- For the Jacobs assessment of demand 'with scheme' it is noted that there is an increase in water consumption of 0.32Mm^3 per annum (14%) by 2026, and 1.46Mm^3 per annum (64%) by 2050 when compared with 2013;

- For the HH assessment of demand 'with scheme' (including airport extension and Hub) it is noted that there is an increase in water consumption of 0.49Mm^3 per annum (21%) by 2026, and 1.64Mm^3 per annum (71%) by 2050 when compared with 2013.

The promoter's scheme will increase the demand for potable water resources in a region that is already under water stress. The additional demand will be partially offset through the loss of demand from 246 houses and commercial premises (65.5ha); the promoters estimate this to be in the region of 31,000 m^3. However, some of these properties will be relocated within the same WRZ resulting in little or no change in demand. Aside from the expansion of the airport and passenger numbers, there will also be the increase in demand from the associated Heathrow Hub infrastructure (e.g. transport links). Whilst the increased demand provided by the promoter includes this, the Jacobs assessment has not considered demands

from the Heathrow Hub interchange in the assessment preventing a direct comparison from being completed.

Aside from the expansion of the airport and passenger numbers, water use during the construction phase is likely to have a significant short term impact on water resources. These demands were not discussed in detail in the promoter's submission, but should be considered in this assessment of the overall scheme impact. To minimise water use during construction it is recommended that measures outlined by WRAP[8] on water efficiency in construction are implemented.

The expansion of the airport will not only impact on the water demand from the site, as discussed above. The diversion, culverting and combining of watercourses across the site has the potential to effect the hydrological regimes of the watercourses and impact downstream sites and users; of particular importance are the designated sites as discussed in this report and the Biodiversity Assessment (Jacobs, 2014c).

There is also going to be a significant increase in impermeable area, amounting to approximately 400ha, as a result of the development. The consequence of this in relation to flood risk is covered in the Flood Risk Assessment (Jacobs, 2014d). However, the increased impermeable surface along with proposals to capture and reuse rainwater and site surface water runoff will result in a change to the discharges to neighbouring watercourse, potentially impacting on flow sensitive sites and users downstream.

9.4 Heathrow Airport Extended Northern Runway Mitigation Measures

The increased water demand resulting from growth at the airport and any potential mitigation were discussed at a high level and consideration was given to a number of measures that could reduce the impact of the Heathrow ENR scheme on water resources. These included:

- Grey-water recycling systems to intercept greywater water, and permit this water to be treated, stored and recycled for use in toilet flushing and irrigation. The proportion of potable water that may be recycled from wash basins and showers will be dependent upon the range of appliances that are installed within the extended airport however the promoters indicate there is the potential to reduce potable water demand by up to 27 per cent;

- Rainwater harvesting for non-potable uses such as WC flushing, washing aircraft / cars, fire-fighting drills and irrigation. HH have assumed a potential annual capture volume of 48,000 m^3 and have proposed a storage capacity of 9,000m^3 based on a 1 in 100 year, 6 hour long rainfall event. This is estimated to be able to meet approximately 9% of the additional demand;

- Use of water efficiency measures such as low flush toilets, flow regulated showers, spray taps and auto shut off valves to toilet areas have the potential to reduce water demand by approximately 30%; and

- On site Water Management Plan.

The promoter has calculated that the airport and associated Hub would increase demands for water by 0.746Mm^3 without incorporating the above efficiency measures. With these measures in place this increase in demand would be reduced to 0.491Mm^3.

9.5 Commentary on Promoter's Submission

The promoter's submission has provided some detail on the overall impacts of the proposed scheme on water consumption but the levels of effectiveness proposed are greater than those reported at other airports and estimated by Jacobs. Of particularly note is the 30% reduction in demand from water efficiency measures. . The high level assessment completed by Jacobs into water efficiency measures adopted at other airports indicates that savings of between 10 and 15% to potable water demand could be achieved with the use of water efficiency measures, increased on site water management and rainwater harvesting.

The following areas lacking detail were identified in the HH submission:

- Climate change impacts on water consumption were not specifically included in the discussion on water resources;
- Estimates of baseline passenger water consumption or baseline total annual water consumption were not provided in the submission. Neither were the total annual water consumption values, or passenger consumption rates for the with scheme; and
- Estimates of passenger numbers extend to 2050 and not for the full design life (60 years) to 2086.

9.6 Conclusion

The HH submission did not present estimates of water demand for the airport extension alone and mitigation for either the baseline or total demands with the scheme in place which made comparison difficult or with scheme scenarios. The Jacobs 'with scheme', estimates an increase in total water consumption of 0.30Mm³ per annum (13%) in 2026 and 1.46Mm³ per annum (64%) in 2050, when compared with 2013 consumption. The Jacobs estimate is lower than the 0.49Mm³ (21%) and 1.64Mm³ (71%) increase in demand for 2026 and 2050 respectively forecast by HH, but it should be noted that the increase demand stated in the HH submission was a combined value for the airport extension and Heathrow Hub Interchange.

Jacobs' assessment and review of the HH submission documents and subsequent comparison of demand against a baseline derived by Jacobs leads us to conclude that:

- The HH submission did not present detailed estimates of water consumption either for the baseline or with scheme scenarios. Therefore estimates of water consumption have been derived by Jacobs based on predicted passenger numbers and the limited estimates of increased demands for the airport extension and Heathrow Hub Interchange. This indicates an increase in total consumption. This absence of baseline and total demand information has led to uncertainty with regard to the calculation of impacts on water resources from the HH submission.
- Assumptions relating to the forecast rates of consumption and total consumption have been made when assessing the impacts on water resources as actual values are not available;

- The HH submission has stated that the additional demand can feasibly be met from increased abstraction from surface waters and shallow groundwaters in the Maidenhead to Sunbury catchment area or by the confined Chalk aquifer across the entire area. However, given the already water stressed nature of the region this would need to be investigated further;

- The HH submission has not considered water consumption throughout the scheme's lifetime to 2086.

Glossary

Berm	A depositional feature at the margin of a river.
De-icer	De-icer is a fluid based on propylene glycol. De-icing on the ground is usually done by spraying the aircraft.
Deposition	Laying down of part, or all, of the sediment load of a stream on the bed, banks or floodplain. Mostly occurs as high flows recede. The process forms various sediment features such as bars, berms and floodplain deposits.
Diffuse source pollution	Primarily associated with run-off and other discharges related to different land uses such as agriculture and forestry, from transport infrastructure and from septic tanks associated with rural dwellings and from spreading of industrial, municipal and agricultural wastes to land.
Ecological status	Surface waters are classified as being of good ecological status when each of the quality elements representing indicators of ecological quality of the water body are classified as being good or high. The quality elements fall into three categories, i) biological quality elements, ii) chemical and physicochemical quality elements and iii) hydromorphological quality elements.
Erosion	Removal of sediment or bedrock from the bed or banks of the channel by flowing water. Process mostly occurs during high flows and flood events. Forms various river features such as scour holes and steep outer banks.
Floodplain	A floodplain is flat or nearly flat land adjacent to a stream or river, stretching from the banks of a channel (or channels) to the foot of the enclosing valley walls and (under natural conditions) experiencing periods of high discharge and flooding.
Geomorphology	The study of landforms and the processes that create them.
Good ecological status	WFD term denoting a slight deviation from 'reference conditions' in a water body, or the biological, chemical and physiochemical and hydromorphological conditions associated with little or no human pressure.
Made Ground	A term used to describe deposition of soil material (by man) of unknown composition. Soil will have been 'tipped' rather than placed by engineering methods and may contain potential contaminants.
Moderate status	WFD term denoting a moderate deviation from the 'reference condition' in a water body, for biological, chemical and morphological elements.
Morphology	Describes the physical form and condition of a water body, for example the width, depth and wetted perimeter of a river channel, the structure and condition of the river bed and banks.
Planform	The shape of a river channel as viewed from the air (such as meandering or braided).
Pool	A topographic low point in the bed of a channel providing a relatively deep area of water.

Reference Condition	'High status' is defined as the biological, chemical and morphological conditions associated with no or very low human pressure. This is also called the 'reference condition' as it is the best status achievable - the benchmark. These reference conditions are type-specific, so they are different for different types of rivers, lakes or coastal waters so as to take into account the broad diversity of ecological regions in Europe.
Re-meandering	Establishing a new or former course of a river channel, but accounting for a more natural channel length.
Re-profiling	The reshaping of a river bank. May be a reflection of channel modification (impact) or restoration.
Riffle	A riffle is a short, relatively shallow and coarse-bedded length of stream. It is a natural topographical high point in the bed of the channel and riffles commonly alternate with deeper pools.
Riparian zone (or area)	The riparian zone or riparian area is the interface between land and a stream or river. Plant habitats and communities along the river margins and banks are called riparian vegetation, characterised by hydrophilic plants. Riparian zones are significant because they have a role to play in soil conservation (e.g. from adjacent farmland), habitat diversity and their influence on fauna and aquatic ecosystems (including grassland, woodland and wetland). Other terms used are riparian woodland, riparian forest, riparian buffer zone or buffer strip. However the term riparian zone is used in this report to be a wider area and an adequate buffer strip may be many metres in width.
River Basin Management Plan (RBMP)	A plan that must be produced for each River Basin District within a Member State in accordance with Article 13 of the WFD. The plan must include the information detailed in Annex VIII of the WFD. For this study this is the Thames River Basin Management Plan.
Sediment	Organic and inorganic material that has precipitated from water to accumulate on the floor or within the water column of a water body, watercourse or trap.
Sediment Regime	The nature of the dominant sediment processes that occur in a river.
Special Site of Scientific Interest (SSSI)	A conservation designation denoting a protected area in the United Kingdom.
Sinuosity	River sinuosity can be defined as the length of the river divided by the length of the river valley. It is a description of a river's tendency not to follow a straight path.
Syphon	A syphon is where (a part of) the river passes underneath a rock obstruction
Total Organic Carbon (TOC)	Total organic carbon (TOC) is the amount of carbon bound in an organic compound and is often used as a non-specific indicator of water quality or cleanliness of pharmaceutical manufacturing equipment.
Two-stage	Two-stage channels incorporate berms or ledges that

channel	function as floodplains. However, in comparison to floodplains in natural streams, these are artificial features and their width is often small due to the confining geometry of a constructed channel.
Water body	Discrete section of a river, groundwater area, lake or coast that is a defined management unit under the WFD.
Water column	A conceptual column of water from surface to bottom sediments.
Water Framework Directive	A substantial piece of EU water legislation that came into force in 2000, with the overarching objective to get all water bodies in Europe to attain Good or High Ecological Status. River Basin Management Plans (RBMP) have been created which set out measures and potential mitigation to ensure that water bodies in England and Wales achieve 'Good Ecological Status'.
Woody debris	Woody debris comprises the logs, sticks, branches, and other wood falling into streams and rivers. This debris can influence the flow and shape of a stream channel.

References

Affinity Water (2014). Affinity Water Final Water Resources Management Plan. Available Online at: https://stakeholder.affinitywater.co.uk/water-resources.aspx [Accessed 15 July 2014]

Airports Commission (April 2014) Appraisal Framework

Airports Commission (2014). Assessment of Need Carbon Capped

AMEC Environment and Infrastructure UK Ltd (prepared for Heathrow Airport Limited (HAL)) (2014) Water Quality and Hydro-ecology Assessment in Heathrow's North-West Runway.

Brookes, A (1988) River Channelization: perspectives for environmental management, John Wiley and Sons, Chichester

Brookes, A and Shields, F (1996) (eds.) River Channel Restoration: guiding principles. Wiley and Sons, Chichester (see references to Wraysbury River enhancement)

CEEQUAL (2013) The Twin River Diversion Scheme. Available online at: http://www.ceequal.co.uk/awards_009.htm [Accessed 7 August 2014].

CH2MHILL (2014) (prepared for Gatwick Airport Limited (GAL)) Appendix A12 Water and Flood Risk in A Second Runway for Gatwick.

CIRIA (2010). Culvert Design and Operation Guide Report C689. Available online at: http://www.blissbooks.co.uk/documents/323298.pdf [Accessed 7 August 2014].

Department of Transport (1996) Proof of Evidence of Andrew Brookes., Topic 4 Ecology and Nature Conservation., Heathrow Terminal 5 Access (Twin Rivers Mitigation Evidence)

Environment Agency (1999) Policy Regarding Culverts – Policy Statement. Available online at https://www.whatdotheyknow.com/request/153315/response/378193/attach/3/Culvert%20Policy%20Policy%20Statement.pdf [Accessed 8 August 2014]

Environment Agency (2002) Scoping Guidance for Projects at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296952/geho0411btrf-e-e.pdf

Environment Agency (2006). The Mole Catchment Abstraction Management Strategy. Available Online at: http://www.westofcrawley.gov.uk/Assets/River%20Mole%20CAMS%20Part1.pdf [Accessed 24 July 2014].

Environment Agency (2007a). The Colne Catchment Abstraction Management Strategy. Water Abstraction – Getting the Balance Right. Available Online at: https://www.gov.uk/government/publications/colne-catchment-abstraction-licensing-strategy

Environment Agency (2007b). The Thames Corridor Catchment Abstraction Management Strategy. Available Online at:

https://www.gov.uk/government/publications/thames-catchment-abstraction-licensing-strategy [Accessed 15 July 2014]

Environment Agency (2008) Fluvial Design Guide – Chapter 8, Section 8.6 Culverting of watercourses

Environment Agency (2009a) Environment Agency Policy Regarding Culverts – Policy Statement. Available online at: https://www.whatdotheyknow.com/request/153315/response/378193/attach/3/Culvert%20Policy%20Policy%20Statement.pdf [Accessed 7 August 2014]

Environment Agency (2009b) Chapter 8: Works in the river channel in The Fluvial Guide. Available online at: http://evidence.environment-agency.gov.uk/FCERM/Libraries/Fluvial_Documents/Fluvial_Design_Guide_-_Chapter_8.sflb.ashx

Environment Agency (2010a). Guidance on selecting mitigation measures. Available online at: http://evidence.environment-agency.gov.uk/FCERM/en/SC060065/Decisiontree.aspx [Accessed 29 August 2014].

Environment Agency (2010b). About the Water Framework Directive. Available online at: http://evidence.environment-agency.gov.uk/FCERM/en/SC060065/About.aspx [Accessed 29 August 2014].

Environment Agency (2014) River Thames scheme: reducing flood risk from Datchet to Teddington See https://www.gov.uk/government/publications/river-thames-flood-risk-management-scheme/river-thames-flood-risk-management-scheme
Gardiner, J.L., Dearsley, A.F. and Woolnough, J.R. (1987) The appraisal of Environmentally sensitive options for flood alleviation using mathematical modelling., Water and Environmental Management., 1,2, 171-184

Gatwick Airport (2012). Gatwick Master Plan. Available Online at: http://www.gatwickairport.com/PublicationFiles/business_and_community/all_public_publications/2012/2012-07-18-gal_masterplan.pdf [Accessed 18th July 2014].

Gatwick Airport Limited (2013). Section 106 Annual Monitoring Report 2012. Available Online at: http://www.gatwickairport.com/PublicationFiles/business_and_community/all_public_publications/corporate_responsibility/S106_2013_Report.pdf [Accessed 15 July 2014]

Heathrow Airport Limited (2013). Responsible Heathrow: 2013 Sustainability Performance Summary v1. Available Online at: http://www.heathrowairport.com/static/HeathrowAboutUs/Downloads/PDF/Sustainability/2013_sustainability_summary_report.pdf [Accessed 15/07/2014]

Heathrow Airport Limited (HAL) (2014a) Taking Britain Further – Heathrow's plan for connecting the UK to growth. Technical Submission – Volume 3. Chapter 5: Enhancing the Natural Environment - Appendix 25 (Flood Risk Mitigation Strategy).

Heathrow Airport Limited (HAL) (2014b) Taking Britain Further: Heathrow's plan for connecting the UK to growth. Volume 1. Available Online at: http://www.heathrowairport.com/about-us/company-news-and-information/airports-commission/our-reports [Accessed 15/07/2014]

Heathrow Airport Limited (HAL) (2014c). Heathrow's North West Runway – Resource Use Assessment. Appendix to 5.8 – A resource efficient Heathrow: Taking Britain Further, Volume 1: Technical Submission - '10 Heathrow 3RNW - Resource Efficiency.pdf'. Available Online at: http://www.heathrowairport.com/about-us/company-news-and-information/airports-commission/our-reports [Accessed 15/07/2014]

Jacobs (2014a) Module 9: Water and Flood Risk: Baseline Report, Prepared for the Airports Commission, Jacobs

Jacobs (2014b) Heathrow Hub Option 2 Proposed Runway Extension General Arrangement (Jacobs Revision) Figure B1988000-PH2-1.3-SK003 Version 1.0

Jacobs (2014c) Module 7: Biodiversity: Assessment, Prepared for the Airports Commission, Jacobs

Jacobs (2014d). Module 9: Water and Flood Risk: Flood Risk Assessment, Prepared for the Airports Commission, Jacobs

Jacobs (2014e) Module 10: Place Baseline Report, Prepared for the Airports Commission, Jacobs

Kondolf, G.M. 1996. A cross section of stream channel restoration. Journal of Soil and Water Conservation 51:119-125.

National Rivers Authority (1997) Scoping Guidance for the Environmental Assessment of Projects, unpublished guidance, NRA, Bristol, UK.

Rickard, C., Day, R. and Purseglove, J (for the Environment Agency). 2003. River Weirs – Good Practice Guide. R&D Publication W5B-023/HQP (Research Contractor: Mott MacDonald Ltd and University of Hertfordshire). Available online at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/290655/sw5b-023-hqp-e-e.pdf [Accessed 5 August 2014].

Runway Innovations Ltd and Heathrow Hub Ltd. (2014). Heathrow Expansion: Updated Design Scheme – Submission to the Airports Commission. 'RIL_HH Updated Scheme Design Main 140514.pdf'

Sutton and East Surrey Water (2014). Final Water Resources Management Plan. Available Online at: http://www.waterplc.com/pages/about/publications/water-resources-and-drought-reports/final-wrmp/ [Accessed 15 July 2014]

Thames Water (1988) Lower Colne Study: Environmental Impact Assessment Report. Thames Water, March 1988

URS (prepared for Runway Innovation Ltd) (2014) Heathrow Expansion - Stage 2 Submission, Attachment 5-1

Appendix A Methodology – Water Quality

The aim of the Water Framework Directive and Water Quality Impacts report is to assess the potential impact of the three individual airport scheme proposals on surface water and groundwater.

Each scheme is assessed as detailed in Airports Commission: Appraisal Framework (Airports Commission, 2014) to analyse:

- "*The water environment in terms of surface waters, groundwaters, estuaries and coastal waters (surface waters include streams, rivers, lakes, reservoirs and wetlands)"; and,*
- *"The water quality, assessed using the WFD classification system, considering impacts on protected areas, no deterioration of water bodies, status and achieving good status in water bodies (this includes ecological and chemical quality as well as quantitative status)".*

Estuarine and coastal waters have not been considered within this report due to the inland nature of the three proposed development locations.

The report specifically addresses water quality and the European Water Framework Directive (WFD) water bodies. In relation to WFD water bodies, it assesses whether the developments could lead to a deterioration in water body status or the prevention of a water body from achieving Good Ecological Status (GES) or Good Ecological Potential (GEP). There have been several examples of good practice restoration, mitigation and enhancement on watercourses close to (or directly affected by) the existing Heathrow and Gatwick Airports and a selection is given. Consideration is given to mitigation likely to be required to minimise/eliminate potential impacts and the subsequent residual impacts that could potentially remain even after mitigation.

This assessment has been undertaken as a desk-based review of potential impacts that could arise from the promoters' proposals and the potential mitigation measures that they have suggested as compensation. An assessment by Jacobs of the potential impacts for each of the three schemes is also given. This draws on the information provided in the Water Quality and Flood Risk Baseline report (Jacobs 2014a) and readily available information. An overview of the generic impacts affecting all three developments is initially provided, looking at potential structures and modifications that could affect the water environment. A summary of the baseline conditions is given, based on the Water and Flood Risk Baseline report completed by Jacobs (2014a). Jacobs' impact assessment (including potential mitigation) of the proposals is then provided. This is then followed by an assessment of the specific impacts and mitigation measures detailed by the individual promoter in their submissions.

The assessment by Jacobs of the potential impacts is primarily based on readily available information. A search of literature and web-based information concerning potential impacts and mitigations has also been undertaken and where gaps remain a degree of professional judgement based on experience has been given.

It is recognised that the promoters' proposals are still in the outline phase and currently only provide a high level insight into the proposed works; this has been taken into account when conducting this assessment. The Individual Impact Assessment of each proposal takes account of potential changes to hydromorphology, biology and physico-chemical elements within the water

environment and the corresponding consequence on WFD status and the ability for water bodies to meet good status. Ecological status can be defined as 'High', 'Good', 'Medium', 'Poor' or 'Bad'. These classes are established on the basis of specific criteria defined against biological, physico-chemical and hydromorphological elements. Biological assessment uses numeric measures of communities of plants and animals (for example, fish, invertebrates and rooted plants). The physico-chemical assessment looks at elements such as temperature and levels of nutrients. Hydromorphological quality assesses the water flow, sediment composition and movement, continuity and the structure of physical habitat (Environment Agency, 2010b).

The overall Status of a water body is assessed by whichever of these elements is the poorer. For example, a water body might pass 'Good Status' for chemical and physico-chemical assessments, but be classed as 'Moderate Status' for the biological assessment; in this case it would be classed overall as 'Moderate Ecological Status' (Environment Agency, 2010b). To achieve the overall aim of Good status, the Directive requires that surface waters be of at least Good Ecological Status and Good Chemical Status. To achieve High Status, the WFD requires that the hydromorphological Quality Elements are also in place. For lower classes, although hydromorphological quality is not explicitly required, it is a supporting element of the biological and physico-chemical status and must therefore be taken into account (Environment Agency, 2010b).

Jacobs' assessment of mitigation measures is also based on readily available information and professional judgement. Table 1 produced by the Environment Agency (2010a) was used as a basis for mitigation, with further information from the National Rivers Authority (1997) and Environment Agency (2002) added as applicable.

Table 1 - Guidance on selecting mitigation measures for a range of activities associated with river management (Environment Agency, 2010a)

Activity and function	Potential hydromorphological change	Mitigation measures
Point structure (pipe, inlet, outlet, off-take) To enable controlled discharge of water through the flood defence	Change in flow dynamics Loss of structure and condition of the riparian zone	Improve Fish Passage Remove Obsolete Structure
Culvert To enable conveyance of water across other functions, e.g. transport infrastructure	Change in flow dynamics Loss of morphological diversity (rivers) Loss of structure and condition of the riparian zone	Modify or Enhance Structure Improve Fish Passage Good Practice Vegetation Management Remove Obsolete Structure Manage and Restore Aquatic and Riparian Habitats
Weir To increase upstream water levels and/or detain discharge or address slope changes	Change in flow dynamics Disruption to river continuity (rivers) Regulation of flow regime by impoundment	Modify or Enhance Structure Improve Fish Passage Good Practice Sediment Management Manage and Restore Aquatic

Activity and function	Potential hydromorphological change	Mitigation measures
		and Riparian Habitats Remove Obsolete Structure
Channel resectioning and bank reprofiling To increase conveyance, reduce erosion of the bed or bank, reduce morphological change, reduce sediment supply	Loss of structure and condition of the riparian zone Loss of morphological diversity (rivers) Change in sediment regime (rivers)	Good Practice Vegetation Management Remove Obsolete Structure Manage and Restore Aquatic and Riparian Habitats Good Practice Sediment Management
Channel deepening, widening & regrading To increase conveyance	Change in substrate conditions (rivers) Change in flow dynamics Change in surface/ground water interaction Loss of morphological diversity (rivers) Change in sediment regime (rivers)	Good Practice Vegetation Management Good Practice Sediment Management Manage and Restore Aquatic and Riparian Habitats
Channel realignment To reduce conveyance, increase localised flood risk, reducing downstream flood risk, reduce bed stress	Loss of structure and condition of the riparian zone Change in flow dynamics	Good Practice Vegetation Management Manage and Restore Aquatic and Riparian Habitats Remove Obsolete Structure
Bank protection To prevent / reduce erosion of the channel banks	Change in sediment regime (rivers) Change in surface/ground water interaction Loss of structure and condition of the riparian zone Loss of sediment transfer to the floodplain	Good Practice Sediment Management Good Practice Vegetation Management Manage and Restore Aquatic and Riparian Habitats Remove Obsolete Structure Modify or Enhance Structure
Bed protection To prevent / reduce erosion of the channel bed	Change in sediment regime (rivers) Change in substrate conditions (rivers) Change in surface/ground water interaction Loss of morphological diversity (rivers)	Good Practice Sediment Management Manage and Restore Aquatic and Riparian Habitats

Appendix B Culverting of Watercourses

Taken from Fluvial Design Guide – Chapter 8, Section 8.6 Culverting of watercourses (Environment Agency, 2008).

‘’…..8.6.1 General Policy Regarding Culverts

Environment Agency policy is that no watercourse should be culverted unless there is an overriding need to do so. This is because:

- The ecology of the watercourse is likely to be degraded by culverting;
- Culverting introduces an increased risk of blockage (with consequent increase in flood risk); and,
- It can complicate maintenance because access into the culvert is restricted (in some cases being classified as a confined space and requiring trained operatives and specialist equipment).

A blockage in a culvert can be very difficult to remove and likely to result in a severe flood risk. For these reasons the provision of a screen at the entrance to the culvert is often considered. Such a screen eliminates the risk of a blockage inside a culvert, but introduces a significant maintenance obligation (to ensure that the screen is kept clean) which far exceeds the typical maintenance requirements of an open watercourse.

Alternatives to culverting include:

- Construction of a bridge – much lower impact on the watercourse hydraulics and ecology;
- Constructing the infrastructure elsewhere – often not a practical option;
- Diverting the watercourse – this has its own disadvantages but also some opportunities for environmental and hydraulic improvement; and,
- For small streams, constructing a ford.

8.6.2 Impacts of Culverting

The culverting of a watercourse can have a many different impacts on the water environment including ecology, channel form, flow regime and chemistry. Table 8.3 summarises the impacts that need to be considered in the design of any new culvert in addition to the risk of blockage and impact on flood regime described above.

Table 8.3 - Impacts to be considered in the culvert design

Aspect Affected	Description of Impact
Ecology	Culverts can be impassable to riverine fauna and can create barriers to the movement of fish. Culverting results in the loss of natural in-stream and bankside habitats through direct removal and loss of daylight.
Pollution	In urban areas, culverted watercourses are often highly polluted due to misconnected foul sewers, overflows from blocked sewers or discharges of contaminated surface water.
Morphology	Culverted sections may create or exacerbate downstream or upstream bank and bed erosion or promote sediment deposition, as a result of altered water velocities and disruption to the natural transport of sediment.
Restoration	Culverts can hinder future restoration options. This is particularly significant where urban development results in the burial of once open watercourses beneath housing or commercial centres, or where new development is placed on top of existing culverted watercourses which otherwise might be available for restoration.
Landscape and amenity	Culverting of urban waters leads to the loss and degradation of distinctive components of the local landscape. Culverting leads to the loss of green amenity space along river banks and reduced access for recreational opportunities such as angling, walking or canoeing.

8.6.3 Culvert Design

In cases where culverting is unavoidable it is necessary to seek land drainage consent from the Environment Agency to allow culverting to go ahead. The Environment Agency scrutinises design submissions carefully to ensure all steps have been taken to reduce environmental degradation (or mitigate it) and to reduce the risk of blockage. Box 8.3 sets out the 'golden rules' of culvert design.

Detailed guidance on the design of culverts can be found in Culvert design guide (CIRIA, 1997). An updated version of this guide is expected to be published in 2009 as Culvert design and operation guide.

Box 8.3 'Golden rules' of culvert design

Size
Design the culvert to flow freely (part-full rather than surcharged) unless there are overriding reasons to do otherwise.

Choose a size that readily accommodates the design flow (for example, the 1% annual flood) with no appreciable increase in water level upstream. Allow for future development of the catchment upstream and for climate change effects (it is suggested that 20% is added to the estimated 1% flood to allow for this).

Adopt a single barrel in preference to multiple barrels, so as to present the largest possible waterway through the culvert and hence reduce the risk of large debris getting trapped inside it. Multiple barrels are acceptable for large watercourses and they have environmental benefits if one or more of the barrels are above normal water level (reduced sedimentation risk and provision of passage for mammals).

Length
Adopt the shortest length possible. Fish will migrate through a short culvert, but will be discouraged by a long culvert. The shorter the culvert the less likely are problems associated with blockage, and the lower the hazard associated with unauthorised or accidental entry into the culvert.

Invert level
The invert level of the culvert should generally be set lower than the existing bed level of the channel. This allows for any future regrading of the watercourse and also promotes the formation of a more natural bed through the culvert (which helps to maintain ecological continuity).

Trash and security screens
Avoid – only install in situations where the benefits significantly outweigh the risks (see Section 8.6.3).

Bends, steps, changes of cross section
Avoid – because they reduce the hydraulic efficiency and increase the risk of debris getting trapped.

If a bend is unavoidable, adopt a long gradual bend.

If the bend has to be sharp, provide an access shaft at the bend to afford easy access in the event of a blockage.

Hydraulic performance
Should be investigated for very high and very low flows, as well as for the design flow. If very high flows have the potential to overwhelm the culvert and cause flood damage, then options such as a flood bypass route should be considered.

Low flows should be examined from the perspective of watercourse ecology.

8.6.3 Trash and Security Screens

Screens serve two main purposes:

- Reducing the amount of debris entering a culvert or inverted syphon (where it could cause a blockage); and,
- Preventing unauthorised access into the culvert or inverted syphon (for safety or security reasons).

Regardless of the primary purpose, all screens accumulate trash and debris over time, reducing the hydraulic capacity and causing the water level upstream to rise. The build-up of trash can be rapid, and the consequences can be severe in terms of flood damage to local properties and infrastructure. Many more problems have been caused by blocked screens than have resulted from blocked culverts. The Environment Agency therefore strongly discourages the use of screens and designers are urged to investigate alternative measures such as addressing the trash problem at source.

Screens can also be used to trap coarse bed material (cobble and boulders) that might otherwise cause a problem further downstream. Such screens must be capable of being safely overtopped when blocked by debris. In Boscastle, for example, a coarse screen upstream of the critical areas traps large bed material before it can cause an obstruction at pinch points in the channel through the town. It is located at a point where any trapped material can easily be removed after the flood has passed.

Fully detailed guidance on screens can be found in Trash and security screen guide for flood risk management (Environment Agency, 2009).

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Appendix C Water Framework Directive Water Body Status –Gatwick Airport Second Runway

The following table provides a summary of the WFD status for the water bodies within the Gatwick Second Runway Study Area; this includes seven watercourses and a groundwater body.

Table C.1 - WFD status for water bodies within the Gatwick 2R Study Area[16]

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
Rivers						
GB106039017500	Tilgate Brook, Gatwick Stream and Crawters Brook at Crawley	Heavily Modified	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*
GB106039017621	Mole (Horley to Hersham)	Not Designated A/HMWB	Poor Status	Good	Poor Status	Good
GB106039017510	Mole at Gatwick Airport	Heavily Modified	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*
GB106039017490	Man's Brook (Charlwood to Gatwick Airport)	Not Designated A/HMWB	Moderate Status	Does Not Require Assessment*	Moderate Status	Does Not Require Assessment*
GB106039017480	Mole (Crawley to Gatwick Airport)	Not Designated A/HMWB	Moderate Status	Does Not Require Assessment*	Moderate Status	Does Not Require Assessment*
GB106039017520	Burstow Stream	Not Designated A/HMWB	Bad Status	Good	Bad Status	Good
GB106039017470	Baldhorns Brook	Not Designated A/HMWB	Poor Status	Does Not Require Assessment*	Poor Status	Does Not Require Assessment*

* A water body is labelled as having a chemical status that "does not require assessment" if the priority substances and other specific pollutants are not discharged into this water body in significant quantities.

[16] Note: All water bodies within the Gatwick 2R Study Area have been detailed in the tables, however depending on the nature and extent of the proposed developments, some may not be impacted.

Table C.2 - Current and predicted status of groundwater bodies within the Gatwick 2R Study Area

Water body ID	Water body Name	Current Quantitative Quality	Current Chemical Quality	2015 Predicted Quantitative Quality	2015 Predicted Chemical Quality
GB40602G602400	Copthorne Tunbridge Wells Sands	Good	Good	Good	Good

Appendix D Potential Generic Mitigation and that Proposed by Gatwick Airport Limited (GAL)

Potential Generic Mitigation	GAL Proposal
Water Quality	
Construction • Development and implementation of a Construction Environmental Management Plan (CEMP) which would include: - Procedures to respond to any environmental incidents - Pollution prevention and material storage handling measures to implemented - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location. - Groundwater and surface water monitoring requirements to be carried out before and during construction and during operation. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils. • Storage of excavated materials would be minimised and any temporary storage located away from surface watercourses and areas with permeable soils. • Any contaminated water from excavation or dewatering activities would be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There would be no direct discharge of contaminated water to surface watercourses. **Operation** • Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing takes place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.	**Construction** • A site wide method statement would be developed to mitigate risks during construction • Construction would comply with the CIRIA C698 Site Handbook for the Construction of SuDS document. • Excavated material would be stock piled within designated areas within the site boundary. Remediation would be carried out as required and used as fill. **Operation** Surface water quality • Installation of active wetland treatment that is designed to improve the existing water quality at the discharge point (Aspirational design) • Combined filler drain with a grass or swale top around the edges of the taxiways and the side of the runway • Separation of 'clean' and 'dirty' flows: - Inclusion of a detention basin (or 'clean' pond) to discharge water with a concentration of biological oxygen demand (BOD) of less than 14mg/l - Inclusion of a 'dirty' pond to treat water with a concentration of BOD of greater than 14mg/l • All runoff flows would be pumped up to a balancing tank and treated via an active wetland treatment system. Treatment of 95% of flows to <5mg/l BOD. Water that does not meet this level would be discharged into the existing pollution control system or recycled back through the wetland treatment system. • Centralised de-icing facilities to limit areas in which runoff would be heavily contaminated • De-icer contaminated runoff to be managed through a positive

Potential Generic Mitigation	GAL Proposal
	drainage system and attenuated in a pollution storage lagoon. • Measures to reduce de-icer use and capture de-icer waste at source to be developed. <u>Wastewater treatment</u> • Continue to send contaminated water to an expanded Crawley STW for treatment in a similar manner to that at present or install a local treatment plant to allow contaminated runoff to be treated on-site • Addition of a sewage and waste water wetland treatment system
Impermeable Area	
• Attenuation storage to be provided to mitigate for the increase runoff rates and volume due to the increase in impermeable area	• Attenuation storage would be provided to ensure there is no increase in flood risk up to the 1 in 100 year flood event (including an allowance for climate change). • Slot drains along the edges of taxiways and runway shoulders
Channel Realignment	
• Design should incorporate variations in flow, depth and width to provide a variety of habitats • Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling • Landscape plans should be formulated to minimise the visual impact of artificial structures • Realigned channel should be similar in length, width, depth and gradient to the old (original) channel • Design should incorporate similar bed material to the original channel and be consistent to that of surrounding watercourses • Banks should be vegetated with native species • Channel design to be able to convey high and low flows • Transfer of original/natural substrate to realigned channel • River length, width, depth and gradient not to compromise flow conveyance in downstream/upstream reaches and channels • Design should consider areas of contaminated land. Mitigation could include lining of the channel.	• Gradient to match that of original channel • Channel designed to be similar to original channel • Sediment transport analysis to be undertaken to ensure no excessive erosion or deposition within realigned channel • Further analysis required to determine suitable size of bed sediment • Material used to be locally sourced
Outfalls and Discharges	
• Directing the outfall downstream to minimise impacts to flow patterns	• No mitigation detailed

Potential Generic Mitigation	GAL Proposal
• Directing the outfall away from the banks of the river to minimise any potential risk of erosion • Minimising the size/extent of the outfall where possible to reduce the potential impact on the banks	
Weir	
• Installation of fish passes • Installation of diversion channel • Weir layout to be designed carefully • Headwalls and wing walls should be set within the line of the bank and be married into the surroundings • Use of soft engineering (i.e. willow and reed pilling or crude stoning) rather than hard engineering solutions to avoid downstream river bank erosion • Fencing and signage should be visually consistent • Careful selection of construction material. Stone, brick and timber are appropriate to fit into the river landscape (although these may need to be in association with concrete) • Planting of weir sides with native plants • Involve and seek advice on weir design and mitigation measures from the Environment Agency and Natural England • Alternative/compensation ecological mitigation measures (e.g. nesting boxes, backwaters, bankside planting, otter ramps)	• Specific requirements and mitigation measures provided by the Environment Agency (and other bodies) would need to be followed for the structure to allow suitable fish migration. • Weir design compliant with current legislation and policy • EA to input to and approve design of fish passes • Incorporation of fish and eel pass • Assess the possibility of removing the need for any impoundment by grading the upstream channel to fall with an average bed slope of 1 in 100 and include a series of features, including small head losses and pools over a 250m channel length

Appendix E Water Framework Directive Water Body Statuses – Heathrow Airport Northwest Runway

The following table provides a summary of the WFD status for the water bodies within the Heathrow NWR Study Area; this includes eight watercourses, five lakes and a groundwater body.

Table E.1 - Current and predicted status of water bodies within the Heathrow NWR Study Area ([17] (Environment Agency, 2009b)

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
Rivers						
GB106039023010	Colne Brook (from confluence with Alderbourne to confluence with Horton Brook)	Heavily Modified	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment
GB106039023090	Colne and GUC (from confluence with Chess to Ash)	Heavily Modified	Moderate Potential	Fail	Moderate Potential	Fail
GB106039023480	Ash & Stanwell brook	Heavily Modified	Moderate Potential	Good	Moderate Potential	Good
GB106039023450	Port Lane Brook	Heavily Modified	Moderate Potential	Good	Moderate Potential	Good
GB806100108	Unknown	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB806100097	From King George's Reservoir - ? Linked to 96	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB106039023030	Crane (including part of the Yeading Brook)	Heavily Modified	Poor Potential	Good	Poor Potential	Good

[17] Note: All water bodies within the Heathrow Airport Limited Study Area have been detailed in the tables, however depending on the nature and extent of the proposed developments, some may not be impacted by the scheme

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
GB106039023040	Horton Brook	Not Designated as an Artificial or Heavily Modified Water Body	Moderate Status	Does Not Require Assessment*	Moderate Status	Does Not Require Assessment*
Lakes						
GB30642417	Wraysbury Reservoir	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642334	The Queen Mother Reservoir	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642525	Staines Reservoirs	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642488	King George VI Reservoir	Artificial	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*
GB30642490	Staines Reservoirs	Artificial	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*

* A water body is labelled as having a chemical status that "does not require assessment" if the priority substances and other specific pollutants are not discharged into this water body in significant quantities.

Table E.2 Current and predicted status of groundwater bodies within the Heathrow NWR Study Area (Environment Agency, 2009b)

Water body ID	Water body Name	Current Quantitative Quality	Current Chemical Quality	Upward Chemical Trend	2015 Predicted Quantitative Quality	2015 Predicted Chemical Quality
GB40603G000300	Lower Thames Gravels	Good	Poor	No	Good	Poor

Appendix F Potential Generic Mitigation and that Proposed by Heathrow Airport Limited (HAL)

Potential Generic Mitigation	HAL Proposals
Water Quality	
Construction • Development and implementation of a Construction Environmental Management Plan (CEMP) which would include: - Procedures to respond to any environmental incidents - Pollution prevention and material storage handling measures to implemented - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location. - Groundwater and surface water monitoring requirements to be carried out before and during construction and during operation. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils. • Storage of excavated materials would be minimised and any temporary storage located away from surface watercourses and areas with permeable soils. • Any contaminated water from excavation or dewatering activities would be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There would be no direct discharge of contaminated water to surface watercourses. **Operation** • Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing takes place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas	**Construction** • A CEMP would be developed which would incorporate Pollution Prevention Guidance and Construction Practice guidance. • Surface water quality monitoring including for both chemical and biological parameters would be undertaken in key at risk areas including during the creation of the River Colne Spur channel and other construction areas in close proximity to surface watercourses. This would be continued into operation. • Installation of boreholes to monitor/sample groundwater quality during construction and operation • No storage of excavated materials on permeable surfaces. Excavated materials would not be left exposed on the ground surface. This would reduce the likelihood for migration of contaminations to groundwater or surface water. • Excavated material from different water horizons, geological formations, or of distinctly different quality, should be separated to prevent the potential for cross-contamination • Material to be sampled and treated (if necessary) before using as back-fill. • Material unable to be treated would be disposed of off-site in line with legislative requirements. • Good practice would be followed during borehole drilling and development and other site activities near boreholes into the chalk aquifer. • Good practice would be followed during drilling and the storage of fuel. An emergency response plan would be developed and kept up to date to enable any pollution incidents or extreme weather events to be responded to effectively. • During dewatering operations (likely during construction of basement structures) impermeable structures such as coffer dams would be used to minimise the extent of impact of dewatering on the surrounding groundwater

Potential Generic Mitigation	HAL Proposals
with permeable soils.	body. • Suspended solids or oil generated on site through dewatering or other construction activities would be separated prior to discharge. • Maintenance of impermeable surface water features to prevent deterioration. **<u>Operation</u>** <u>Surface water quality</u> • Implementation of a Sustainable Drainage Strategy which would include: - Dedicated areas for de-icing aircraft and a glycol recovery procedure to reduce the concentration of glycol within surface water runoff - Separate attenuation storage tanks for 'clean' and 'first flush' surface water runoff - An engineered wetland designed to treat excess glycol • Permits for any discharges of treated runoff that are required would be agreed with the EA. There would be no discharges to groundwater due to the risk of mobilising existing contamination. • Development of a fertiliser and pesticide application strategy to reduce the potential for nitrate leaching. • Possible addition of a new Sewage Treatment Works, with some of the treated water to be re-used for non-potable purposes within the Airport. • The bed of the new channel of the River Colne Spur would be lined with impermeable material (e.g. clay) to prevent contamination from the underlying contaminated land entering the river.
Impermeable Area	
• Attenuation storage to be provided to mitigate for the increase runoff rates and volume due to the increase in impermeable area	• Re-use of surface water would be maximised. Rainwater would be harvested from building roofs, treated water from the wetland and soft water from the glycol recovery process would be re-used. This would reduce the volume of water being discharged to watercourses. • Excess water would be discharged to watercourses at greenfield rates. • A perimeter drain around the edge of the impermeable areas of the site would be installed to capture excess surface runoff during storm events. • Oversized pipes would capture water from the perimeter drain providing capacity up to the 1 in 100 flood event (plus climate change). • Surface water would be directed to two centrally located underground

Potential Generic Mitigation	HAL Proposals
	storage tanks, also with storage up to the 1 in 100 year flood event.
Channel Realignment	
• Design should incorporate variations in flow, depth and width to provide a variety of habitats • Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling • Landscape plans should be formulated to minimise the visual impact of artificial structures • Realigned channel should be similar in length, width, depth and gradient to the old (original) channel • Design should incorporate similar bed material to the original channel and be consistent to that of surrounding watercourses • Banks should be vegetated with native species • Channel design to be able to convey high and low flows • Transfer of original/natural substrate to realigned channel • River length, width, depth and gradient not to compromise flow conveyance in downstream/upstream reaches and channels • Design should consider areas of contaminated land. Mitigation could include lining of the channel.	• Channel diversion design to utilise best practice to maximise habitat opportunities • Channels designed to provide high quality aquatic and riparian habitat • Connectivity maintained between all river channels in the Colne valley • Diverted channels designed as natural, meandering channels, including features such as pools, riffles and natural banks and bed • Transfer of cobbles and boulders from current rivers
Channel Creation	
• See 'Channel Realignment' section above	• New channels designed to maintain connectivity of flow in all rivers • Designed to ensure no net change to downstream flow • Bed of new channel to be lined with impermeable material wherever it is necessary to prevent contamination entering the river • Best practice during channel design • Channel designed with natural banks and bed materials wherever possible • Channel would have sufficient space and flexibility for natural evolution of the channel structure • Transfer of cobbles and boulders from original channel
Culverting	
• EA Culvert Guidelines (see Appendix B) • CIRIA Culvert Design and Operation Guide (CIRIA, 2010)	• Follow Environment Agency culvert guidelines (see Appendix) • Consultation with the Environment Agency regarding culvert design • Ensure appropriate depths and velocities of flow, avoiding steps and

Potential Generic Mitigation	HAL Proposals
The above documents include some of the following: • Design should consider the passage of both water and sediment for a range of flows • Design should consider the potential for partial or complete blockage of the culvert by debris or sediment during high flow events • Match the culvert gradient to that of the existing stream to avoid erosion at the head or tail of the culvert • Avoid reducing river length by shortening the river planform • Keep length of culvert to a minimum • Depression of the invert of the culvert to allow for the formation of a natural bed. This can be filled using the excavated material from the channel • Use a culvert of similar cross-section size • Increase the roughness of culvert inverts to help reduce the velocity of the water • Consideration of potential use of lighting options (dependent on surroundings and available resources)	perched sections • Use of a two-stage channel • Consideration of potential use of lighting options • Culverts designed to facilitate fish passage • Compensation by the creation of a new natural channel with diverse aquatic and riparian habitats - the 'River Colne Spur'
Outfalls and Discharges	
• Directing the outfall downstream to minimise impacts to flow patterns • Directing the outfall away from the banks of the river to minimise any potential risk of erosion • Minimising the size/extent of the outfall where possible to reduce the potential impact on the banks	• No mitigation detailed
Weir	
• Installation of fish passes • Installation of diversion channel • Weir layout to be designed carefully • Headwalls and wing walls should be set within the line of the bank and be married into the surroundings • Use of soft engineering (i.e. willow and reed pilling or crude stoning) rather than hard engineering solutions to avoid downstream river bank erosion • Fencing and signage should be visually consistent • Careful selection of construction material. Stone, brick and timber are	• Use of appropriate fish passes • Fish passes would be designed to accommodate medium swimming strength coarse fish

Potential Generic Mitigation	HAL Proposals
appropriate to fit into the river landscape (although these may need to be in association with concrete) • Planting of weir sides with native plants • Involve and seek advice on weir design and mitigation measures from the Environment Agency and Natural England • Alternative/compensation ecological mitigation measures (e.g. nesting boxes, backwaters, bankside planting, otter ramps)	

Appendix G Water Framework Directive Water Body Statuses – Heathrow Airport Extended Northern Runway (Heathrow ENR)

The following table provides a summary of the WFD status for the water bodies within the Heathrow ENR Study Area; this includes 14 watercourses, six lakes and a groundwater body.

Table G.1 Current and predicted status of water bodies within the Heathrow ENR Study Area [18] (Environment Agency, 2009b)

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
Rivers						
GB106039023010	Colne Brook (from confluence with Alderbourne to confluence with Horton Brook)	Heavily Modified	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment
GB106039023090	Colne and GUC (from confluence with Chess to Ash)	Heavily Modified	Moderate Potential	Fail	Moderate Potential	Fail
GB106039023080	Alderbourne	Not Designated as an Artificial or Heavily Modified Water Body	Good Status	Does Not Require Assessment*	Good Status	Does Not Require Assessment*
GB106039023480	Ash & Stanwell brook	Heavily Modified	Moderate Potential	Good	Moderate Potential	Good
GB106039023450	Port Lane Brook	Heavily Modified	Moderate Potential	Good	Moderate Potential	Good
GB106039023231	Thames (Cookham to Egham)	Heavily Modified	Moderate Potential	Good	Moderate Potential	Good
GB106039023232	Thames (Egham to Teddington)	Heavily Modified	Poor Potential	Fail	Poor Potential	Good
GB106039023520	Datchet Common	Heavily Modified	Moderate Potential	Does Not Require	Moderate Potential	Does Not Require

[18] Note: All water bodies within the Heathrow ENR Study Area have been detailed in the tables, however depending on the nature and extent of the proposed developments, some may not be impacted by the scheme

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
	Brook			Assessment*		Assessment*
GB806100108	Unknown	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB70610078	Grand Union Canal, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm, Regents Canal up	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB806100097	From King George's Reservoir - ? Linked to 96	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB70610252	Grand Union Canal, Maple Lodge to Uxbridge (Rivers Colne and Chess plus canal sections)	Artificial	Good Potential	Does Not Require Assessment*	Good Potential	Does Not Require Assessment*
GB106039023030	Crane (including part of the Yeading Brook)	Heavily Modified	Poor Potential	Good	Poor Potential	Good
GB106039023040	Horton Brook	Not Designated as an Artificial or Heavily Modified Water Body	Moderate Status	Does Not Require Assessment*	Moderate Status	Does Not Require Assessment*
Lakes						
GB30642417	Wraysbury Reservoir	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642489	Wraysbury II Gravel Pit/ Wellapool Lake	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642334	The Queen Mother Reservoir	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642525	Staines Reservoirs	Artificial	Poor Potential	Does Not Require Assessment*	Poor Potential	Does Not Require Assessment*
GB30642488	King George VI Reservoir	Artificial	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*

Water body ID	Water body Name	Hydromorphological Status	Current Overall Ecological Quality	Current Chemical Quality	2015 Predicted Ecological Quality	2015 Predicted Chemical Quality
GB30642490	Staines Reservoirs	Artificial	Moderate Potential	Does Not Require Assessment*	Moderate Potential	Does Not Require Assessment*

* A water body is labelled as having a chemical status that "does not require assessment" if the priority substances and other specific pollutants are not discharged into this water body in significant quantities.

Table G.2 Current and predicted status of groundwater bodies within the Heathrow ENR Study Area (Environment Agency, 2009b)

Water body ID	Water body Name	Current Quantitative Quality	Current Chemical Quality	Upward Chemical Trend	2015 Predicted Quantitative Quality	2015 Predicted Chemical Quality
GB40603G000300	Lower Thames Gravels	Good	Poor	No	Good	Poor

Appendix H Potential Generic Mitigation and that Proposed by Heathrow Hub Limited (HH)

Potential Generic Mitigation	HH Proposals
Water Quality	
Construction • Development and implementation of a Construction Environmental Management Plan (CEMP) which would include: - Procedures to respond to any environmental incidents - Pollution prevention and material storage handling measures to implemented - Details about location specific risks to groundwater and surface water quality and specific mitigation measures required at each location. - Groundwater and surface water monitoring requirements to be carried out before and during construction and during operation. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils. • Storage of excavated materials would be minimised and any temporary storage located away from surface watercourses and areas with permeable soils. • Any contaminated water from excavation or dewatering activities would be passed to attenuation features such as treatment wetlands, ponds or storage tanks. There would be no direct discharge of contaminated water to surface watercourses. **Operation** • Runoff from operational areas where activities such as de-icing, aircraft cleaning and aircraft servicing takes place should be passed to attenuation and treatment features. There should be no direct discharge of contaminated water to surface watercourses. The capacity and treatment levels to be achieved by the drainage system should be agreed with the Environment Agency and/or sewerage undertaker as appropriate, during the design phase. • Storage of potentially polluting substances including fuel, oils, de-icer and other chemicals to be located away from surface watercourses and areas with permeable soils.	**Construction** • Follow Pollution Prevention Guidance • Development and implementation of CEMP • Surface water runoff and water from dewatering activities would be discharged to sewers or local watercourses, with the water meeting the standards required by the sewerage undertaker. • SuDS would be used to treat and attenuate runoff to greenfield rates. • Avoid creating new pollution pathways to groundwater; **Operation** Surface water quality • Surface runoff from paved areas (which is likely be contaminated) would receive at least two levels of treatment: - Surface water from adopted highways would be intercepted by source control features such as filter drains which provide a primary level of treatment. Retention ponds or detention basins to be designed to provide secondary level treatment. - Surface runoff from the extended runway and apron would be intercepted by linear drainage channels before being directed into a network of collector pipes which would convert flows to a petrol/oil interceptor. The discharge from the interceptor would be directed via an online Total Organic Carbon detector to either clean attenuation tanks or polluted water holding tanks. Clean water would be discharged and polluted water treated. • The interceptor would also provide storage for any major spills • Runoff would be directed from the petrol interceptor via an online Total Organic Carbon (TOC) quality monitoring to detect the presence of de-icers. Runoff contaminated with de-icers would be diverted to treatment whereas non-contaminated water would be discharged to the normal attenuation storage. • Polluted runoff would be attenuated within a polluted water holding tank

Potential Generic Mitigation	HH Proposals
	and released for treatment at a rate agreed with the treatment plant operator • Where TOC is below the agreed trigger level it would be directed to a clean attenuation pond or tank and released to a watercourse • Runoff from external areas (e.g. highways) would internally be intercepted by source control features (e.g. porous paving) • Attenuated runoff should be directed via site control features (i.e. retention ponds and detention basins) <u>Groundwater quality</u> • Storage areas for fuels and chemicals should be located away from SuDS and soils which are highly permeable; • SuDS should incorporate pollution prevention into its design; • Infiltration systems should not be located where contamination is already present; • Routine maintenance of drainage systems; • Implement a regime of post-construction monitoring of groundwater levels including use of appropriate trigger levels and appropriate actions.
Impermeable Area	
• Attenuation storage to be provided to mitigate for the increase runoff rates and volume due to the increase in impermeable area	• Attenuation storage and long term storage would be provided to mitigate impacts from the increase in the peak runoff and the total volume of runoff due to the increase in impermeable surface area. <u>Long term storage</u> • Long term storage would be provided to delay the additional surface water volume from being discharged to watercourses, by infiltration, rainwater harvesting or by restricting the discharge rate to 2l/s/ha. • Surface water runoff from roofs, including those of new buildings (generally uncontaminated) would be intercepted and directed to rainwater harvesting systems for potable water reuse. <u>Attenuation storage</u> • Attenuation storage (using suitable SuDS features) would be provided at rates equivalent to the existing greenfield runoff rates. Discharge would be conveyed to receiving watercourses to mimic existing conditions. Attenuation storage would be provided to both the airport and highway corridor.
Channel Realignment	
• Design should incorporate variations in flow, depth and width to provide a variety of habitats	• Natural materials used for the bed and banks wherever possible • Channels designed with a variety in width and depth

Potential Generic Mitigation	HH Proposals
• Materials used should be environmentally appropriate and include timber and local rock rather than concrete or sheet piling • Landscape plans should be formulated to minimise the visual impact of artificial structures • Realigned channel should be similar in length, width, depth and gradient to the old (original) channel • Design should incorporate similar bed material to the original channel and be consistent to that of surrounding watercourses • Banks should be vegetated with native species • Channel design to be able to convey high and low flows • Transfer of original/natural substrate to realigned channel • River length, width, depth and gradient not to compromise flow conveyance in downstream/upstream reaches and channels • Design should consider areas of contaminated land. Mitigation could include lining of the channel.	• Incorporation of two-stage channel • Meandering channel where possible • In-channel flow deflectors to vary the velocities and direction of flow • Gradient and planform of realigned channel to be similar to the current channel so as not to increase scour and induce turbidity and sediment problems
Culverting	
• EA Culvert Guidelines (see Appendix B) • CIRIA Culvert Design and Operation Guide (CIRIA, 2010) The above documents include some of the following: • Design should consider the passage of both water and sediment for a range of flows • Design should consider the potential for partial or complete blockage of the culvert by debris or sediment during high flow events • Match the culvert gradient to that of the existing stream to avoid erosion at the head or tail of the culvert • Avoid reducing river length by shortening the river planform • Keep length of culvert to a minimum • Depression of the invert of the culvert to allow for the formation of a natural bed. This can be filled using the excavated material from the channel • Use a culvert of similar cross-section size • Increase the roughness of culvert inverts to help reduce the velocity of the water • Consideration of potential use of lighting options (dependant on	• Follow Environment Agency culvert guidelines (see Appendix B) • Consideration of potential use of lighting options • Inclusion of natural substrate in the bed and (where practical) the banks • Design of substrate should encourage diversity and the formation of quiescent zones for fish and eel rest • Insertion of stub groynes or flow deflectors for flow diversity • Avoidance of bends to prevent blockages and blind spots • Regular maintenance would be undertaken using best practice approaches

Potential Generic Mitigation	HH Proposals
surroundings and available resources)	
Outfalls and Discharges	
• Directing the outfall downstream to minimise impacts to flow patterns • Directing the outfall away from the banks of the river to minimise any potential risk of erosion • Minimising the size/extent of the outfall where possible to reduce the potential impact on the banks	• Discharge location agreed with the consent holder and Environment Agency if necessary • Discharge from clean attenuation pond/tank would be released at the 'allowable' rate

Appendix I WFD Water Bodies, Proposed Work and Proposed Mitigation[19]

Water body name	WFD status	Reason for current status (if overall objective is not good status by 2015)	Proposed works	Mitigation proposed
Gatwick 2R				
Mole (Crawley to Gatwick Airport)	Moderate Status	Disproportionately expensive, technically infeasible	Remove from culvert and divert around western extent of new runway	• Matching gradients of existing and new channels • Designing a channel to be similar to original channel • Completing sediment transport analysis • Determining suitable bed sediment size • Using locally sourced materials
			Weir installation	• Following specific requirements and mitigation measures provided by the Environment Agency (and other bodies) to ensure the structure facilitates fish migration. • Designing weirs to be compliant with current legislation and policy • Upstream channel graded to an average bed slope of 1 in 100 and include a series of features, including small head losses and pools • EA to input to and approve design of fish passes • Incorporating a fish and eel pass
Heathrow NWR				
Colne Brook (from confluence with Alderbourne to confluence with Horton Brook)	Moderate Potential	Disproportionately expensive	Diverting approximately 1km of the Colne Brook around the western extent of the new runway	• Designing channel diversion to utilise best practice to maximise habitat opportunities • designing channels to provide high quality aquatic and riparian habitat • Maintaining connectivity between all river channels in the Colne valley • Designing diverted channels as natural, meandering channels, including features such as pools, riffles and natural banks and bed • Transferring cobbles and boulders from current rivers
			Modifying a section of the Colne Brook	• Maintaining river flow regimes for ecology
Colne and GUC (from confluence	Moderate	Disproportionately expensive, Technically	Combining all channels within the	• Following Environment Agency culvert guidelines (see Appendix) • Consulting with the Environment Agency over culvert design

19 Note: does not include generic impacts and mitigation related to water quality and increase in impermeable surface. Mitigation relating to these can be seen in Appendix D, H and F.

Water body name	WFD status	Reason for current status (if overall objective is not good status by 2015)	Proposed works	Mitigation proposed
with Chess to Ash	Potential	infeasible	Colne and GUC in a single culvert underneath the new runway	• Ensuring appropriate depths and velocities of flow, avoiding steps and perched sections • Using a two-stage channel • Considering potential use of lighting options • Designing culverts to facilitate fish passage • Creating a new natural channel with diverse aquatic and riparian habitats - the 'River Colne Spur' as a compensation measure
			Diverting part of the Colne and GUC to the south of the runway	• Designing channel diversion to utilise best practice to maximise habitat opportunities • Designing channels to provide high quality aquatic and riparian habitat • Maintaining connectivity between all river channels in the Colne valley • Designing diverted channels as natural, meandering channels, including features such as pools, riffles and natural banks and bed • Transferring cobbles and boulders from current rivers
Ash & Stanwell brook	Moderate Potential	Disproportionately expensive, Technically infeasible	Culverting the Ash & Stanwell brook underneath the new runway	• Following Environment Agency culvert guidelines (see Appendix) • consulting with the Environment Agency regarding culvert design • Ensuring appropriate depths and velocities of flow, avoiding steps and perched sections • Using a two-stage channel • Considering potential use of lighting options • Designing c culverts to facilitate fish passage • Creating a new natural channel with diverse aquatic and riparian habitats - the 'River Colne Spur' as compensation
			Diverting part of the Ash & Stanwell brook to the south of the runway	• Designing channel diversion to utilise best practice to maximise habitat opportunities • Designing channels to provide high quality aquatic and riparian habitat • Maintaining connectivity between all river channels in the Colne valley • Designing diverted channels as natural, meandering channels, including features such as pools, riffles and natural banks and bed • Transferring cobbles and boulders from current rivers
Port Lane Brook	Moderate Potential	Disproportionately expensive, Technically infeasible	Culverting part of the Port Lane Brook underneath the new runway	• Following Environment Agency culvert guidelines (see Appendix) • consulting with the Environment Agency regarding culvert design • Ensuring appropriate depths and velocities of flow, avoiding steps and perched sections

Water body name	WFD status	Reason for current status (if overall objective is not good status by 2015)	Proposed works	Mitigation proposed
				• Using a two-stage channel • Considering potential use of lighting options • Designing culverts to facilitate fish passage • Creating a new natural channel with diverse aquatic and riparian habitats - the 'River Colne Spur' as compensation
			Diverting part of the Port Lane Brook to the south of the runway	• Designing channel diversion to utilise best practice to maximise habitat opportunities • Designing channels to provide high quality aquatic and riparian habitat • Maintaining connectivity between all river channels in the Colne valley • Designing diverted channels as natural, meandering channels, including features such as pools, riffles and natural banks and bed • Transferring cobbles and boulders from current rivers
Horton Brook	Moderate Status	Technically infeasible	Realignment	• Designing channel diversion to utilise best practice to maximise habitat opportunities • Designing channels to provide high quality aquatic and riparian habitat • Maintaining connectivity maintained between all river channels in the Colne valley • Designing diverted channels as natural, meandering channels, including features such as pools, riffles and natural banks and be • Transferring cobbles and boulders from current rivers
			Modifying a section of the Horton Brook	• Maintaining river flow regimes for ecology
Heathrow ENR				
Colne Brook (from confluence with Alderbourne to confluence with Horton Brook)	Moderate Potential	Disproportionately expensive	Diverting the Colne Brook (from confluence with Alderbourne to confluence with Horton Brook) around the west end of the extended north runway	• Using natural materials used for the bed and banks wherever possible • Designing channels with a variety in width and depth • Incorporating a two-stage channel • Meandering the channel where possible • Using in-channel flow deflectors to vary the velocities and direction of flow • Creating a gradient and planform of the new realigned channel to be similar to the current channel so as not to increase scour and induce turbidity and sediment problems

Water body name	WFD status	Reason for current status (if overall objective is not good status by 2015)	Proposed works	Mitigation proposed
Colne and GUC (from confluence with Chess to Ash	Moderate Potential	Disproportionately expensive, Technically infeasible	Culverting the Colne and GUC underneath the proposed runway	• Following Environment Agency culvert guidelines (see Appendix B) • Considering potential use of lighting options • Including natural substrate in the bed and (where practical) the banks • Designing substrate to encourage diversity and the formation of quiescent zones for fish and eel rest • Inserting stub groynes or flow deflectors for flow diversity • Avoiding bends inside culverts to prevent blockages and blind spots • Regularly maintaining using best practice approaches
Ash & Stanwell brook	Moderate Potential	Disproportionately expensive, Technically infeasible	Culverting the Ash & Stanwell brook underneath the proposed runway	• Following Environment Agency culvert guidelines (see Appendix B) • Considering potential use of lighting options • Including a natural substrate in the bed and (where practical) the banks • Designing substrate to encourage diversity and the formation of quiescent zones for fish and eel rest • Inserting of stub groynes or flow deflectors for flow diversity • Avoiding bends to prevent blockages and blind spots • Regularly maintaining using best practice approaches
Port Lane Brook	Moderate Potential	Disproportionately expensive, Technically infeasible	Culverting the Port Lane Brook underneath the proposed runway	• Following Environment Agency culvert guidelines (see Appendix B) • Considering potential use of lighting options • Including natural substrate in the bed and (where practical) the banks • Designing substrate to encourage diversity and the formation of quiescent zones for fish and eel • Inserting stub groynes or flow deflectors for flow diversity • Avoiding bends inside culverts to prevent blockages and blind spots • Regularly maintaining using best practice approaches

Appendix J Methodology - Water Quantity

This Appendix outlines the methodology used to undertake the assessment of demands reported in the promoters' submissions against the Jacobs calculated demands, and the resulting impacts to water resources.

Three datasets were used for the overall assessment of water quantity impacts:

1. Passenger numbers;
2. Total annual water consumption; and
3. Water consumption per passenger per year.

Table A1 presents the input data used to derive these figures; documentary sources were preferred over estimates. Total annual water consumption and water consumption per passenger were not always available in the format needed, and therefore calculated from other data sets or assumed.

Table A1 - Data Sources for Overall Assessment of Water Quantity

Data source	Passenger numbers	Total annual water consumption	Water consumption per passenger per year
Documents (*preferred*)	Airports Commission forecasts Promoters' submissions	Promoters' submissions	Promoters' submissions
Calculated (*only where documents are not available*)	N/A	Only estimated if passenger numbers and water consumption per passenger per year available.	Only estimated if passenger numbers and total annual water consumption available.

Each submission's baseline demands were assessed against the baseline case as described in Jacobs Baseline Report (2014). The baseline case includes an assessment of the forecast rise in demand from an increase in passenger numbers, based on the Airports Commission's forecast assuming constrained growth, and the change in climate anticipated between the years 2025 (Gatwick) / 2026 (Heathrow) and 2085 (Gatwick) / 2086 (Heathrow). The climate change impacts were derived from the WRMP assessment of increases to non-household demand over the planning horizons.

The differences between the Jacobs Baseline and promoters' Baseline values used for passenger number increases, rates of consumption and total demand were noted.

Jacobs assessed the impact of water efficiency measures at other airports to determine the potential for them to be implemented at Gatwick and Heathrow. The outcome from this assessment allowed for the Jacobs Baseline demands to be adjusted to factor in the effect of implementing these measures and then for a comparison to be undertaken against the promoters' forecast demands with the scheme in place.

A comparison was then undertaken between the Jacobs and the promoters' forecast demands; with the scheme and mitigation measures in place. The results of the

comparison between the passenger numbers, rates of consumption and total demand were noted.

The mitigation measures proposed by the promoters in their submissions were assessed and the feasibility of the measures to reduce water use was evaluated in the context of previous reductions in water consumption at other airports, if data were available, and against the assessment completed by Jacobs.

The impact, either positive or negative, on water resources was determined and considered against current and future water resource positions as identified in the Jacobs Baseline Report (2014). The feasibility of the mitigation measures proposed by the promoters was commented upon along with the any uncertainties with the assessment.

Appendix K Review of Water Efficiency Measures

Measure	Airport	Details	Saving
Water Efficiency - Waterless urinals - Low flush toilets - Aerated taps / showers	London – Heathrow	- waterless urinals at T3 - water efficiency measures in T1 and T4 - WC's account for approximately 40% of total water demand	29,295 m^3/year of potable water saved at T3
	London – Gatwick	- Retrofitting water efficiency measures (unspecified)	reduction in water consumption of 31% between 2010 and 2012
	Amsterdam – Schiphol	- Water efficient showers / taps - Waterless urinals	Not quantified
	Frankfurt – Main	- Aerated taps - Flush stop devices in WCs	Not quantified
	Paris - Charles De Gaulle	- Installation of water-saving equipment in sanitary blocks (flow regulators, water-saving flushing apparatuses, etc.).	At Aéroports de Paris headquarters, new timed faucets deliver a flow of 6 litres/minute instead of 24 litres/minute. A reduction of 75%.
	Dubai	- Flow aerators	Saved 6,397m^3 between 2011 - 12
	Dallas Fort Worth	- Water efficiency measures (unspecified)	Saved 20,819m^3/month (249,828m^3/yr)
	Singapore – Changi Airport	- Installing flow rate regulators for wash basins in selected areas of the airport - Installing taps with water saving devices such as on-off sensors. - Educating tenants to use water efficient fittings in their premises. - Introducing low-flush toilets with NEWater being used for flushing.	Flow regulators - reduce water usage by 66% from 6 litres per minute to 2 litres per minute.
Rainwater Harvesting	London – Heathrow	- T5 – potential for 85% rainfall capture - T2 – no data	Meets 8% of T5 non-potable water use (from 2010 figures). Approximately 1% of total airport demand.
	London – Gatwick	- No scheme currently in place - **Proposed scheme** - GAL have assumed that 70% (allowing for wetting/evaporation/overflow) of the rainfall that falls on the roof surface (134,900m^2) will be captured. Average annual rainfall = 750mm. Annual potential collection of 70,849m^3. Total WC usage = 266,043m^3. Best case meets 26.6% of WC demand. Storage volume based on ability to store 18 days WC flushing usage = 13,119m^3.	
	Amsterdam – Schiphol	- Rainwater to flush toilets	Not quantified
	Frankfurt – Frankfurt	- The system collects water from roofs of the new terminal (26,800m^2).	Not quantified

Measure	Airport	Details	Saving
		- The water is collected in the basement of the airport where six tanks have been put up, with a storage capacity of 100 m³ per tank - The water is mainly used for toilet flushing, watering plants and cleaning the air conditioning system with refined river water.	
	Paris - Charles De Gaulle	- Recovery of rain water for industrial uses (cooling for refrigeration units at Paris-Orly) and for use in restrooms (connecting building A-C at Paris Charles de Gaulle); - Installation of two partly underground tanks of 35,000 litres each to supply rainwater to a new building linking terminals A and C.	Not quantified
	Singapore – Changi Airport	- Rainfall from site captured in 2 impounding reservoirs and used for non-potable functions	Accounts for approximately 28 – 33% of total water used, saving approximately £185
Grey water recycling / vehicle wash reclaim	*Airport*	-	
Metering	*Airport*	-	
Smart Buildings / Control	*Airport*	-	
Leakage Detection / Reduction / Prevention	London – Gatwick	- During 2011 infrastructure management and leak detections / fixing	20% reduction in demand
	Paris - Charles De Gaulle	- Reducing leakage through its monitoring software, which automatically cuts the water beyond a certain flow rate.	The leakage rate for 2012 is less than 10%, a threshold that corresponds to a network in good condition;
Increased use on non-potable water for washing vehicles/planes etc.	*Singapore – Changi Airport*	- Substituting of domestic water with NEWater (recycled water) for non-potable use. - Using NEWater for applications such as irrigation, fire-fighting, sanitation and cooling purposes in place of potable water.	
Efficient irrigations	Amsterdam – Schiphol	- Drought resistant plants that don't require summer watering	Not quantified
	Paris - Charles De Gaulle	- Optimised watering of landscaped areas: avoid spraying in the middle of the day in summer, thus reducing the evaporation of water	Not quantified
On Site Water Management Plans	*Airport*	-	
Staff training / awareness	*Airport*	-	
Operational Changes	Frankfurt – Main	- Converting from disinfection with chlorine to electrochemical disinfection of the tanks used in vehicles supplying water to aircraft - Introduction of systems operating with circuits in vehicle washer systems	Not quantified
	Paris - Charles De Gaulle	- Reduced consumption for cleaning interior surfaces and exterior roads with new processes such as dry cleaning;	Not quantified

Appendix L Airport Water Consumption

Airport	Year	Total Water Consumption	Annual Passenger Nos	Per Passenger Consumption	Comment
London – Heathrow	2013 2012 2011 2010 2009	2.3 Mm^3 2.2 Mm^3 2.2 Mm^3 2.2 Mm^3 2.4 Mm^3	72.3 Mn 69.9 Mn 69.4 Mn 65.7 Mn 65.9 Mn	0.032 m^3 0.030 m^3 0.032 m^3 0.034 m^3 0.036 m^3	Supplied by: - Potable Main (≈85%) - On site boreholes (≈14%) - Rainwater Harvesting (≈1%)
London – Gatwick	2013 2012 2011 2010 2009	- 0.72 Mm^3 0.75 Mm^3 0.96 Mm^3 1.06 Mm^3	35.4 Mn 34.2 Mn 33.6 Mn 31.3 Mn 32.4 Mn	- 0.021 m^3 0.022 m^3 0.031 m^3 0.033 m^3	Supplied by: - Potable Main (100%)
Amsterdam - Schiphol	2013 2012 2011 2010 2009	- - - - -	52.6 Mn 51.0 Mn 49.8 Mn 45.2 Mn 43.6 Mn	13.3 l / 0.0131 m^3 13.6 l / 0.0136 m^3 14.0 l / 0.0140 m^3 15.9 l / 0.0159 m^3 15.5 l / 0.0155 m^3	passenger drinking water consumption ONLY
Paris - Charles de Gaulle	2013 2012 2011 2010 2009	1.919 Mm^3 2.359 Mm^3 2.406 Mm^3 - -	62.0 Mn 61.6 Mn 61.0 Mn 58.1 Mn 57.9 Mn	0.031 m^3 0.038 m^3 0.039 m^3 - -	
Frankfurt – Main	- 2013 2012 2011 2010 2009	- 2.146 Mm^3 2.114 Mm^3 2.363 Mm^3 2.286 Mm^3 1.824 Mm^3	- 58.0 Mn 57.5 Mn 56.4 Mn 53.0 Mn 50.9 Mn	- 0.037 m^3 0.037 m^3 0.042 m^3 0.043 m^3 0.036 m^3	Drinking water / Service water (surface/rain/ground) split 72% / 28% 76% / 24% 62% / 38% 65% / 35% 74% / 26%
New York – JFK	2013 2012 2011 2010 2009	- - - - 33,183,524 gallons	50.4 Mn 49.3 Mn 47.6 Mn 46.5 Mn 45.9 Mn	- - - - -	
Dallas Fort Worth	2013 2012 2011 2010 2009	- 4.34 Mm^3 4.86 Mm^3 - -	60.4 Mn 58.6 Mn 57.8 Mn 56.9 Mn 56.0 Mn	- 0.074 m^3 0.084 m^3 - -	