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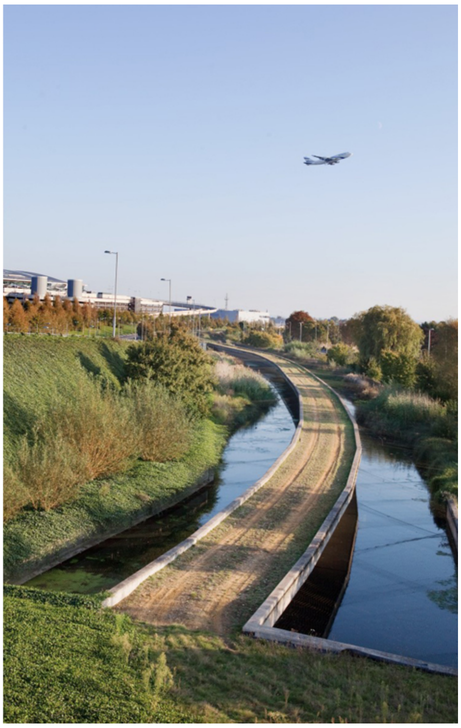
Heathrow Airport Limited

Heathrow's North-West Runway

Sustainable Drainage Assessment



16 June 2014

AMEC Environment & Infrastructure UK Limited

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Non-Technical Summary

This Sustainable Drainage Report has been prepared by AMEC Environment & Infrastructure on behalf of Heathrow Airport Limited (HAL). The purpose of this report is to present an evidence base which supports the Sustainable Drainage Strategy presented in Volume 1 of HAL's submission to the Airports Commission[1].

The Sustainable Drainage Strategy aims to protect the quality of surface and groundwater, use water resources efficiently and minimise flood risk. A Sustainable Drainage Systems (SuDS) management approach, focusing on an interlinked sequence of measures, was adopted in the development of the strategy and has resulted in, a cohesive, robust, sustainable and credible solution. The solution was reached following a SuDS selection assessment process, which has also ensured that the proposed strategy will not result in an unacceptable increase in the risk of wildlife/ bird strike. This report demonstrates how the proposed strategy meets the requirements of the Airports Commission's Sustainability Appraisal Framework (SAF)[2], the National Planning Policy Framework (NPPF)[3] and the Water Framework Directive (WFD)[4]. The Sustainable Drainage Strategy works alongside the Flood Risk Strategy by ensuring that the rates and volumes of run-off to receiving water bodies will not be increased. The pollution control measures incorporated within this strategy work to support the objectives set out in the Water Quality and Hydro-ecology Assessment[5].

This technical assessment shows that the development will be safe from a surface water flood risk perspective and, will not result in increased flood risk to people and properties in neighbouring communities. The proposed strategy will capture all surface water run-off which will drain under gravity to a centrally located attenuation storage tank, including exceedance events. Run-off rates will be returned to greenfield rates, thus providing betterment on the current situation.

The requirements of the Airports Commission's Appraisal Framework are met through a combination of the following four key elements of the Sustainable Drainage Strategy:

- **Flood risk prevention:** The system will ensure that all events up to the 1% AEP plus climate change event will be captured, attenuated and treated on-site. Onsite attenuation is provided which is

[1] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth

[2] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

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

[4] European Parliament & Council (2000) Water Framework Directive (Directive 2000/60/EC)

[5] AMEC (2014) Heathrow's North0West Runway– Water Quality and Hydro-ecology Assessment

sufficiently large to store the 1 % Annual Exceedance Probability (AEP) event including an allowance for climate change;

- **Enhanced capture of de-icer:** To maximise the potential for the capture and re-use of the de-icing chemical glycol, dedicated areas for de-icing aircraft are proposed. This will enable the highest concentrations of glycol to be captured separately, thus reducing the concentrations entering the surface water run-off system requiring treatment. An extensive engineered floating treatment wetland will ensure that surface water run-off from the remainder of the airfield is treated in a sustainable manner;

- **Rain water harvesting and water re-use:** To reduce the water demand of the airport, re-use of surface water run-off will be maximised. Rainwater will be harvested from the roofs of the terminal and satellite buildings, treated water from the wetland will be re-used, and soft water arising from the glycol recovery process will be used for airside cleaning. Or the water could be blended for re-use – initial trials have indicated that the water from recovery has good properties for diluting 'raw' glycol prior to use in the de-icing process. Excess water will be released from the system at controlled greenfield runoff rates to nearby watercourses, such as the River Colne and the Duke of Northumberland's River; and

- **Pollution Control:** The sustainable drainage strategy proposed will ensure releases from the engineered floating treatment wetland are monitored and controlled, both in terms of quantity as well as quality, whilst minimising the water demand of the airport. Visual aspects relating to water pollution will also be considered at the detailed design stage.

Abbreviations

AEP	Annual exceedance probability
BGS	British Geological Survey
Defra	Department for Environment, Food and Rural Affairs
DCLG	Department of Communities and Local Government
DCO	Development Consent Order
DO	Dissolved Oxygen
EA	Environment Agency
FRA	Flood Risk Assessment
HAL	Heathrow Airport Limited
m AOD	metres Above Ordnance Datum
NIP	National Infrastructure Planning
NPPF	National Planning Policy Framework
NPS	National Planning Statement
SAF	Sustainability Appraisal Framework
STW	Sewage Treatment Works
SuDS	Sustainable Drainage System
SWMP	Surface Water Management Plan
WFD	Water Framework Directive

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Appendices

1. Introduction

1.1 Background

This Sustainable Drainage Technical Report has been prepared by AMEC Environment & Infrastructure on behalf of Heathrow Airport Limited (HAL). To meet the growing need for additional air capacity, HAL has proposed an extension to the existing Heathrow Airport[6]. The proposed development would include:

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

Further details of the development can be found in HAL's submission to the Airports Commission[6].

This report provides the technical assessment and details underlying the Sustainable Drainage Strategy presented in Volume 1 of HAL's submission to the Airports Commission[6]. The assessment of potential effects with and without mitigation was undertaken in accordance with the Commission's Sustainability Appraisal Framework (SAF)[7] as described below.

Section 2 of the report describe the legislative and policy context relevant to the assessment and provides details of the consultation carried out to inform this report. **Section 3** describes the baseline related to drainage with **Section 4** describing potential effects of the proposed development with and without mitigation. The proposed sustainable drainage strategy is outlined in **Section 5** and conclusions are given in **Section 6**.

1.2 Airports Commission Requirements

The Airports Commission's Sustainability Appraisal Framework (SAF)[2] has guided the development of the Sustainable Drainage Strategy along with the requirements anticipated in the relevant National Planning Statement (NPS), as discussed further in **Section 2**.

[6] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth

[7] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

Ver	Date	Description Of Change	Drn

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Model / Content References List - Name, Version & Status:
R3500-XX-M2-904-000067 - 3R North West V3.dwg
R3500-XX-M2-904-000070 - 3R North West V3 - Subsurface
LHR Raster Combined.dwg

Title

3R Masterplan

North West - V3

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Project Name	Heathrow Project No.
Heathrow 2025	315789
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Company	Drawn By	Chk/Approved	Drawn Date	Status
Mott MacDonald			04/02/2014	P1

Location-Level-Sub Series/System-Identifier	Version
R3500-XX-GA-904-000082	3.9

Specifically the overall objective of the Airports Commission for Water and Flood Risk (Annex 9) is to protect the quality of surface and ground waters, use water resources efficiently and minimise flood risk. The Commission also requires water use and disposal to be integrated into the needs of the local environment, and that water consumption is sustainable, both now and for at least 60 years into the future. 60 years is the appraisal period over which the Commission will consider the impact on water quality and quantity (paragraph 9.4), over which allowance for climate change allowances need to be considered.

1.3 Heathrow's Objectives

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

This Sustainable Drainage Technical Report, upon which the Sustainable Drainage Strategy has been developed, also sits alongside the Flood Risk Strategy and works to support the objectives set out in the Water Quality and Hydro-ecology Assessment[8] which has also been submitted to the Airports Commission. The primary objective is to develop a sustainable and effective strategy that will ensure flood risk is not increased, and protects river flows, water quality and aquatic ecology during and beyond the lifetime of the development that takes into account the potential impacts of climate change.

The objective of Heathrow's drainage strategy are to:

- Manage flood risk on-site and, where feasible, reduce flood risk elsewhere by reducing the rates of storm water run-off from the Airport to the surrounding environment;
- Manage the water quality of discharges to receiving watercourses;
- Maximise glycol recovery for reuse;
- Maximise water recycling and rainwater capture to reduce water supply demands on the environment.

The mitigation measures that have included as part of the strategy will not result in an unacceptable increase in the risk of bird strike, and will ensure that all relevant legislation and planning policy, such as the Water Framework Directive (WFD)[9] and the National Planning Policy Framework (NPPF)[10] are met.

Heathrow aim to meet these requirements by providing a sustainable strategy that incorporates the latest treatment, recycling and harvesting technologies to manage and treat all surface water generated by the Airport.

[8] AMEC (2014) Heathrow's North-West Runway – Water Quality and Hydro-ecology Assessment

[9] European Parliament & Council (2000) Water Framework Directive (Directive 2000/60/EC)

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

2. Legislative and Policy Context

Consent for the new runway at Heathrow will likely need to be sought via a Development Control Order (DCO) application, and therefore the policy context will ultimately be provided in the relevant NPS. The NPS for Aviation has not yet been published, even in draft for consultation[11]. However, it is deemed very likely that the requirements relevant to drainage in the NPS for Aviation will closely mirror those provided in the NPPF[10] and its supporting documents. Therefore, the Sustainable Drainage Strategy (and this supporting report) have been prepared in accordance with the requirements of the NPPF[10], its associated Technical Guidance[12] and the recently released Planning Practice Guidance for Flood Risk and Coastal Change[13].

The flood risk objectives of the NPPF[10] are captured in paragraph 100, which states that: 'inappropriate development in areas at risk of flooding should be avoided, but where development is necessary, making it safe without increasing flood risk elsewhere,' including an allowance for climate change.

The WFD[9] requires that there be no adverse impacts to watercourses as a result of development. In the absence of a drainage strategy, the quality of the run-off arising from the site would be adversely affected, due to the use of de-icers and any potential spillages.

The NPPF requires that priority be given to the use of Sustainable Drainage Systems (SuDS) ahead of traditional/conventional systems.

2.1 Consultation

This report has been written following consultation with the Environment Agency (EA). A summary of the technical consultations carried out are provided in **Table 2.1**. The site is not located within an Internal Drainage Board district, therefore no Internal Drainage Boards have been consulted as part of the assessment.

[11] National Infrastructure Planning website. http://infrastructure.planningportal.gov.uk/legislation-and-advice/national-policy-statements/ Provided by the Planning Inspectorate. (last accessed 16/05/2014)

[12] Department for Communities and Local Government, 2012. Technical Guidance to the National Planning Policy Framework

[13] Department for Communities and Local Government, 2014. Planning Practice Guidance. Flood Risk and Coastal Change

Table 2.1 Consultation Summary

Description of Consultation	Contact for Correspondence	Date of Consultation
Meeting with the EA to discuss principals of the assessment and high level mitigation options	Charles Thompson	6 February 2014
EA response to specific questions and general advice on environmental constraints, requirements and guidance associated with the proposals. (NE/2014/120109/01)	Nick Beyer – Major Projects Officer	7 April 2014
Meeting with EA to discuss the water related mitigation strategies and results of modelling.	Charles Thompson	29 May 2014

The consultation response is included in **Appendix A**.

3. Baseline

This chapter provides information about the baseline water environment conditions for the proposed development site and the surrounding area.

3.1 Site Description

Within this section the following are discussed:

- The existing Airport;
- A high level description of the North West Runway Project;
- Topography;
- Local hydrology;
- Geology and hydrogeology; and
- Land Quality.

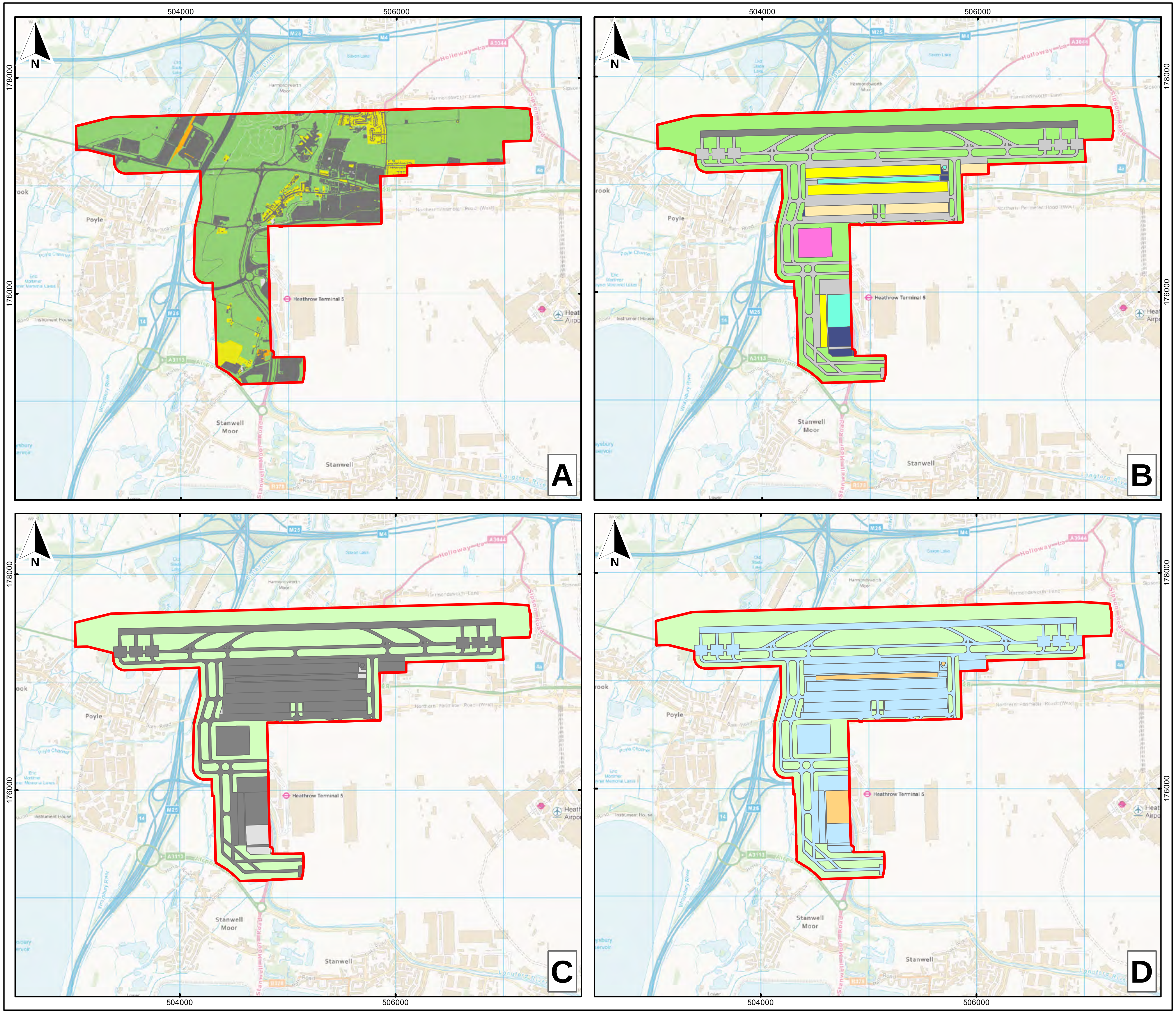
Existing Airport

Heathrow Airport is located approximately 15 miles west of central London. The existing Airport covers approximately 1.2 km^2 and operates two parallel runways (the northern and southern runways).

North-west Runway Project

The proposed development will occupy an area of land that is already partially developed. The focus of the Sustainable Drainage Strategy has been on the management of run-off from the airfield and airfield buildings. For the purposes of this Report this area has been termed the 'main airport sub-catchment' and is depicted in **Figure 2**. This sub-catchment excludes ancillary development around the Airport. It has been assumed that these areas will each be each subject to their own local sustainable drainage strategies which will be designed as each site is developed.

An estimate of the existing impermeable area for the main airport sub-catchment was made using Ordnance Survey (OS) Mastermap data and aerial photography. As indicated in **Figure 2**, approximately 30% of the land within the main airport subcatchment is currently covered in hardstanding, which is mostly drained by traditional piped systems. Discharge is to the existing public sewer systems, and ultimately a number of watercourses, including the River Colne, Colne Brook, Wraysbury River, the Duke of Northumberland's River and the Longford River, as discussed below. The remaining 70% of the main airport sub-catchment area currently comprise permeable surfaces, such as green open space, gardens, landfill sites or mineral extraction areas. Some of which may have limited permeability, as such the estimate is a conservative one.



Key:

Main airport sub-catchment

A
Land permeability (%)
- 0
- 25
- 50
- 75
- 100

B
Masterplan land use
- Airport buildings
- Ancillary
- Grass/green space
- Movement area
- Parking
- Pier serviced stands
- Remote stands
- Runway

C
Impermeability (%)
- 0
- 95
- 100

D
Roofs/rainwater harvesting areas
- Roofs/rainwater harvesting areas
- Main drainage system
- Permeable area

Scale: 1:35,000 @ A3

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Figure 2
Existing and proposed land use plan for the main airport sub-catchment

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A greenfield run-off rate of approximately 4 litres per second per hectare (l/s/ha) which equates to 1526 l/s (1.5m^3s) for the 380 ha main airport sub-catchment, has been estimated based on the method described in **Appendix B**.

Topography

The topography at the site of the proposed new runway is relatively flat, with a gentle gradient to the south, and with ground elevations ranging from 21m AOD in the southern section of the site to a high point of approximately 27 m AOD in the north eastern corner. The majority of the site is between 24 and 26 m AOD. Existing ground elevations in the vicinity of Stanwell Moor, where the engineered wetland is proposed, range from 20.5 to 22.5 m AOD. Elevations across the existing Airport generally range from around 22.5 to 24.5 m AOD.

Hydrology

The Airport is located within the hydrological catchment of the River Thames, and across the boundary of two tributary catchments, the River Crane to the east of the airport and the River Colne to the west. The Colne Valley contains a complex system of rivers. From west to east these are the Horton Brook, Colne Brook, Wraysbury River (connected to the Colne Brook by the Poyle Channel), River Colne, Longford River and Duke of Northumberland's River, as discussed further in the Flood Risk Report[14] that forms part of this technical submission.

The Duke of Northumberland's River and Longford River, known as the' twin rivers', flow along the western and southern boundaries of the site. Although referred to as 'rivers', they are actually man-made canals dating back to the 1600s. The course of the twin rivers was initially changed in the 1940s due to the construction of Heathrow Airport and they were diverted again, and daylighted (e.g. removed from culvert), to accommodate Terminal 5[15]. After the diversion was completed the rivers were both covered with nets for the majority of the diverted lengths to help deter birds and limit the risk of bird strike on aircraft[16]. Flows in the Duke of Northumberland's River are sourced from the River Colne catchment upstream of the Airport, but eventually outfall to the River Crane downstream of the Airport near Feltham, thus transferring rainfall from one catchment to the other. The River Crane flows in a southerly direction, less than 1km east of Heathrow Airport.

All waterbodies in the UK have been classified under the WFD on the basis of ecological status or potential. Like many urban rivers, all rivers in the environment local to Heathrow Airport fail to achieve the main aim of the WFD of 'Good' ecological potential. The River Colne (including Wraysbury River) and the Crane are classified as 'Poor' while the Colne Brook and Longford River/ Duke of Northumberland's River are classified as 'Moderate'. There are a range of factors contributing to this situation, including in channel structures that form barriers to fish migration and high phosphorus levels (released into the upstream river catchment), which is a common problem around the country. Water quality and the WFD are discussed further in the Water Quality and Hydro-ecology Assessment[8].

[14] AMEC (2014) Heathrow's North-West Runway – Flood Risk Report

[15] British Airports Authority (2002) Twin Channel Diversion Environmental Statement. Non-Technical Summary.

[16] Heathrow Airport Limited (2010) Twin Diverted Rivers, Biodiversity Management Plan 2010 -2015.

The EA has advised that the River Crane suffers from very low flows during dry weather, which is a concern in respect of meeting the WFD. According to information provided by the EA on their mitigation strategy for the River Crane catchment, the strategy for the lower Crane (Reference: GB106039023030) is to increase the flow in the lower Crane, particularly during low flow periods. This could supplement the steady flow to the Crane which is provided by Heathrow Airport's Eastern Drainage Catchment.

Geology and Hydrogeology

Heathrow Airport and the surrounding area are underlain by shallow deposits known as the Taplow Gravels. These gravels form part of a wide expanse of terraced river sands and gravels across the Thames floodplain. They consist predominantly of sand and gravel, but with local lenses of silt, clay or peat. The Taplow Gravels are highly permeable and range from 3 to 6 m thick. The thickness across the site varies due to natural variation and as a result of past gravel extraction. The groundwater levels in the gravels are usually shallow and within 2 m of the ground surface[17]. The Taplow Gravels overlie the London Clay Formation. The London Clay Formation is greater than 50 m thick and an impermeable barrier to groundwater interaction between the Taplow Gravel and the underlying Chalk aquifer. There is a shallow hydraulic gradient across Heathrow with groundwater in the Taplow Gravels flowing in a general north-east to south-west direction.

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

Land Quality

Previous investigations have highlighted areas of groundwater and land surface contamination within the existing Airport. There are a number of other potentially contaminated areas within the wider Colne Valley associated with historic gravel abstraction and subsequent landfilling. There are also known pollution incidents to land and groundwater which have the potential to pose ongoing sources of contamination. This is discussed further in the Water Quality and Hydro-ecology Assessment[8] and the Geo-Environmental Assessment[18]. Further investigation will however, be required before any development was to commence to confirm in more detail the specific land and groundwater quality.

3.2 Drainage Arrangements for the existing Airport

Heathrow's existing strategy for the sustainable management of surface water and run-off from the airfield and associated buildings ensures that water leaving the Airport is of the appropriate quality and that flood risk is not

[17] British Airports Authority (2000) Terminal 5 Project, Twin Rivers Diversion, Design Note 3 T5-ES-LF-34-00-WP-00003.

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

increased. Expansion gives the Airport the opportunity to further improve the quality of run-off, for example through the introduction of de-icing pads.

Heathrow's existing approach to sustainable drainage includes:

- Monitoring discharges from the airfield prior to discharge and reducing pollution risks by treating water. For example, Heathrow constructed a managed wetland at Mayfield Farm This pollution treatment facility was then subsequently improved through the introduction of aeration; and

- Heathrow produced a Surface Water Management Plan (SWMP) for the entire Airport within Q6 (2014 to 2019). This plan focuses on reducing impacts on the environment, identifying risks and implementing measures to achieve the defined environmental outcomes that Heathrow agreed with the EA.

In terms of providing a high level conceptual overview of the drainage arrangements for the existing Airport, there are a number of key elements. Surface water run-off across the Airport is collected using a traditional/ conventional piped drainage system. The site is divided into three main sub-catchments, which ultimately discharge to lakes within former gravel pits located to the south and south east of the site and to the River Crane from the Eastern Catchment. Contaminated run-off is treated at the Airport and some is discharged to the Thames Water sewage treatment works (STW) at Mogden, to the east of the site.

4. Assessment of Effects

4.1 Development Proposal

The development comprises an extension to the existing Airport, including:

- A north-west runway that crosses the route of a number of existing watercourses in the Colne Valley;
- Two new terminal buildings;
- Aircraft movement areas and taxiways;
- Various aircraft stands (pier serviced stands and remote stands);
- Car parking; and
- Ancillary uses.

Development of the NW runway will increase the impermeable footprint of the site. In the main Airport sub-catchment (covering all new areas of airfield and airfield buildings), it has been calculated that the impermeable footprint will increase by approximately 18%, from approximately 30% at present to approximately 48% once developed.

Airports can be a source of a number of contaminants that are potentially damaging to the environment, including hydrocarbons that occur as a result or accidental spillages and/ or leakages, and the intentional applications of chemical de-icers such as glycol which are used to de-ice aircraft, as well to de-ice the ground in airside areas of the Airport. During the design stages of the treatment facility attention will also focus on the treatment of diffuse pollution substances including cadmium, mercury, as well as other metals.

4.2 Effects of the Development without Mitigation

In the absence of measures to control run-off from the site, *i.e.* a drainage strategy, surface water run-off from new development would be uncontrolled. Uncontrolled run-off would result in both an increase in flood risk to local communities and the potential for increased pollution to the water environment, including from pollutants such as hydrocarbons and glycol.

4.3 Effects after Mitigation

The principal objective of the Sustainable Drainage Strategy is to provide an innovative and sustainable strategy, incorporating the latest treatment, recycling and harvesting technologies to manage and treat all surface water generated by the Airport.

It is a requirement of the NPPF[10] that the development will be safe (with respect to flooding), will not increase flood risk elsewhere and where possible will reduce flood risk overall. This strategy will satisfy these requirements, with discharges from the site being restricted to greenfield rates of run-off, achieved through the provision of on-site attenuation. Pollution prevention is the second primary requirement of this strategy and through an integrated system of recovery and treatment of potential pollutants, this strategy meets the requirements of local, national and European legislation and Policy. **Section 5** of this report demonstrates how the potential effects are credibly mitigated.

The calculated attenuation volumes and discharge rates are potentially subject to modification as the scheme is optimised and as the supporting assessments are further refined. In the development of the strategy, alternative options were assessed and discounted, these are discussed and explanations provided as to why these have not been taken forward.

This technical report is not an engineering design document.

5. Mitigation Strategy

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

Mitigation will be provided via the implementation of a Sustainable Drainage Strategy that meets all the requirements of the Airports Commission's Appraisal Framework[7], the NPPF[10] and the WFD[9] and the objectives of the strategy as set out in **Section 1.3**.

5.1 Requirements of the Drainage Strategy

The requirements of the Drainage Strategy are set out below, these relate specifically to legislation and the requirements of the Airports Commission. It is around these requirements which the objectives (**Section 1.3**) have been based. The requirements are:

- Protect the quality of surface and groundwaters (SAF) by managing the quality of discharges, such that there are no adverse impacts to watercourses/ waterbodies (WFD);
- Use water resources efficiently (SAF);
- Minimise flood risk (SAF) by managing surface water on-site to ensure that the development is safe, without increasing flood risk elsewhere, and if possible reduce flood risk overall (NPPF);
- Consider the potential impacts of climate change (NPPF), over a 60 year lifetime (SAF), either in the initial design or in the capability of the development to adapt to climate change in the future (managed adaption) (NPPF and the Appraisal Framework); and
- Prioritise the use of sustainable drainage techniques.

It is also necessary to ensure that the Drainage Strategy does not result in an unacceptable increase in the risk of bird strike.

5.2 Methodology

This proposed Drainage Strategy has been prepared in accordance with established best practice for surface water run-off management. The approach and methodology has been informed by the guidance in the SuDS manual[19]

[19] Construction Industry Research and Information Association (2007) The SuDS Manual (C697)

and the Defra and EA report on 'Rainfall run-off management for developments'[20], including the calculation of run-off rates, volumes, water quality and climate change.

The proposed sustainable drainage strategy has been prepared according to the principles of:

- **Capture** – provide a solution that captures surface water run-off so that it can be controlled on-site, including separate systems for capturing rainwater from roofs and 'dirty' water from apron areas;
- **Attenuate** – provide a solution that attenuates surface water run-off so that flows can be controlled to maximise treatment opportunity and ensure that the flood risk off-site is not increased;
- **Treat** – provide a treatment solution that is capable of dealing with the water quality characteristics associated with an airport, that maximises the potential for re-use on-site and/or ensures that off-site discharges will not have a detrimental impact on the environment;
- **Reuse/controlled release** – provide a solution that maximises the potential for water re-use to reduce the water demand of the airport, and ensure that releases from the system are controlled, both in terms of quantity as well as quality (chemical and visual).

In accordance with the guidance provided in the SuDS Manual[19] a management train approach has been taken, whereby an interlinked series of measures are proposed which work together to form a cohesive, robust, sustainable and credible solution. This solution was reached following a SuDS selection assessment process, which is documented in **Appendix B**. The layout of the proposed drainage strategy is shown in **Figure 3**.

Please note that in developing this strategy three supporting assessments have been undertaken:

- WinDes modelling to determine the required attenuation volumes (**Appendix B**);
- A SuDS Selection Assessment (**Appendix C**); and
- A rainwater harvesting volume assessment (**Appendix D**).

The assessments presented in **Appendices B, C** and **D** include detailed methodologies of the assessments undertaken.

5.2.1 Discussion of Assumptions

Please note that paragraph 9.4 of the Commission's Appraisal Framework indicates that:

"The Commission's appraisal will consider the impact of an airport scheme on water quality and quantity, and subsequent impacts, over a ***60 year*** *appraisal period."*

Therefore, a climate change allowance for 2055 to 2085, as given in Table 5 of the NPPF Technical Guidance[12], has been used in the assessment, comprising an increase in peak rainfall intensity of 20%. In line with the

[20] Department for the Environment, Food and Rural Affairs/ Environment Agency (2013) Rainfall runoff management for developments. Report SC0300219

guidance[20], to ensure a conservative approach is taken, present day greenfield rates have not been uplifted to account for climate change.

The Sustainable Drainage Strategy focuses on the main airport sub-catchment, comprising the additional airside areas (e.g. all the areas in which glycol is applied and the roofs of all the new main Airport buildings) and some pockets of landside areas within the north-west runway project boundary, as indicated in **Figure 2**. Three other sub-catchments also exist within the masterplan, comprising ancillary developments and car parking located around the periphery of the masterplan boundary. It has been assumed that there will be no permitted development rights within the airfield, as such an allowance for ‘urban creep’ as required by the guidance, has not been included at this stage. Drainage within each of the three other sub-catchments will be dealt with separately and likely on the site of the development itself. SuDS drainage systems, designed in accordance with the NPPF[10] and best practice, should be provided for these additional ancillary areas and car parks to ensure that run-off from each sub-catchment is managed.

The engineered reedbed has not been designed or optimised at this stage. At this stage, preliminary sizing of the reed bed has been undertaken, in order to provide a facility of sufficient size to achieve the required water quality improvements prior to discharge. A detailed wetland design will be required as part of the design process related to the DCO application, with the aim being to ensure that the treatment facility meets the requirements of this strategy through a process of optimisation.

Groundwater ingress into the piped drainage system has not been accounted for as part of the storage calculations. This potential source of additional water will be reviewed in detail at the design stage and alterations to storage volumes will be made accordingly.

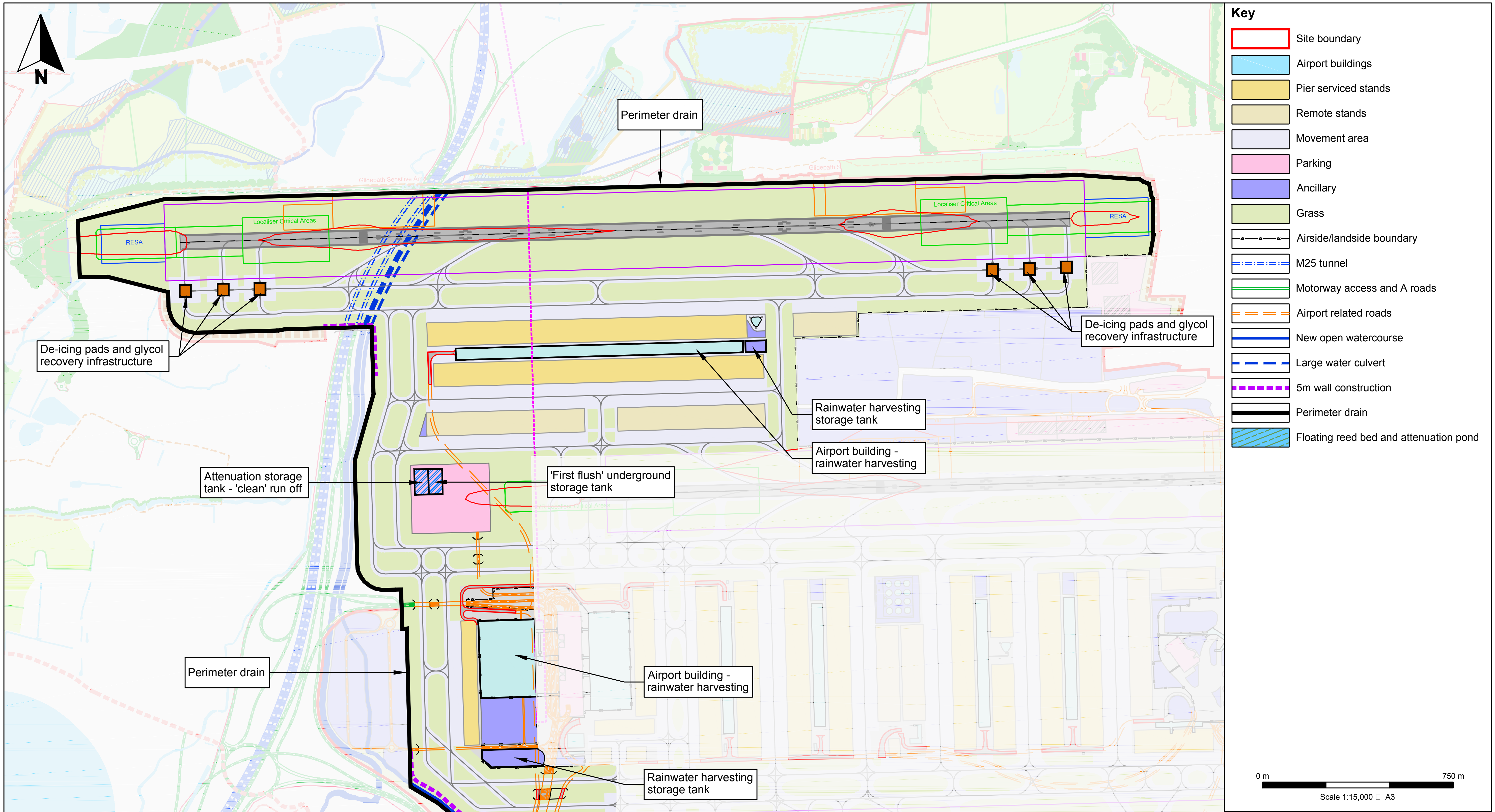
5.3 The Sustainable Drainage Strategy

The schematic for the drainage system, including flow routes, is provided in **Figure 4b** which indicates how each element of the system fits together to provide a complete solution. The location of the key elements of the strategy are shown in **Figure 3**. Where necessary, explanations for flow routes are provided on the schematic and therefore each element has not been described in detail in the section below. Only those elements for which further description would be of benefit to the reader are discussed further below. Specifically these are:

- Glycol recovery and re-use;
- Main airport sub-catchment drainage; and
- Rainwater harvesting.

5.3.1 Glycol Recovery and Recycling

To minimise the concentrations of glycol within the surface water run-off, dedicated areas for de-icing aircraft form part of the strategy.



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Heathrow's North-West Runway Sustainable Drainage Assessment

Figure 3
Drainage Strategy Layout Plan

June 2014
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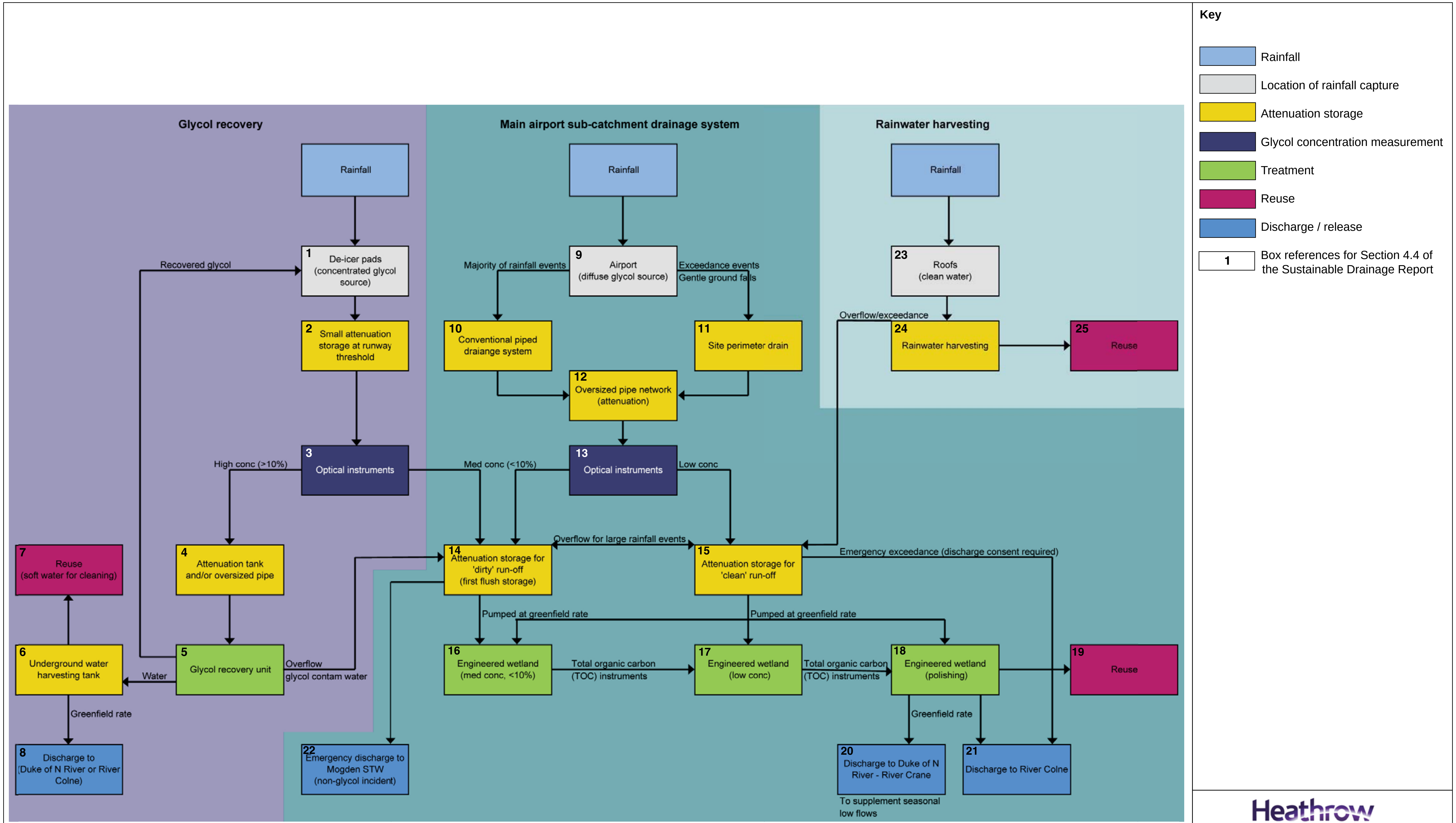

Heathrow
Making every journey better

Heathrow's North-West Runway
Sustainable Drainage Assessment

Figure 4
Drainage Strategy Schematic

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De-icer Pads

Purpose-built permanent aircraft de-icing pads (Box 1 in **Figure 4**) will be located at the entry taxiways at both ends of the third runway, as shown in **Figure 3**. The de-icer pad approach will ensure that the most intensive de-icing operations, associated with aircraft de-icing prior to take-off, will be concentrated in areas in which recovery will be possible. A dedicated drainage network will ensure that the highest concentrations of glycol contaminated surface water run-off will be captured at source, this may be supplemented with mobile recover vehicles. The proposed approach will reduce the concentrations of glycol in the surface water run-off that will require treatment in the engineered wetland. This will enhance the capability of the wetland to provide the greatest improvement in water quality possible.

Attenuation Storage at Runway Threshold

Small attenuation storage facilities serving the de-icing pads (Box 2 in **Figure 4**) will be located at the runway thresholds so as to allow measurement of glycol concentration in the run-off using appropriate real time monitoring instruments (Box 3 in **Figure 4**) prior to routing highly concentrated run-off to the glycol recovery unit for recovery, and routing the runoff with lower concentrations (unrecoverable glycol) towards the wetland for treatment.

Glycol Recovery Unit

The high concentration run-off will be stored (Box 4 in **Figure 4**) and then transferred at controlled rates to a dedicated recovery and distillation unit (Box 5 in **Figure 4**), from which high grade glycol will be produced for re-use, thus reducing the overall consumption of glycol and contributing to the Airport's overall strategy to minimise resource use. Tried and tested technology is already in place at international airports like Munich. HAL intend to trial this technology within the existing airfield as part of exiting plans to improve sustainability.

Glycol Recycling

A by-product of glycol recovery is soft water, which will be harvested (Box 6 in **Figure 4**) and used for aircraft and window washing, reducing the demand on the local water supply (Box 7 in **Figure 4**). The re-cycled water from the recovery process has good properties for being used to dilute 'raw' glycol prior to being used in de-icing activities. On the rare occasions that there is excess soft water, this will either be discharged into a nearby watercourse (Box 8 in **Figure 4** - subject to meeting the water quality criteria of the environmental permit) or could be discharged back into the drainage system and discharged through the engineered wetland.

5.3.2 Main Airport Sub-catchment Drainage System

Piped System

De-icer will continue to be used across the hardstanding areas of the airfield (i.e. in addition to the de-icer pads) during cold weather, providing a diffuse source of glycol (Box 9 in **Figure 4**) that will need to be collected by the main drainage system and treated in the engineered wetland. A conventional positive drainage system (Box 10 in

Figure 4), comprising gullies and pipes that drain under gravity, will capture surface water run-off across the main airport subcatchment and direct flows towards the wetland for treatment, via the storage reservoir which provides attenuation. Due to frequent use of the site by heavy vehicles and the widespread application of de-icing chemicals, source control measures such as permeable paving are not deemed to be appropriate. The closed system provided by the conventional pipe network will ensure that all contaminants and glycol in particular, are contained and conveyed to a dedicated treatment facility, in this case an engineered wetland, which will be designed with the specific purpose of treating glycol-contaminated surface water.

Site Perimeter Drain

Piped systems can be overwhelmed during intense rainfall events, resulting in overland flow. Without any additional measures to capture surface water, there could be run-off from the site without any attenuation. By using gentle gradients to direct surface flows towards a perimeter drain running around the perimeter main airport sub-catchment, all exceedance flows will be captured (Box 11 in **Figure 4**). The perimeter drain is indicated in **Figure 3**. The perimeter drain will drain under gravity back into the oversized piped system discussed further below for attenuation and subsequent treatment. This gravity driven system to capture rainwater will ensure that the risk of flooding associated with an exceedance rainfall event or system failure is minimised. This system will ensure that all surface water run-off up to the 1% AEP event, including an allowance for climate change, will be attenuated on-site. This will ensure that the development does not increase flood risk downstream, as required by the NPPF[10].

Above ground storage measures such as swales have not been proposed on the airfield because such features can exacerbate the risk of bird strike. There is also a requirement for a ‘clear graded area’ i.e. flat surfaces around runways and taxiways for aircraft safety and therefore there is little scope to utilise surface SuDS to capture rainwater at the ground surface.

Oversized Pipes

Oversized pipes (Box 12 in **Figure 4**) will be used to reduce the required storage capacity of the attenuation storage tanks and reduce the risk of the pipe system being exceeded locally. They will also provide a means by which exceedance events routed towards the site perimeter drain will be able to enter the piped network.

The network of oversized pipes (with bore diameters of approximately 1.0 m and 1.5 m) will provide approximately 10% of the total attenuation storage volume required. Their oversized nature will provide a capacity such that 1% AEP plus climate change event flows from the site perimeter drain can be accommodated, thus providing a means by which the site perimeter drain will be able to drain during exceedance events. At the design stage the pipe sizes can be increased or decreased to optimise performance and improve cost effectiveness of the scheme.

Attenuation Storage Tanks

To minimise the risk of attracting wildlife/ bird strikes, areas of open water have not been incorporated into drainage strategy. Similarly, the requirement for a clear graded area around the runways and taxiways for aircraft safety meant that surface SuDS were not a feasible option for source control/localised water storage. Therefore, surface water collected by the piped system will be directed to two centrally located underground attenuation storage tanks. As indicated in **Figure 3**, the storage tanks will be located under the car park to the north of Terminal 6, ensuring that access for maintenance will be possible without disrupting airfield operations. By locating the storage tanks underground, the positive drainage gradients across the site will be maximised, thus minimising the risk of the piped system being exceeded.

Industry standard WinDes software was used to estimate the storage volumes required to attenuate flows to the limiting values of 4 l/s/ha. The preliminary storage calculations indicate that the main airport sub-catchment, as indicated in **Figure 2**, will require a total of approximately 130,00 0 m^3 of storage to ensure that the 1% AEP plus climate change critical storm duration event can be stored on-site. This storage volume assumes a greenfield discharges rate of 4 l/s/ha (which equates to a rate of 672 l/s for the 168 ha development footprint).

At this stage, it is thought that 90% of this storage volume would be provided by the underground tanks, with a total depth of approximately 10 m and with a surface area of 11,000 m^2.

The total storage volume will be provided in two tanks located adjacent to each other, into which surface water run-off of differing concentrations of glycol can be directed (Box 13 in **Figure 4**). The de-icing pads (Box 1 in **Figure 4**) and glycol recovery system (Box 5 in **Figure 4**) will have captured the highest concentrations of glycol contaminated run-off. As a result only diffuse glycol contamination, at medium or low concentrations, will be entering the piped drainage system. It is envisaged that one tank would be used to store 'dirty' run-off (medium concentration of glycol, i.e. less than 10% - Box 14 in **Figure 4**) and the other to store 'clean' run-off (low or very low concentrations of glycol – Box 15 in **Figure 4).** Appropriate real time monitoring at the inlet will continuously monitor concentrations of glycol in the surface water run-off, and direct flows to the appropriate tank as required for optimal use of the system at any given moment (Box 13 in **Figure 4**).

The principle of 'first flush' is set out in the SuDS Manual[19], whereby the first 5mm of any rainfall event usually flushes the vast majority of contaminants out of the system. The ability to separate the medium concentrations of glycol in the 'first flush' improves the control over the subsequent treatment process in the downstream wetland. By locating the 'clean' and 'dirty'/ 'first flush' tanks adjacent to one another, flexibility has been incorporated into the system to ensure that the combined system will be able to store the critical duration 1 in 100 year (plus an allowance for climate change) rainfall storm event. Under this extremely unlikely scenario both tanks would be used for storage irrespective of glycol concentrations, whilst ensuring that the combined discharge from both tanks would not exceed the undeveloped greenfield rates.

Pumping

The majority of the drainage system will drain under gravity, but a pumped link will be required to transfer run-off from the underground tanks to the wetland for treatment (Boxes 14 and 15 to Boxes 16 and 17 in **Figure 4**). The underground tanks have been sized based upon a greenfield run-off rate discharge and therefore excessive pump capacities will not be required. The need for pumping is twofold. Firstly a preference for gravity driven drainage across the airfield requires a centrally located deep rainwater storage device, being deep it means that water will eventually need to be pumped to empty the tank into the engineered reed bed. Secondly, the pipework linking the storage tanks to the engineered wetland need to be at depth to avoid the other complex transport and service tunnels and infrastructure which are to be located between the centrally located storage tanks and the wetland.

Risks associated with failure of the pumps will be mitigated by employing a second line of protection in the form of a back up pump, for which individual flood risk assessments, maintenance strategies and emergency plans will be prepared to minimise the risk and impacts of any failure. A secondary supply of electricity will also be provided to ensure pumping is maintained in the event of a loss of grid power.

Engineered Wetland

Because of the potential effects to water quality, and therefore aquatic environment, associated with airport de-icing operations, the identification of an appropriate treatment technique is a primary consideration when determining the SuDS strategy for an airport. Therefore, the identification of a sustainable solution to treat glycol within the surface water run-off was a principle consideration in the selection of an appropriate SuDS management train for the north-west runway project.

As detailed in the SuDS selection assessment in **Appendix B**, few SuDS techniques are capable of consistently treating run-off that contains the high concentrations of organic compounds found in run-off from airfields, such as glycol, and therefore a centralised and specialised treatment technique was considered necessary. Impacts on the environment are associated with the oxygen demand of naturally occurring bacteria, which break down the organic compounds leaving the water with a low dissolved oxygen (DO) concentration. Not only does the treatment technique need to ensure that the glycol has been broken down prior to re-use or discharge to the environment, it also needs to ensure that the dissolved oxygen concentrations have returned to acceptable levels so as not to adversely affect the hydro-ecology of the receiving watercourse.

It is proposed to use an extensive engineered floating treatment wetland to provide the treatment necessary (Boxes 16, 17 and 18 in **Figure 4**), supplementary aeration may be required to optimise performance. The location of the wetland is indicated in **Figure 3**. The SuDS selection assessment (in **Appendix B**) details a number of established treatment solutions that were also considered (including atmospheric aeration/ oxygenation, package treatment works, chemical treatment, oxygen injection and discharge to the Thames Water foul system for treatment at the Mogden sewage treatment works), and the reasons why these were dismissed as potential sustainable options for this strategy. The ongoing operational expenditure costs associated with these other techniques was a recurring factor. Based upon experience and lessons learned at Heathrow, it is understood that biological processes alone may not be entirely sufficient to treat run off to an acceptable standard and some form of intensive aeration may also be required as well as nutrient dosing. The capture of high concentrations of glycol at the de-icer pads will aid to reduce the volume of glycol needing to be treated by the wetland.

The engineered floating treatment wetland will provide a cascade of treatment (Boxes 16, 17 and 18 in **Figure 4**), whereby run-off requiring full treatment could be directed to the first stage of the wetland, whereas ‘clean’ run-off will be directed to the downstream end for final polishing prior to discharge and/ or re-use as grey water within the Airport.

The floating nature of the reedbeds will enable it to provide additional storage capacity required for stormwater attenuation prior to and during extreme rainfall events, when the underground tanks need to be empty so as to ensure that the full capacity of the drainage system is available to store surface water. It has been assumed that the wetland will be capable of either storing or treating run-off at a rate up to the 1% AEP plus climate change greenfield run-off rate, such that this rate could be pumped from the underground storage tanks during the most extreme rainfall events.

The engineered wetland will be isolated from the shallow gravel aquifer so as to avoid the risk of interaction with groundwater.

Re-use

Treated surface water from the wetland will be reused at the airport, thus reducing the water demand of the airport (Box 19 in **Figure 4**). It is anticipated that water could be reused for airport processes such as cleaning, but it is also possible that it could be used as grey water within terminal buildings. There may well be a requirement to consider an additional stage of treatment to provide a suitable level of non-potable quality, including colour/ odour/ suspended solids and trace substances that need to be removed.

Discharge Points

Excess surface water will be discharged to nearby watercourses at greenfield rates (Boxes 20 and 21 in **Figure 4**). In accordance with best practice, a sequential approach to the determination of the proposed discharge locations has been followed, whereby infiltration was considered first, followed by discharge to watercourses, with piped sewer systems only considered if no other options were available. Some may well be susceptible to additional pollution i.e. washing pads external waste areas e.t.c and will drain to the foul sewer. Due to the presence of historic landfills underlying parts of the site, groundwater quality issues and likely shallow depth to groundwater, it was identified that soakaways (and infiltration) are unlikely to be an appropriate means of discharge for the airport. Therefore to ensure that the strategy was robust, the proposed approach did not rely upon infiltration.

The location of the treatment wetland in the south western section of the site provides the opportunity to discharge into both the Duke of Northumberland's River and/or the River Colne valley as necessary. As discussed in **Section 3.1**, according to information provided by the EA's found in their mitigation strategy for the River Crane, the River Crane itself suffers from low flows during dry summer months. It will be possible to improve this situation by discharging into the Duke of Northumberland's River and the ultimately River Crane to supplement low flows during dry summer months. Discharges will be monitored and controlled at the final discharge locations so as to ensure that permitted limits of contaminant concentrations are not exceeded.

Surface water will also be discharged to the River Colne via the EA Main River that passes through Stanwell Moor.

Emergency Overflow

In cases of emergency, the drainage strategy includes an emergency discharge route to the Thames Water sewage treatment works at Mogden (Box 22 in **Figure 4**). This has been included so as to provide an overflow mechanism for non-glycol related incidents, to be used in emergencies only. The key benefit of this arrangement is that it provides flexibility and contingency within the system. Without such an arrangement, the ecology of the wetland could be adversely affected by an emergency pollution incident such that the capability of the wetland to deal with usual contaminant levels could be adversely affected. At the design stage Thames Water will be consulted and alternative options discussed so that an optimal solution is identified.

There will be some onsite upfront control of significant pollution to protect the biological treatment. Fuel and oil in the runoff is possible. Oil interception on stand and perhaps before the wetland treatment will be incorporated. The ability to lockdown the drainage system at critical points will be considered to control pollution as close to source as possible.

5.3.3 Rainwater harvesting

The re-use of water will be maximised by harvesting clean rainwater directly from the roofs of the new terminals and satellite buildings (Box 23 in **Figure 4**).

Rainwater harvesting storage tanks (Box 24 in **Figure 4**) will be oversized to provide storage for roofwater run-off for the 1% AEP event, including an allowance for climate change, thus maximising the capacity of re-use at the site, and reducing the required storage capacity of the attenuation storage tanks.

This means that the maximum possible levels of roofwater would be captured for re-use, as well as reducing the volume of run-off requiring attenuation storage and subsequent treatment in the engineered wetland (Box 25 in **Figure 4**). An annual average yield of 0.23 mega litres a day has been estimated from the roofs of the terminal buildings, the percentage of this stored will depend upon the size of the harvesting tanks and this will go towards supplementing the non-potable water demand within the terminal buildings which has been estimated at 1.9 mega litres per day.

6. Conclusions

Heathrow Airport will develop a sustainable and effective strategy that will ensure flood risk is not increased, and protect river flows, water quality and aquatic ecology during and beyond the lifetime of the development that takes into account the potential impacts of climate change.

This Sustainable Drainage Report, upon which the Sustainable Drainage Strategy has been developed, also sits alongside the Flood Risk Strategy and works to support the objectives set out in the Water Quality and Hydro-ecology Assessment[8] which has also been submitted to the Airports Commission.

The Strategy incorporates the latest treatment, recycling and harvesting technologies to manage and treat all surface water generated by the Airport, and re-use where possible. The mitigation measures that have included as part of the strategy will not result in an unacceptable increase in the risk of bird strike, and will ensure that all relevant legislation and planning policy, such as the WFD and the NPPF are met.

Appendix A
Consultation Response from the Environment Agency

creating a better place

Environment Agency

John Rampley
AMEC plc

Via email:
john.rampley@amec.com

Our ref: NE/2014/120109/01
Alt Ref: PAC/SE/NE/50024

Date: 7 April 2014

Dear John

Heathrow Airport Ltd.

Heathrow Airport Expansion Proposals.

In response to your email dated 11 March 2014, please see the comments in the attached appendices.

We have answered your specific questions where appropriate and possible and have also provided you with general advice with regard to environmental constraints, requirements and guidance associated with the proposals.

Please note that as discussed we have not managed to get technical comments from all of our internal consultees. We will send any further comments from our Catchment Co-ordinator, who leads on partnerships and local delivery of Water Framework Directive as soon as we can.

I hope that the information provided forms a suitable basis for our ongoing engagement.

If I can be of any further assistance, please do not hesitate to contact me.

Yours sincerely

Nick Beyer
Major Projects Officer

Telephone: 0203 263 8051
E-mail: northlondonplanning@environment-agency.gov.uk
Address: Ergon House, Horseferry Road, London, SW1P 2AL

Authorised by:

Charles Thompson
Major Projects Manager

Appendices

Appendix 1 – Surface Water Flood Risk

Important Note: The London Borough of (LB) Hillingdon is now the competent authority on all surface water flood risk matters within Hillingdon. The following comments are provided as advice only and should not outweigh any advice that you are given by LB Hillingdon. We will not be in a position to provide further advice on surface water flood risk issues. We recommend that you contact Vicky Boorman at LB Hillingdon on 01895 250111 for further engagement and advice regarding surface water flood risk issues.

We recommend that the following standards are demonstrated as part of the surface water strategy:

- Runoff rates: Peak discharge rates from site should not increase as a result of the proposed development, up to a 1 in 100 chance in any year including an allowance for climate change storm event. Greenfield rates should be aimed for.

- Storage volumes: Attenuation storage volumes for all events up to a 1 in 100 chance in any year including an allowance for climate change storm event should be provided on site.

- Sustainable drainage techniques: Sustainable Drainage Systems (SuDS) such as green roofs, ponds, swales and permeable pavements should be used where possible. The SuDS hierarchy should be followed as you design the site.

- Residual Risk: The residual risk of flooding should be managed and contained safely on site should any drainage features fail (e.g. pumps or flow control devices) OR during an extreme storm event.

Appendix 2 - Fluvial Flood Risk

In order for us to be confident that the proposals will be acceptable, it will need to be shown that any land raising or increase in built footprint within the 1 in 100 chance (1%) in any year including an allowance for climate change flood extent can be directly compensated for, on a volume-for-volume and level-for-level basis to prevent a loss of floodplain storage. A peak river flow climate change allowance of 20% would be appropriate.

Where floodplain impacts cannot be avoided, floodplain compensatory storage should be provided as substitution for the floodplain storage lost through the development. This is to ensure the mass balance of floodplain storage capacity is maintained within the river catchment, or distinct part thereof. This is critical where more or highly vulnerable receptors, such as dwellings, could be negatively impacted by changes to flood depth/extent/hazard for flood events up to the 1% annual probability flood, including an allowance for climate change.

Where floodplain compensation cannot be provided on a level-for-level basis, wider catchment improvements/floodplain enhancements and other mitigation such as volume-for-volume (but not level-for-level) compensation may be provided elsewhere in the catchment. Detailed hydraulic modelling will need to be undertaken to demonstrate how this storage will function and that risk to people and property will not be increased (and reduced where possible).

Please note that any works in, over, under or within 8 metres of a main river require a Flood Defence Consent. This is a requirement of the Water Resources Act and Thames Regional Byelaws and is irrespective of any other permission that may be granted. We can provide further information on this as you require it.

Appendix 3 – Water Resources

The following comments are provided solely from a water resources and/or abstraction licensing perspective and are predominantly related to scoping point two under your scope related notes.

The primary area of concern from a water resources perspective is linked to potential contamination (due to previous landfill activity) and/or possible implications of construction activities on local groundwater resources. This in turn could have implications for existing abstraction licences (licensed or non licensed protected rights) within the affected area. In addition, there could be implications on existing reservoir capacity should any of the selected proposals reduce/change any of the available water storage areas. The risks associated with the above will need to be comprehensively characterised and appropriate mitigation for the impacts will need to be produced.

The proposed construction method will influence how much displacement of groundwater might take place. This could be through passive means (e.g. actual construction work) or active means (e.g. pumping as with dewatering). The present licensing legislation provides an exemption for dewatering under S29(2) of Water resources Act (WRA) 1991. This exemption is to be removed although the precise date cannot yet be confirmed. It has been suggested autumn 2014 is the likely date. The secondary use of such water for another activity not linked to the dewatering can be licensable, but when the legislation is changed all secondary uses (e.g. dust suppression) will be licensable.

You have indicated that a method statement will be prepared to highlighted environmental risk and dewatering impacts. From a water resources and quality perspective, these investigations should consider the potential implications of groundwater contamination and/or displacement of existing contaminants. The implications of dewatering on existing abstraction sources and the environment should also be considered. This assessment provides an opportunity to propose methods to minimise the need for dewatering activities or provide mitigation for dewatering activities that are required. The long-term alteration to groundwater flows could have implications for current patterns of drainage and shallow groundwater support for flows and/or local designated conservation areas. These factors should not be excluded from the initial desktop assessment.

In addition, mitigation opportunities should consider options for water re-use to minimise the use of potable water as part of construction activities.

Appendix 4 - Biodiversity, Conservation and Water Framework Directive (FWD)

You will need to demonstrate that the proposals will not cause any deterioration to Water Framework Directive (WFD) waterbodies or change in the ecological conditions of the Special Protection Area (SPA). This will need to be ensured and implemented through careful design, mitigation and provision of sites for ecological compensation.

A WFD preliminary compliance assessment should be carried out as an initial overview of where likely impacts may occur and where possible mitigation measures can be realised.

This is essential at an early stage to see how the proposal will fit within the requirements of the Directive.

The reason for this is that new activities and schemes that affect the water environment may impact the biological, hydromorphological and/or physico-chemical quality elements. These impacts could lead to deterioration in the ecological status or potential of a water body which is not permitted under the Water Framework Directive (2000/60/EC) unless these changes are defensible under Article 4.7.

New activities and schemes may also render proposed improvement or mitigation measures ineffective and therefore lead to the water body failing to meet its good status or potential objective.

New activities and schemes must therefore be assessed to identify whether they will:

- cause deterioration to the ecological quality elements
- lead to a failure to achieve ecological objectives
- prevent implementation of actions outlined within Stage 3 investigations thereby obstructing the achievement of 'good' status.

Where a scheme does cause deterioration or failure to meet good status/potential objectives, in order to remain compliant with WFD, a series of conditions set out by Article 4.7 will need to be adequately demonstrated.

We would like to draw your attention to the fact that during dry weather, the River Crane suffers from very low flows, which is causing a WFD failure. Please see the attached spreadsheet containing River Basin Management Plan Mitigation Measures. We would very much welcome any opportunity to implement appropriate mitigation measures to address the low flow problem in the River Crane.

The proposals are in close proximity to the South West London Waterbodies (SWLWB) SPA. The Environment Agency is a competent authority for working on wetland based designated sites. In order to ensure the integrity of the SPA and the supporting wetlands, a Stage 1 Habitats Regulation Assessment will need to be carried out on the SPA and lakes noted 'of relevance' to the SPA. This should be carried out in accordance with guidance from Natural England and will need to dovetail with the WFD assessment considering the impact on lake waterbodies.

We recommend that you are aware of the Crane Catchment Plan - http://cranevalley.org.uk/catchment/catchment-plan/

The Airport currently has a number of permits, regulated by us under the Environmental Permitting Regulations 2010, to discharge site drainage comprising Airport drainage and construction drainage. The Airport currently has a number of Permissions to Discharge site drainage comprising Airport drainage and construction drainage. Under the Environmental Permitting Regulations 2010, the Permit holder (for example, Heathrow Airport Limited) has Permit conditions with environmental standards. Conditions are required to ensure compliance of WFD and to ensure no deterioration in river quality.

The Airport currently has a series of pollution control systems, which enables an assessment of the quality of their airport (surface water) runoff and inform a decision to divert, containment, treat and release to foul or surface waters (controlled waters). A containment strategy and Treatment strategy should both be encompassed within the Water Strategy.

We expect a water strategy that identifies surface water which is non-contaminated and potentially contaminated. The strategy should uphold the principle of pollution prevention, considering emergency planning and factor in the following principles of Pollution Prevention Guidance 22:

- Contain at source
- Contain close to source
- Contain on the surface
- Contain in the drainage system
- Contain on the watercourse

In addition the site wide water strategy should include:

- Water quality, upholding the principle of pollution prevention - containment and sources, reuse, recovery, treatment – disposal.
- Water resources, upholding a sustainable use of resources

Apart from the risk of fuel and other hydrocarbons and the need for oil interceptors to serve areas such as taxiway, runway and car parking, the control of intermittent application of de-icant and anti-icant, which is potentially polluting matter, needs a detailed drainage strategy of containment and treatment.

The following comments relate to your points made in your email under scope related notes.

Point 1: We appreciate that there is a link in proposed appendix 9 to the impact on the South West London Water Bodies (SWLWB) SPA. There is cross-over in this section as many of the SPA lakes are also WFD water bodies.

Point 1(d): Water quality changes should be related to quality elements in WFD status.

Point 3: Waterbodies also includes lake habitats, which should be scoped into the assessment.

Appendix 5 - Groundwater and Contaminated Land

We note and accept that a detailed hydrogeological risk assessment will not be prepared by 9 May, however, in order to achieve confidence that the proposals will not cause unacceptable risks to controlled waters we request a comprehensive preliminary risk assessment/desk study to be produced which has identified the following:

- all previous uses,
- potential contaminants associated with those uses,
- a Conceptual Site Model (CSM) of the site indicating sources, pathways and receptors,
- potentially unacceptable risks arising from contamination at the site.

Ideally, the CSM should includes the results from previous site investigations, site-specific geology and hydrogeology and any new structures that change the current site conditions such as foundations, earthworks, and drainage.

Our records indicate that the proposed development is located on historical landfills. We are not likely to consider the use of soakaways appropriate in this location in order to protect groundwater from further deterioration and pollution via remobilisation of contaminants in soil and/or the creation of preferential pathways for contaminant migration.

If it can be demonstrated that the ground in question is not contaminated, then we would not preclude the use of soakaways, subject to their impacts being adequately demonstrated and addressed.

The following information comes from the document GP3 (Groundwater protection: principles and practice) – Position Statement G9:

We will only agree to the use of deep pit based systems (including boreholes or other structures that bypass the soil layers) for surface water or effluent disposal if the developer can show that all of the following apply:

- there are no other feasible disposal options such as shallow infiltration systems (for surface water) or drainage fields/mounds (for effluents) that can be operated in accordance with current British Standards;

- the system is no deeper than is required to obtain sufficient soakage;

- pollution control measures are in place;

- risk assessment demonstrates that no unacceptable discharge to groundwater will take place, in particular that inputs of hazardous substances to groundwater will be prevented; and

- there are sufficient mitigating factors or measures to compensate for the increased risk arising from the use of deep structures.

GP3 is available on our website here: http://www.environment-agency.gov.uk/research/library/publications/144346.aspx

Appendix 6 – Mitigation Related Questions

With regard to the specific mitigation related questions which you raised, please find our answers below. I have marked these by specific topic.

Q: Is there general acceptance of the concept of an ‘envelope of change’ extending some distance north, west and south of the proposal, in which there will potentially be alterations to the distribution of floodplain storage, altered flow regimes etc. But outside this ‘envelope of change’ the baseline will either remain unchanged or be enhanced.

A: **Flood Risk:** Yes, we accept this providing the risk of flooding to people and property will not be increased.

Q: Is there a general acceptance that given the nature of the scheme flood risk will have to increase in some areas where new floodplain and storage is created?

A: **Flood Risk:** Floodplain impacts should be avoided wherever reasonably possible for all events up to the 1% (including climate change) annual probability. Particular priority should be given to maintaining the conveyance of flows within the channel and “functional floodplain” areas and ensuring that the flood regime (shape of the hydrograph) does not change for these frequent flooding events. We accept that some areas of floodplain may be lost as a result of the proposed development, but this will only be considered acceptable if appropriate compensatory floodplain storage is provided.

Q: Are the EA open to non-standard (for the UK) flood storage options, such as underground storage?

A: **Flood Risk:** We would be open to non-standard flood storage options only after all other opportunities to provide standard, above ground storage, which provides multiple benefits, are explored and exhausted. Non-standard underground storage options will only be considered as a last resort. In addition, it will need to be demonstrated the use of non-standard options will not increase the risk of flooding to people and property and that the storage can be guaranteed and maintained for the lifetime of the development. The storage will also need to be able to include an allowance for the impacts of climate change.

It is likely that detailed modelling will need to be undertaken to demonstrate the operation of all flood storage options.

Q: Would we be expected to maintain the existing split of water which enters the Thames from each of the Colne Valley tributaries at low flows? We assume so.

A: **Water Resources:** Yes, we would expect (unless demonstrated otherwise environmentally beneficial) that current flow splits are retained. The Colne and its various tributaries flow into the River Thames. The Lower Thames supports the major Thames Water abstraction of which the Colne and its various tributaries are contributing a percentage of the flow regime. This would need to be assessed if any proposed changes were being considered. In addition any local environmental implications for the receiving watercourses should be addressed if they are to receive less flow, especially under medium to low flow periods.

Q: We assume that reducing peak flows along the lower reaches of River Colne and Colne Brook will be supported.

A: **Flood Risk:** From a flood risk perspective, we agree with this assumption. Given the size and nature of the proposed development, we see this is a unique opportunity to seek to reduce flood risk across the catchment. Policy option 4 of the Thames Catchment Flood Management Plan (CFMP) also states that the proposed development falls within an area where "...*we may need to take further actions to keep pace with climate change*".

Q: Due to the location of the proposed runway in relation to the Colne valley, some existing lengths of watercourses will be lost or at least diverted or realigned. At a very high level, a combination of diversions, new channels and some culverting may form part of the strategy. We assume that the EA note this.

A: **Flood Risk:** We have a general position against culverting mainly due to the associated impacts on flood risk and ecology and also on the aspirations of the Water Framework Directive. It should be demonstrated that all opportunities to either divert or realign watercourses have been considered and given priority. Culverting should only be considered if these options are not physically possible and we would expect to see full justification of why culverting is the only option.

The length of any culvert should be restricted to the minimum necessary to meet the objective. The proposal must include appropriate assessment of flood risk and environmental impact. You should take into account the possible effects of climate change and future development in the catchment, on the watercourse, when calculating the capacity of the culvert. Mitigation measures such as mammal ledges must be incorporated within the design, and the work must be carried out using best working practice to minimise environmental impact.

The following link provides a useful summary on culvert design:
http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter8.aspx?pagenum=6

Please take particular note of Box 8.3 'Golden Rules' of culvert design.

Water Resources: It is likely that there will be licensing requirements associated with changes to the watercourses.

Q: Enhancements to river reaches both within and beyond the direct influence of the site (i.e. with no change to flow regime) will be considered as part of the mitigation strategy. We would like to find out about any existing or proposed improvement schemes in the lower Colne catchment, including implementation of Mitigation Measures (for those waterbodies designated as HMWBs), and improvements to fish passage, to ensure that any future changes to the baseline are fully understood and ensure that they are taken account of, contributed to or enhanced as part of the mitigation strategy.

A: We have not yet managed to provide an answer to this question, but will endeavour to provide you with an answer in due course.

Appendix B
WinDES Drainage Calculations

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	4.621	4.621	454.9	0.0	454.9	60076.8	O K
30 min Summer	5.284	5.284	486.5	0.0	486.5	68693.6	O K
60 min Summer	6.023	6.023	519.4	0.0	519.4	78300.8	O K
120 min Summer	6.823	6.823	552.8	0.0	552.8	88693.7	O K
180 min Summer	7.302	7.302	571.9	0.0	571.9	94931.7	O K
240 min Summer	7.639	7.639	584.9	0.0	584.9	99301.6	O K
360 min Summer	8.087	8.087	601.8	0.0	601.8	105132.5	O K
480 min Summer	8.370	8.370	612.2	0.0	612.2	108807.6	O K
600 min Summer	8.556	8.556	619.0	0.0	619.0	111227.5	O K
720 min Summer	8.678	8.678	623.4	0.0	623.4	112818.6	O K
960 min Summer	8.776	8.776	626.9	0.0	626.9	114092.7	O K
1440 min Summer	8.714	8.714	624.7	0.0	624.7	113275.9	O K
2160 min Summer	8.536	8.536	618.3	0.0	618.3	110972.1	O K
2880 min Summer	8.333	8.333	610.9	0.0	610.9	108329.9	O K
4320 min Summer	7.603	7.603	583.5	0.0	583.5	98842.7	O K
5760 min Summer	6.968	6.968	558.6	0.0	558.6	90588.0	O K
7200 min Summer	6.422	6.422	536.3	0.0	536.3	83481.8	O K
8640 min Summer	5.949	5.949	516.2	0.0	516.2	77343.1	O K
10080 min Summer	5.534	5.534	497.8	0.0	497.8	71938.4	O K
15 min Winter	5.181	5.181	481.7	0.0	481.7	67352.8	O K
30 min Winter	5.925	5.925	515.1	0.0	515.1	77026.5	O K
60 min Winter	6.756	6.756	550.1	0.0	550.1	87833.4	O K
120 min Winter	7.662	7.662	585.8	0.0	585.8	99601.2	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	194.105	0.0	58
30 min Summer	111.206	0.0	72
60 min Summer	63.712	0.0	100
120 min Summer	36.501	0.0	158
180 min Summer	26.351	0.0	216
240 min Summer	20.912	0.0	272
360 min Summer	15.097	0.0	388
480 min Summer	11.981	0.0	504
600 min Summer	10.014	0.0	620
720 min Summer	8.649	0.0	736
960 min Summer	6.848	0.0	968
1440 min Summer	4.928	0.0	1342
2160 min Summer	3.546	0.0	1688
2880 min Summer	2.808	0.0	2072
4320 min Summer	1.963	0.0	2888
5760 min Summer	1.523	0.0	3704
7200 min Summer	1.251	0.0	4536
8640 min Summer	1.065	0.0	5304
10080 min Summer	0.929	0.0	6088
15 min Winter	194.105	0.0	58
30 min Winter	111.206	0.0	72
60 min Winter	63.712	0.0	100
120 min Winter	36.501	0.0	156

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	8.209	8.209	606.3	0.0	606.3	106722.3	O K
240 min Winter	8.596	8.596	620.4	0.0	620.4	111746.1	O K
360 min Winter	9.118	9.118	639.0	0.0	639.0	118539.6	O K
480 min Winter	9.455	9.455	650.7	0.0	650.7	122918.8	O K
600 min Winter	9.684	9.684	658.6	0.0	658.6	125892.2	O K
720 min Winter	9.841	9.841	663.9	0.0	663.9	127935.3	Flood Risk
960 min Winter	9.991	9.991	668.9	0.0	668.9	129881.1	Flood Risk
1440 min Winter	9.993	9.993	669.0	0.0	669.0	129907.4	Flood Risk
2160 min Winter	9.725	9.725	659.9	0.0	659.9	126421.4	Flood Risk
2880 min Winter	9.469	9.469	651.2	0.0	651.2	123100.0	O K
4320 min Winter	8.534	8.534	618.2	0.0	618.2	110940.4	O K
5760 min Winter	7.688	7.688	586.8	0.0	586.8	99938.8	O K
7200 min Winter	6.947	6.947	557.8	0.0	557.8	90310.4	O K
8640 min Winter	6.303	6.303	531.3	0.0	531.3	81940.0	O K
10080 min Winter	5.740	5.740	507.0	0.0	507.0	74620.8	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	26.351	0.0	212
240 min Winter	20.912	0.0	268
360 min Winter	15.097	0.0	382
480 min Winter	11.981	0.0	496
600 min Winter	10.014	0.0	610
720 min Winter	8.649	0.0	722
960 min Winter	6.848	0.0	950
1440 min Winter	4.928	0.0	1386
2160 min Winter	3.546	0.0	1756
2880 min Winter	2.808	0.0	2204
4320 min Winter	1.963	0.0	3116
5760 min Winter	1.523	0.0	4000
7200 min Winter	1.251	0.0	4856
8640 min Winter	1.065	0.0	5712
10080 min Winter	0.929	0.0	6496

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 505200 176950 TQ 05200 76950
C (1km)	-0.026
D1 (1km)	0.316
D2 (1km)	0.308
D3 (1km)	0.237
E (1km)	0.305
F (1km)	2.569
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time / Area Diagram

Total Area (ha) 167.864

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	15.547	8-12	15.547	16-20	15.547	24-28	15.547	32-36	15.547	40-44	12.394
4-8	15.547	12-16	15.547	20-24	15.547	28-32	15.547	36-40	15.547		

Appendix C
SuDS Selection Assessment

SuDS Selection Assessment
Heathrow - north-west runway

1. Introduction

1.1 Purpose

This Sustainable Drainage System (SuDS) selection assessment forms an appendix to the sustainable drainage report for the north-west runway project at Heathrow. This Technical note is Appendix C of the Sustainable Drainage Technical Report (AMEC 2014).

This SuDS selection assessment provides a high level assessment of the different SuDS techniques and solutions which may or may not provide appropriate techniques for accommodating and treating the surface runoff from the north-west runway project.

The assessment addresses the quality, quantity and amenity impact on the future development proposals as well as the opportunity to combine various SuDS techniques to produce a recognised management/treatment train solution.

As highlighted in the Sustainable Drainage Technical Report (AMEC, 2014), the treatment of surface water run-off contaminated with de-icers such as glycol is a primary consideration for the SuDS strategy because of the potential impacts to water quality, and therefore the aquatic environment. One of the key requirements of the proposed SuDS strategy is therefore to treat the glycol-contaminated surface water run-off in a sustainable manner.

This is not an engineering design statement.

1.2 SuDS Options

This SuDS selection process is based on the guidance given in the SuDS manual produced by CIRIA C697 dated 2007.

The Manual identifies the following SuDS techniques for consideration:

Table 1.1 SuDS Options

SuDS Group	SuDS Technique
Retention	Retention Pond
	Subsurface Storage
Wetland	Shallow wetland
	Extended detention wetland
	Pond/wetland
	Pocket wetland
	Submerged gravel wetland
	Wetland channel
Infiltration	Infiltration basin
	Infiltration trench
	Soakaway
Filtration	Surface sand filter
	Sub surface sand filter
	Perimeter sand filter
	Bio-retention / filter strip
	Filter trench
Detention	Detention Basin
Open channels	Conveyance swale
	Enhanced dry swale
	Enhanced wet swale
Source Control	Green roof
	Rain water harvesting
	Pervious pavements

Source: Table 5.2 of the SuDS Manual (CIRIA, 2007).

2. SuDS Assessment Parameters

2.1 Introduction

An understanding of the key parameters of the site conditions is required so that the most appropriate techniques can be selected. The SuDS manual identifies five key selection criteria for assessing the suitability of SuDS techniques:

- land use characteristics;
- site characteristics;
- catchment characteristics;
- quantity and quality performance requirements; and
- amenity and environmental requirements.

In addition to these standard criteria, additional considerations are relevant to airports:

- wildlife/birdstrike implications;
- aircraft safety;
- contaminants requiring specialised treatment techniques;
- the presence of frequent heavy vehicles.

The constraints related to these selection criteria are discussed in the sections below.

2.2 Assessment parameters – landside

The selection assessment parameters for most SuDS systems are, from the Airports Commission's perspective, generally applicable to 'landside' developments. That is, as opposed to 'airside' areas, *i.e.* beyond border control and/or areas frequented by aircraft. Additional selection parameters apply for 'airside' areas, as discussed further in Section 2.3, but in the first instance the 'landside' parameters were considered. The key assessment parameters used to determine the most appropriate SuDS techniques for landside areas are shown in Table 2.1.

Table 2.1 Assessment parameters

Parameter	Comments	Reference
Proposed Land use	International Airport, including a new runway, terminals, movement areas, stands, car parking and ancillary land uses.	
Topography	Generally flat lying. The topography of the site will be re-graded as required for the proposed use of the site, including drainage requirements. Site slopes are currently between 0 and 5%. Available head varies across the site, with several metres difference between the highest and lowest areas of the site.	
Area of catchment	The main airport sub-catchment, which in the most part is covered by 'airside' areas, covers approximately 390ha. It is anticipated that approximately 48% of this will be covered in impermeable ground cover. Excluding the terminal buildings the area is reduced to approximately 380ha, of which approximately 45% will be impermeable.	
Soil type	There are areas of made ground associated with gravel extraction and subsequent landfilling. The natural geology comprises shallow river terrace deposits known as the Taplow Gravels (3 to 6m thick), underlain by the London Clay Formation, of over 50m in thickness.	
Permeability	The Taplow Gravels are highly permeable and range from 3 to 6m thick. For the purpose of SuDS selection, the London Clay Formation can be considered to be impermeable.	
Depth to water table	The groundwater levels in the gravels are usually shallow and within 2m of the ground surface (AMEC, 2014). Further investigation would be required to confirm whether groundwater is within 1m of the surface locally. Below the shallow gravel aquifer is the London Clay Formation, which is generally regarded to be an aquitard, i.e. a geological body within which groundwater has little influence. Limited site data has currently been made available.	
Former land use	Parts of the north-west runway project site are occupied by landfill sites, including the eastern end of the runway. Previous investigations have highlighted areas of groundwater and land surface contamination within the existing Heathrow airport. There are a number of other potentially contaminated areas within the wider Colne Valley associated with historic gravel abstraction and subsequent landfilling. There are also known pollution incidents to land and groundwater which have the potential to pose ongoing sources of contamination. Further investigation will be required to confirm the land and groundwater quality.	
Receiving water sensitivity	Groundwater: parts of the site are underlain by a Principal aquifer and a Secondary A aquifer, both of which are related to the superficial deposits. Much of the site is not underlain by an aquifer. The underlying solid geology, comprising the London Clay Formation, is classified as a non-aquifer. There are no groundwater Source Protection Zones (SPZs) at the site, however, there are a number of local abstractions and watercourses fed by groundwater in the vicinity of the site. Therefore, groundwater is considered to have a moderate to high sensitivity. Surface water sensitivity has been assessed as moderate to high due to the presence of a number of watercourses that pass through or in the vicinity of the site.	
Environmental sensitivity of site	There are no ecological designations on-site (SSSI, SACs, SPA, etc). The Staines Moor SSSI is located downstream of the site (on the River Colne) and the South West London SPA is in the vicinity too, the nearest of which are the Wraysbury Reservoir to the south west (west of the M25), King George VI and Staines Reservoir to the south (east of M25).	
Available space for SuDS	There is a large amount of space in the proposed north-west runway masterplan, but little of it is available for surface SuDS due the requirements associated with aircraft safety, as discussed further below. Beyond the boundary of the proposed masterplan space greater potential space for SuDS is available but in the context of the overall size of the airport it is still fairly.	

2.3 Assessment Parameters – on the airfield

The additional considerations of relevance to airports are discussed in Table 2.2 below:

Table 2.2 Assessment parameters – airport related

Parameter	Comments	Reference
Wildlife/birdstrike	The minimisation of wildlife-aircraft interactions is of paramount concern at all airports. Wildlife and birds present a safety risk to aircraft and passenger safety and so features that can exacerbate the risk of wildlife/bird strike must be avoided. Even at sites where wildlife is not present under existing conditions, nearby or migratory wildlife could be attracted by new SuDS features that are inappropriately designed.	
Aircraft safety	A clear graded area is required at all airports around the runways and taxiways for aircraft safety.	
Contaminants requiring specialised treatment techniques	Surface run-off from all airports is likely to contain contaminants associated with airside operations. In cold and temperate climates this is likely to include de-icing chemicals, such as glycol. Treatment of such chemicals is necessary prior to discharge, necessitating collection and treatment in dedicated facilities that provide the necessary conditions for treatment and residence times.	
Heavy vehicles	The airside areas of all airports are frequented by heavy vehicles, including aircraft. Ground cover is required to withstand frequent use by such vehicles without requiring too frequent maintenance.	

2.3.1 Latest CIRIA advice on aircraft safety

As advised in the early release materials for the SuDS Manual update (CIRIA, 2014), arrangements for airport safeguarding are explained in ODPM Circular 1/2003 which includes the text of the Town and Country Planning (Safeguarded Aerodromes, Technical Sites and Military Explosives Storage Areas) Direction 2002 (ODPM, 2003). In all cases, aerodrome safeguarding responsibility rests with the aerodrome licence holder/operator, not the Civil Aviation Authority (CAA). The CAA does however have a role in providing relevant aviation safety advice upon request. The latest CIRIA advice (CIRIA, 2014) states:

"The CAA has identified SuDS features, in particular ponds, wetlands and green roofs, as a potential hazard to aircraft. Although the main concern is wildfowl, including flocks of ducks, geese and swans, there is also concern about other flocking species such as rooks, starlings and gulls. Further advice is provided in Safeguarding of Aerodromes, Advice Note 6 published by the Airport Operators Association (2006)."

"The risk to aircraft can be mitigated by good ecological design including:

- *Long grass rather than short grass preferred by geese*
- *Small pools and ponds with edges accessible by predators such as foxes*

- *Planting design to reduce the risk of roosting by birds in large numbers."*

"The use of certain SuDS features near to aerodromes will also depend on the site specific circumstances such as location relative to the aerodrome and location of other features in the area that are attractive to birds. This is a complex subject and specialists in bird strike prevention and safeguarding aerodromes should be consulted. Smaller open features such as rills, small canals (channels), small swales and small shallow ponds are not likely to attract birds any more than a garden pond or lawn."

3. Treatment train components required

The design of a SuDS scheme will normally require the use of two or more techniques that are linked together. Each technique will perform uniquely with regard to water quality treatment and storm water attenuation. To achieve the best results, treatment trains should be combined to form a SuDS management train. The number of treatment trains needed for the runoff catchment characteristic of any particular site is provided in Table 3.1 below.

Table 3.1 Number of treatment train components required

	Receiving water sensitivity		
Runoff catchment characteristic	**Low**	**Medium**	**High**
Roofs only	1	1	1
Residential roads, parking areas, commercial zones	2	2	3
Refuse collection/ industrial areas/ loading bays/ lorry parks/ highways	3	**3**	**4**

Source: Table 5.6 of the SuDS Manual

The number of treatment trains needed is likely to be three, associated with the nature of the airside operations, which include de-icing, and a moderately sensitive water receptor, as identified in Table 2.1.

In practice, unlike the majority of SuDS systems, discharges from the SuDS system for the north-west runway will be monitored in line with the conditions of the environmental permit (details of which will be confirmed in due course). As a result, the likely number of treatment stages indicated in Table 3.1 is only indicative (for the purposes of this SuDS selection assessment) at this stage because a bespoke system will be designed to ensure that all the necessary treatment is provided before discharge.

4. Identification of Possible SuDS Techniques

A preliminary assessment of the possible SuDS techniques that could be employed at the site has been carried out as shown in Table 4.1, based on the key assessment parameters identified in Table 2.1 and Table 2.2 above. Techniques in Table 4.1 that achieve 'Y's are likely to be most appropriate.

Table 4.1 has been split into two sections, with the landside considerations (as informed by Table 5.4 of the SuDS Manual) listed on the left-hand side of table, and the airfield considerations on the right. Finally, conclusions are presented in the final column, which focuses on determining which techniques are potentially appropriate and where (landside and/or on the airfield).

Table 4.1 Site characteristics selection matrix (landside criteria based on Table 5.4 of the SuDs Manual)

SuDS group	Technique	Landside parameters												Landside assessment conclusion	Airfield parameters				Airside assessment conclusion	AMEC overall conclusions
		Soils		Area draining to a single SuDS component		Minimum depth to water table		Site slope		Available head		Available space			Wildlife/ birdstrike	Aircraft safety	Contaminants requiring specialised treatment techniques	Heavy vehicles		
		Impermeable	Permeable	0 - 2 ha	>2ha	0-1m	> 1m	0-5 %	>5%	0 to 1m	1 – 2m	Low	High	Suitability	Acceptable risk	Suitable within clear graded area around runways and taxiways	Treatment of glycol	Suitable for use by heavy vehicles	**Suitability**	SuDS potential for the north-west runway
Retention	Retention pond	Y	Y[1]	Y	Y[5]	Y	Y	Y	Y	Y	Y	N	Y	Y[9]	N[10]	N	Y[11]	N	Unsuitable in airside areas	Yes, used for the existing airport. Ponds will need to be located in landside areas. Wildlife netting and additional treatment techniques may be required.
	Subsurface Storage	Y	Y	Y	Y[5]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Suitable for attenuation storage	Yes, in both airside and landside areas, but only for attenuation storage (no quality treatment function)
Wetland	Shallow Wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	Y	N	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
	Extended detention wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	Y	N	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
	Pond/wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	Y	N	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
	Pocket Wetland	Y[2]	Y[4]	Y[4]	N	Y[2]	Y[2]	Y	N	Y	Y	Y	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
	Submerged gravel wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	Y	N	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
	Wetland Channel	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	Y	N	Y	Y	N[10]	N	Y	N	Unsuitable in airside areas	Yes, suitable treatment if located in landside areas
Infiltration	Infiltration trench	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	N[8]	N[8]	N[8]	N[8]	N[8]	Likely unsuitable due to groundwater risks	No, due to potential groundwater risks
	Infiltration basin	N	Y	Y	Y[5]	N	Y	Y	Y	Y	N	N	Y	N[8]	N[8]	N[8]	N[8]	N[8]	Likely unsuitable due to groundwater risks	No, due to potential groundwater risks
	Soakaway	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	N[8]	N[8]	N[8]	N[8]	N[8]	Likely unsuitable due to groundwater risks	No, due to potential groundwater risks

Filtration	Surface sand filter	Y	Y	Y	Y[5]	N	Y	Y	N	N	Y	N	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Unlikely to be suitable for glycol treatment or conveyance
	Sub surface sand filter	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Unlikely to be suitable for glycol treatment or conveyance
	Perimeter sand filter	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Unlikely to be suitable for glycol treatment or conveyance
	Bio-retention/ filter strip	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Unlikely to be suitable for glycol treatment or conveyance
	Filter trench	Y	Y[1]	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Unlikely to be suitable for glycol treatment or conveyance
Detention	Detention basin	Y	Y[1]	Y	Y[5]	N	Y	Y	Y	N	Y	N	Y	Y	Y	N	N	N	Unsuitable in airside areas	Yes, if located in landside areas, but only for attenuation storage during extreme events
Open channels	Conveyance swale	Y	Y	Y	N	N	Y	Y	N[3]	Y	N	N	Y	Y	Y	N	N	N	Unsuitable for glycol treatment or conveyance	Potentially suitable in landside areas for conveyance of low concentration glycol run-off
	Enhanced dry swale	Y	Y	Y	N	N	Y	Y	N[3]	Y	N	N	Y	Y	N	N	N	N	Unsuitable for glycol treatment or conveyance	No, due to potential to attract wildlife
	Enhanced wet swale	Y[2]	Y[4]	Y	N	Y	Y	Y	N[3]	Y	N	N	Y	Y	N[10]	N	N	N	Unsuitable for glycol treatment or conveyance	No, due to potential to attract wildlife
Source control	Green roof	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N/A	N/A	N/A	Unsuitable - potential to attract wildlife	No, due to potential to attract wildlife
	Rain water harvesting	Y	Y	Y	N	Y	Y	Y	Y	Y			Y	Y	Y	N/A	N/A	N/A	Suitable	Yes, in both airside and landside areas
	Pervious pavements	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	Unsuitable for glycol treatment or conveyance. Also unsuitable for sustained and frequent use by heavy vehicles	No, due to heavy vehicles and presence of glycol

Notes
(1) with liner
(2) with surface base flow
(3) unless follows contours
(4) with linear and constant base flow or high ground water table
(5) possible but not recommended (implies appropriate management train not in place)
(6) where high flows are diverted around SuDS component
(7) further on site investigation may be needed to prove soakaways will work

As indicated in Table 4.1, a variety of SuDS techniques may be appropriate in various areas of the site. The majority of techniques are unlikely to be appropriate within the airfield (only sub-surface storage and rainwater harvesting have been identified as being completely appropriate on the airfield), but a number of other techniques would be appropriate in nearby landside areas if surface water run-off could be conveyed to these areas effectively.

At this stage, it is considered unlikely that infiltration and/or filtration techniques would be suitable due to the potential for shallow groundwater and existing contamination within the underlying ground. The surface water run-off from the airfield may contain high concentrations of contaminants, such as de-icers (e.g. glycol), which require careful treatment process prior to any type of discharge, including infiltration. Seasonality in groundwater levels should also be considered. The potential for infiltration could be investigated further at the detailed application stage, but for such techniques have been omitted from the SuDS selection process in order to demonstrate that a suitable SuDS solution could be achieved if infiltration was not possible.

SuDS devices that provide treatment at source (such as filter strips) are considered unlikely to be capable of providing the level of treatment (or conveyance) necessary to deal with glycol contaminated run-off and are unlikely to be suitable in clear graded areas or in areas frequented by heavy vehicles such as aircraft. Similarly, permeable paving is not considered appropriate on the airfield.

4.1 Quality and quantity treatment

The SuDS techniques identified in Table 4.1 were then considered with respect to their quantity (hydraulic control) treatment performance and then separately their quality treatment performance, as indicated in Table 4.2 and Table 4.3.

4.1.1 Quality

As discussed previously, quality treatment potential is a key consideration in the SuDS selection process for an airfield in which the use of de-icers is widespread. The system will need to be capable of removing dissolved glycol from the surface water, which is usually achieved by degradation by naturally occurring bacteria, and subsequent restoration of dissolved oxygen levels following the biological oxygen depletion caused by aforementioned bacteria. As indicated in Table 4.2 sub-surface storage, detention basins and rainwater harvesting do not provide the necessary quality treatment function. The bacteria which remove glycol from the water colonise the surfaces of submerged plant roots. Reed beds have been identified as the most appropriate technique. Table 5.7 of the SuDS manual (reproduced in Table 4,2 below) does not have a ‘Glycol removal’ category, but for the purpose of this assessment the ‘nutrient removal’ has been used as a proxy.

Table 4.2 Quality treatment performance selection table (Based on Table 5.7 of the SuDS Manual)

SuDS Group	Technique	Total suspended solids removal	Heavy metals removal	Nutrient removal e.g. (phosphorous, nitrogen) removal	Bacteria removal	Capacity to treat fine suspended sediments and dissolved pollutants
Retention	Retention pond	High	Medium	Medium	Medium	High
	~~Sub-surface Storage~~	~~Low~~	~~Low~~	~~Low~~	~~Low~~	~~Low~~
Wetland	Shallow Wetland	High	Medium	High	Medium	High
	Extended detention wetland	High	Medium	High	Medium	High
	Pond/wetland	High	Medium	High	Medium	High
	Pocket Wetland	High	Medium	High	Medium	High
	Submerged gravel wetland	High	Medium	High	Medium	High
	Wetland Channel	High	Medium	High	Medium	High
~~Detention~~	~~Detention basin~~	~~Medium~~	~~Medium~~	~~Low~~	~~Low~~	~~Low~~
Open channels	Conveyance swale	High	Medium	Medium	Medium	High
~~Source control~~	~~Rainwater harvesting~~	~~Medium~~	~~Low~~	~~Low~~	~~Low~~	~~n/a~~

n/a = not applicable, High = High potential, Medium = Medium potential, Low = Low potential

4.1.2 Quantity

Quantity control is a key consideration at the airfield, to provide sufficient storage such that discharges from the airfield can be returned to greenfield rates. As indicated in Table 4.3, all of the potential SuDS techniques identified in Table 4.1 can perform a quantity control function, but only retention ponds, sub-surface storage, detention basins, conveyance swales and oversized rainwater harvesting systems can provide the hydraulic control necessary to attenuate the 1% AEP (100 year return period) rainfall event. Rainwater harvesting and conveyance swales have medium potential to reduce run-off volumes.

Table 4.3 Quantity (hydraulic control) treatment performance selection table (Based on Table 5.7 of the SuDS Manual)

SuDS Group	Technique	Runoff volume reduction	Suitability for flow rate control (return period event)		
			1/2 Year	**10/30 year**	**100 Year**
Retention	Retention pond	Low	High	High	High
	Subsurface Storage	Low	High	High	High
~~Wetland~~	~~Shallow Wetland~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
	~~Extended detention wetland~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
	~~Pond/wetland~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
	~~Pocket Wetland~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
	~~Submerged gravel wetland~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
	~~Wetland Channel~~	~~Low~~	~~High~~	~~Medium~~	~~Low~~
Detention	Detention basin	Low	High	High	High
Open channels	Conveyance swale	Medium	High	High	High
Source control	Rain water harvesting	Medium	Medium	High	Low/High[1]

High = High potential, Medium = Medium potential, Low = Low potential

[1] Rainwater harvesting systems can be oversized so as to provide stormwater storage. In such cases the suitability for flow rate control would be high (BS, 2009).

4.1.3 Quality and quantity treatment conclusions

It is clear from Table 4.2 and Table 4.3 that the most appropriate SuDS system will include a management train whereby quantity (hydraulic control) treatment is provided by one technique, such as a retention pond, sub-surface storage and/or an oversized rainwater harvesting system, and the quality treatment (to deal with the glycol contamination) is dealt with in an engineered wetland. Retention ponds and conveyance swales could also provide a treatment function, but have less potential for nutrient removal than wetlands and so are less appropriate.

4.2 Ecological and amenity benefits

For the main airport sub-catchment, the amenity and environmental/ecological benefits are of lesser importance. Due to the requirement to minimise how attractive the system will be to wildlife, the most appropriate SuDS techniques will actually be those that provide the least ecological benefits. When this is considered with due regards for the need to treat glycol-contaminated surface water run-off, which impacts biological oxygen demand and thus the ecological potential of any SuDS device, then isolation of the highest concentrations of contaminated run-off from the wider ecological system is likely to be beneficial. Similarly, the

SuDS solution will not be accessible to public and therefore amenity benefits will not factor into the selection assessment process either.

As indicated in Table 4.4, each of the potential techniques that could provide the quality treatment required (retention ponds, wetlands and conveyance swales), provide either medium or high habitat creation potential and therefore measures may be required in order to minimise their attractiveness to wildlife, such as netting. Table 4.4 also indicates that, of the potential techniques that could provide the quantity treatment required (retention ponds, sub-surface storage, detention basins, conveyance swales and rainwater harvesting), sub-surface storage and rainwater harvesting are the most appropriate owing to their limited ability for habitat creation, *i.e.* low risk of attracting wildlife. Sub-surface storage also requires low maintenance.

Table 4.4 Community and Environmental Factors (Based on Table 5.9 of the SuDS Manual)

SuDS Group	Technique	Maintenance	Community acceptability	Cost	Habitat creation potential
Retention Pond	Retention pond	Medium	High	Medium	High
	Subsurface Storage	Low	High	Medium	Low
Wetland	Shallow Wetland	High	High	High	High
	Extended detention wetland	High	High	High	High
	Pond/wetland	High	High	High	High
	Pocket Wetland	High	Medium	High	High
	Submerged gravel wetland	Medium	Low	High	Medium
	Wetland channel	High	High	High	High
Detention	Detention basin	Low	High	Low	Medium
Open channels	Conveyance swale	Low	Medium	Low	Medium
Source control	Rain water harvesting	High	Medium	High	Low

High = High potential, Medium = Medium potential, Low = Low potential

5. Possible SuDS Solutions

Based on the selection process provided in Table 4.1, Table 4.3 and Table 4.4 the most appropriate SuDS solutions for hydraulic control are:

- Retention ponds;
- Sub-surface storage;
- Detention basins;

- Conveyance swales; and
- An oversized rainwater harvesting system.

These could be supplemented by additional quantity control provided in a wetland.

Owing to its capacity to be located within the airfield, minimal land take requirements (because it can be located underneath another land use) and inherent lack of attractiveness to wildlife, sub-surface storage is considered to present the most appropriate hydraulic control technique within the airfield.

Based on the selection process provided in Table 4.1, Table 4.2 and Table 4.4, the most appropriate SuDS solutions for quality control are:

- Retention ponds (medium potential for nutrient removal);
- Wetlands (high potential for nutrient removal and glycol removal); and
- Conveyance swales (medium potential for nutrient removal).

None of these are appropriate within the airfield. As a result, it is unlikely that significant lengths of conveyance swales will be appropriate – conveyance of surface water run-off from the airfield to an off-site (landside) treatment location would be better served by an underground system that has minimal land take requirements, can be traversed by heavy vehicles, is appropriate in clear graded areas and has a very low potential to attract wildlife.

A wetland is considered to be the most appropriate treatment solution. It provides that greatest capacity for nutrient removal and with recent advances in engineered wetland technology, is considered a more sustainable solution for treating glycol than retention ponds which require further techniques such as aeration to ensure that the dissolved oxygen concentrations are returned to acceptable levels suitable for discharge. It would be possible to design a wetland that provided distinct treatment stages, such that the treatment train requirements detailed in Section 3 are met.

Table 5.1 summarises the selected SuDS solution in terms of its effectiveness and practicality.

Table 5.1 Selected SuDS solution

SuDS Group	SuDS technique	Suitability and benefits
Retention	Sub-surface storage	Very good. Sub-surface storage can be provided within the airfield. This minimises the risk of the conveyance system from being exceeded. Minimal land take and minimal attractiveness to wildlife. Low maintenance cost. No water quality treatment benefits, but by using optical instruments, it will be possible to separate highly contaminated run-off (first flush) from 'clean' run-off and store this separately, providing greater control over subsequent treatment stages, whilst ensuring that the total volume of the tank remains available during the most extreme events.
Wetland	Various wetland techniques	Very good. A wetland located downstream of the sub-surface storage (which would have already provided the quantity control) in a landside area would be appropriate. Treatment potential is high and there is also the potential for further quantity control if required. Measures to ensure the wetland would not be attractive to wildlife may be required, such as netting.
Source Control	Rainwater Harvesting	Good. A system can be installed where rainwater is reused within the building for toilet flushing etc, thus reducing the water demand of the airport. Requires minimal space, minimal attractiveness to wildlife and can be oversized so as to provide stormwater storage capacity.
N/A	Piped system	A piped system is proposed to convey water around the SuDS system. A piped system will have minimal attractiveness to wildlife and will be capable of conveying the 'first flush' to the underground storage tanks for separation efficiently and effectively. A piped system can be located throughout the airfield, including within clear graded areas, with minimal land take and low maintenance.
N/A	Perimeter drain	To account for the use of a piped system, the capacity of which could be exceeded during the most intense rainfall events, a means by which surface water could be captured is necessary. A conveyance swale around the perimeter of the airfield could serve this purpose, but as advised by HAL, land take along the perimeter would be an issue. A hard engineered perimeter drain would serve this purpose and could be more appropriate owning to its minimal attractiveness to wildlife and capacity to convey any contaminated run-off to the sub-surface storage tanks efficiently (thus allowing the first flush to be captured separately to clean flows).

6. Alternatives

6.1 Treatment techniques

As discussed previously, the treatment of glycol contaminated surface water run-off was a primary consideration when determining the SuDS strategy for the north-west runway because of the potential impacts to water quality, and therefore the aquatic environment. There are a number of potential treatment techniques that can used to mitigate against the presence of de-icers such as glycol in the surface water run-off and return concentrations of dissolved oxygen to acceptable levels required for discharge.

Potential alternatives available for treating glycol-contaminated surface water run-off include:

- atmospheric aeration/oxygenation;
- package treatment works;
- chemical treatment;
- oxygen injection; and
- discharge to a third party (water company) sewage treatment works.

The ongoing operational expenditure costs associated with each of the above techniques is a recurring factor for why they are not as sustainable as a wetland. Of the above potential techniques, only atmospheric aeration could be considered to be feasibly sustainable on cost grounds. Atmospheric aeration is already used in the existing ponds/lakes at Heathrow, using either propellers to mix the water (high energy/electricity usage) and/or diffusers to turn over the water column. Both aeration techniques suffer from residence time unknowns, particularly during the key winter periods for de-icing, generally associated with the temperature dependence of the bacteria within the water. Aeration using diffusers is likely to be the most sustainable option of the two, but would likely require longer residence times and a greater land take than is likely to be required for a wetland.

7. Conclusions

A SuDS solution involving a sub-surface storage (quantity control) and a wetland (quality control), combined with rainwater harvesting (water re-use and quantity control) has been identified as the most appropriate SuDS solution. This will be served by a piped drainage system (which is appropriate across the airfield and will help to separate first flush flows from cleaner flows) and a perimeter drain to capture exceedance events.

Such a solution would provide the necessary stormwater attenuation requirements, as many treatment stages as required to meet the conditions of the environmental permit (within the wetland), and would provide the airfield with a sustainable, cost effective solution that is unlikely to present significant problems with respect to attracting wildlife (bird strike).

8. References

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Appendix D
Rainwater Harvesting Assessment

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.459	0.459	38.8	0.0	38.8	4223.3	O K
30 min Summer	0.524	0.524	38.8	0.0	38.8	4825.2	O K
60 min Summer	0.597	0.597	38.8	0.0	38.8	5496.0	O K
120 min Summer	0.677	0.677	38.8	0.0	38.8	6226.4	O K
180 min Summer	0.725	0.725	39.9	0.0	39.9	6666.1	Flood Risk
240 min Summer	0.758	0.758	40.8	0.0	40.8	6975.2	Flood Risk
360 min Summer	0.803	0.803	41.9	0.0	41.9	7389.3	Flood Risk
480 min Summer	0.832	0.832	42.7	0.0	42.7	7651.8	Flood Risk
600 min Summer	0.851	0.851	43.2	0.0	43.2	7825.6	Flood Risk
720 min Summer	0.863	0.863	43.5	0.0	43.5	7941.1	Flood Risk
960 min Summer	0.874	0.874	43.7	0.0	43.7	8037.2	Flood Risk
1440 min Summer	0.869	0.869	43.6	0.0	43.6	7995.4	Flood Risk
2160 min Summer	0.855	0.855	43.3	0.0	43.3	7862.6	Flood Risk
2880 min Summer	0.837	0.837	42.8	0.0	42.8	7699.2	Flood Risk
4320 min Summer	0.768	0.768	41.0	0.0	41.0	7065.2	Flood Risk
5760 min Summer	0.705	0.705	39.4	0.0	39.4	6482.3	Flood Risk
7200 min Summer	0.646	0.646	38.8	0.0	38.8	5941.9	O K
8640 min Summer	0.591	0.591	38.8	0.0	38.8	5437.5	O K
10080 min Summer	0.539	0.539	38.8	0.0	38.8	4954.8	O K
15 min Winter	0.515	0.515	38.8	0.0	38.8	4733.5	O K
30 min Winter	0.588	0.588	38.8	0.0	38.8	5409.9	O K
60 min Winter	0.670	0.670	38.8	0.0	38.8	6163.6	O K
120 min Winter	0.759	0.759	40.8	0.0	40.8	6984.6	Flood Risk

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	194.105	0.0	27
30 min Summer	111.206	0.0	41
60 min Summer	63.712	0.0	72
120 min Summer	36.501	0.0	130
180 min Summer	26.351	0.0	190
240 min Summer	20.912	0.0	248
360 min Summer	15.097	0.0	368
480 min Summer	11.981	0.0	486
600 min Summer	10.014	0.0	606
720 min Summer	8.649	0.0	724
960 min Summer	6.848	0.0	962
1440 min Summer	4.928	0.0	1318
2160 min Summer	3.546	0.0	1668
2880 min Summer	2.808	0.0	2052
4320 min Summer	1.963	0.0	2860
5760 min Summer	1.523	0.0	3688
7200 min Summer	1.251	0.0	4480
8640 min Summer	1.065	0.0	5280
10080 min Summer	0.929	0.0	6056
15 min Winter	194.105	0.0	27
30 min Winter	111.206	0.0	41
60 min Winter	63.712	0.0	70
120 min Winter	36.501	0.0	128

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
180 min Winter	0.813	0.813	42.2	0.0	42.2	7482.2	Flood Risk
240 min Winter	0.851	0.851	43.2	0.0	43.2	7833.4	Flood Risk
360 min Winter	0.903	0.903	44.5	0.0	44.5	8308.3	Flood Risk
480 min Winter	0.936	0.936	45.3	0.0	45.3	8614.4	Flood Risk
600 min Winter	0.959	0.959	45.8	0.0	45.8	8822.1	Flood Risk
720 min Winter	0.974	0.974	46.2	0.0	46.2	8965.1	Flood Risk
960 min Winter	0.990	0.990	46.5	0.0	46.5	9103.5	Flood Risk
1440 min Winter	0.991	0.991	46.6	0.0	46.6	9113.1	Flood Risk
2160 min Winter	0.965	0.965	46.0	0.0	46.0	8877.1	Flood Risk
2880 min Winter	0.940	0.940	45.4	0.0	45.4	8647.7	Flood Risk
4320 min Winter	0.846	0.846	43.0	0.0	43.0	7786.9	Flood Risk
5760 min Winter	0.758	0.758	40.8	0.0	40.8	6975.8	Flood Risk
7200 min Winter	0.676	0.676	38.8	0.0	38.8	6221.0	O K
8640 min Winter	0.598	0.598	38.8	0.0	38.8	5503.9	O K
10080 min Winter	0.521	0.521	38.8	0.0	38.8	4793.9	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
180 min Winter	26.351	0.0	186
240 min Winter	20.912	0.0	244
360 min Winter	15.097	0.0	362
480 min Winter	11.981	0.0	478
600 min Winter	10.014	0.0	594
720 min Winter	8.649	0.0	708
960 min Winter	6.848	0.0	936
1440 min Winter	4.928	0.0	1372
2160 min Winter	3.546	0.0	1736
2880 min Winter	2.808	0.0	2192
4320 min Winter	1.963	0.0	3112
5760 min Winter	1.523	0.0	3984
7200 min Winter	1.251	0.0	4832
8640 min Winter	1.065	0.0	5704
10080 min Winter	0.929	0.0	6456

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 504950 177000 TQ 04950 77000
C (1km)	-0.026
D1 (1km)	0.316
D2 (1km)	0.308
D3 (1km)	0.237
E (1km)	0.305
F (1km)	2.569
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time / Area Diagram

Total Area (ha) 11.700

Time (mins)	**Area (ha)**	**Time (mins)**	**Area (ha)**	**Time (mins)**	**Area (ha)**
0-4	4.100	4-8	4.100	8-12	3.500