Appendix 12A
Flood Risk Assessment

Bristol Airport Limited

Flood Risk Assessment

Wood Environment & Infrastructure Solutions UK Limited – December 2018

Report for

Bristol Airport Ltd

Main contributors

Chris Grange
Richard Breakspear

Issued by

....
Chris Grange

Approved by

....
Richard Breakspear

Wood

Redcliff Quay
120 Redcliff Street
Bristol BS1 6HU
United Kingdom
Tel +44 (0)117 317 8950

Doc Ref. 40506r013i1

h:\projects\40506 bristol airport interim planning and eia support\eia\es\12 surface water and flood risk\fra\40506_r013i1_fra.docx

Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with the management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

Document revisions

No.	Details	Date
1	First Complete Internal Draft	03/10/18
2	Draft Final Version for client	10/11/18
2	Final Version	13/11/18

Executive Summary

Purpose of this report

This report has been produced for the purpose of presenting a Flood Risk Assessment (FRA) undertaken by Wood Environment and Infrastructure Solutions UK Limited (Wood) to support the Proposed Development to expand Bristol Airport to a capacity of 12 million passengers per annum (mppa), on behalf of Bristol Airport Limited (BAL). This FRA has been prepared to support the planning application for the Proposed Development. The FRA reviews available hydrological and flood risk information against the development proposals to ensure that the design is acceptable in terms of the requirements of the *National Planning Policy Framework* (NPPF).

Development proposals

The Proposed Development includes the following elements, which are considered in this FRA:

- Northside - expansion of the existing terminal building and associated new service yard, construction of a gyratory road with internal surface car parking, and a new multi-storey car park;
- Airside - widening of taxiways and fillets;
- Southside - extension to the Silver Zone Car Park phase 2; and
- Improvements to the A38 between West Lane and the Bristol Airport's northern access roundabout.

Development components such as changes to flight restrictions, seasonal usage of the Silver Zone Car Park, removal of restrictions on aircraft stands 38 and 39 are not assessed on the basis that they have no hydrological implications. The proposed new east pier and walkway is not assessed on the basis that it will cross above existing impermeable surfaces.

Flood risk

The application site has been demonstrated to be situated within Environment Agency Flood Zone 1. All development will therefore be located within Flood Zone 1. The location meets the aims of the NPPF Sequential Test. An assessment of tidal, fluvial, artificial and groundwater flood risk has shown that the application site is at a very low to low risk of flooding from these sources. The majority of the application site is also shown to be at very low risk of surface water flooding. However, several areas of the application site are at risk of surface water flooding, with both ponded areas and pathways being shown as being at low, medium and high risk.

Drainage design

Suitable drainage systems (SuDS), incorporating SuDS principles have been designed to support both the elements of the Proposed Development located at Bristol Airport and the adjacent A38 highways improvements (refer to Section 4). All runoff will be managed on-site via infiltration. This will ensure that the Proposed Development mimics the natural hydrological cycle as closely as possible, and runoff rates leaving the application site are kept at or below greenfield rates and volumes. These have been designed to the 1% Annual Exceedance Probability (AEP) + a climate change allowance event as required by NPPF. The Proposed Development's drainage design will also include suitable measures for the management of water quality and exceedance flows. For several elements of the Proposed Development, the new drainage systems will result in betterment over existing where the drainage of existing impermeable areas is intercepted and directed to new infiltration features constructed to the current 1% AEP + climate change allowance design standard. The drainage system designs are considered to comply with the guidance provided by *CIRIA SUSDRAIN*, *CIRIA C753*, and the *West of England Sustainable Drainage Developer Guide*. Appropriate detail has been incorporated in the designs commensurate with the type of planning permission sought (outline). Full details are provided in the associated Drainage Strategies (refer Appendix D for the Bristol Airport part of the application site, and Appendix E for the A38 part of the application site).

A suitable foul drainage system (refer to Appendix D) has been designed with the required capacity to meet the expected foul flows associated with the growth of Bristol Airport. Agreement has been reached with Wessex Water with regards to the discharge rates.

Incorporated flood risk mitigations

Appropriate design mitigations have been identified (refer to Section 5) for the components of the Proposed Development that interact with areas of surface water flood risk. All runoff from the Proposed Development will be managed within the application site for rainfall events up to the design event. This will ensure the risk to existing off-site development is not increased. For the Proposed Development itself, the specified measures include the raising of ground floor levels (by 300mm above local ground level), local profiling of ground levels and the incorporation of exceedance flow pathways in the design to manage surface water flooding or drainage exceedance within the application site. Incorporation of these measures will ensure that flood risk from this source is appropriately managed.

Conclusions and recommendations

With the incorporation of these measures flood risk will be suitably managed both on and off the application site, both currently and with future climate change in-line with the requirements of NPPF and relevant good practice guidance.

Contents

wood.

1. Introduction

1.1 Context

1.1.1 Wood Environment and Infrastructure Solutions UK Ltd (hereafter referred to as Wood) has been commissioned by Bristol Airport Limited (hereafter referred to as BAL) to undertake a Flood Risk Assessment (FRA) to support a planning application for development at Bristol Airport (the 'Proposed Development'). The application site includes the current operational airport (i.e. existing buildings and hardstanding), and new areas of development on adjacent greenfield land. Improvements to the A38 to the northeast of Bristol Airport are also included in the scheme.

1.1.2 A Master Plan for the Proposed Development is included in Appendix A. The FRA has been prepared following consultation with North Somerset Council (NSC) as Lead Local Flood Authority (LLFA) (Appendix B). Due to the strategic nature of the development, the Environment Agency (EA) have also been consulted, with regards to disposal of surface water via infiltration and the risk to aquifers (Appendix C). A Drainage Strategy (DS) for the Proposed Development at Bristol Airport has been prepared by Hydrock and is included in Appendix D. A separate DS has been prepared for the proposed A38 highway improvements by C-TAS, included at Appendix E.

1.1.3 The EA Flood Map for Planning[1] classifies the whole of the Bristol Airport part of the application site as Flood Zone 1 (less than 0.1% Annual Exceedance Probability (AEP)).

1.1.4 This FRA has been prepared in accordance with the *National Planning Policy Framework*[2] (NPPF). The NPPF states that a site-specific FRA is required for:

- Development proposals of 1 hectare (ha) or greater in Flood Zone 1;
- For all proposals for new development located in Flood Zones 2 and 3;
- Any proposal in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the EA); and
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

1.1.5 This FRA has been prepared primarily since this site is greater than 1ha in area. The purpose of the FRA, as detailed in the NPPF[2], is to demonstrate how flood risk to the proposed development and any potential increased flood risk to third parties due to the development, will be managed over the lifetime of the development, taking climate change into account.

1.1.6 The Proposed Development that this FRA supports is for the expansion of Bristol Airport's capacity from 10 million passengers per annum (mppa) to 12 mppa. In order to increase to this capacity, the Proposed Development will consist of the improvement of existing infrastructure, construction of new infrastructure and the amendment of current operations. These infrastructure changes are discrete in the sense that they involve development on specific areas of land within and adjacent to the operational airport, rather than widespread construction works. The present day operational airport forms the 'baseline' site, against which this report assesses the flood risk posed by new and improved infrastructure. The Proposed Development components are listed in Table 2.2. In this

[1] Environment Agency (2018). Flood map for planning, [online]. Available at: https://flood-map-for-planning.service.gov.uk/ [Checked 23/08/18].

[2] Ministry of Housing, Communities and Local Government (2018). National Planning Policy Framework, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733637/National_Planning_Policy_Framework_web_accessible_version.pdf [Checked 01/08/2018].

report the term 'application site' is used to describe the Proposed Development's overall footprint and includes the Bristol Airport plus the adjacent section of the A38 where highway improvements are proposed.

1.2 Structure of this report

1.2.1 The report is structured as follows:

Section 2 - Site Description: development proposals and planning context;

Section 3 - Flood Risk Appraisal: this provides an assessment and a summary of the various sources of flood risk to the application site and specifies appropriate mitigation measures;

Section 4 – Drainage Strategy - details the relevant guidance for development design, and summarises the drainage proposals for the Proposed Development, referencing the more detailed DS prepared for the Proposed Development (Bristol Airport part of the application site - surface water and foul drainage - Hydrock, see Appendix D, or A38 highway improvement surface water drainage, see Appendix E);

Section 5 – Flood risk mitigation: this section provides an outline of recommended measures which will help adequately mitigate against the key sources of flood risk at the application site; and

Section 6 – Conclusions and recommendations: provides a summary of the main findings of the report and the key recommended measures.

1.2.2 Figures are presented within each section while supporting documents are presented at the end of the report in the form of appendices. In total there are five appendices, as follows:

Appendix A – Site Master Plan;

Appendix B – Lead Local Flood Authority Consultation;

Appendix C – EA Consultation;

Appendix D - Hydrock DS (Bristol Airport part of the application site); and

Appendix E - DS (A38 part of the application site).

1.3 Terminology

Annual exceedance probability (AEP)

1.3.1 In this report, the probability of a flood occurring is expressed in terms of AEP, which is the inverse of the annual maximum return period. For example, the 100-year flood can be expressed as the 1% AEP flood, i.e. a flood that has a 1% chance of being exceeded in any year.

1.3.2 Table 1.1 is provided to clarify the use of the AEP terminology as well a description of the Flood Zone definitions as set out in the NPPF, flood risk and coastal change guidance.

Table 1.1 Flood Zone definitions and associated annual exceedance probability

Flood Zones	Probability of flooding	AEP	Definition
Flood Zone 1	Low Probability	<0.1% AEP of river or sea flooding	Land with less than 1 in 1,000 probability of flooding from rivers or the sea, in any given year.
Flood Zone 2	Medium Probability	1% - 0.1% AEP of river flooding 0.5% – 0.1% AEP of sea flooding	Land with between a 1 in 100 and 1 in 1,000 of river flooding; or land having between a 1 in 200 and 1 in 1,000 probability of sea flooding.
Flood Zone 3a	High Probability	>1% AEP of river flooding >0.5% AEP of sea flooding	Land having a 1 in 100 or greater probability of river flooding in any year; or Land having a 1 in 200 probability or greater of sea flooding in any year.
Flood Zone 3b	Functional Floodplain	>5% AEP of river or sea flooding; or a designated area designed to flood	Land having a 1 in 20 or greater probability of river of sea flooding in any year.

1.4 Sources of data and information

1.4.1 Further sources of information utilised in this report are detailed below:

NPPF[2];

Planning Practice Guidance[3];

C753: The SuDS Manual[4];

Flood map for planning[1];

Flood warning information service map[5];

What's in your backyard[6];

Multi-Agency Geographic Information for the Countryside mapping[7];

NSC *Strategic Flood Risk Assessment*[8]; and

NSC *Preliminary Flood Risk Assessment*[9].

NSC *Local Flood Risk Management Strategy*[10]

[3] Ministry of Housing, Communities & Local Government (2014). Planning practice guidance, Climate change, [online]. Available at: https://www.gov.uk/guidance/climate-change [Checked 31/08/28].
[4] CIRIA (2015). C753: The SuDS Manual, [online]. Available at: https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx [Checked 28/08/18].
[5] Environment Agency (2018). Flood warning information service map, [online]. Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map [Checked 22/08/18].
[6] Environment Agency (2018). What's in your backyard, [online]. Available at: http://apps.environment-agency.gov.uk/wiyby/default.aspx [Checked 22/08/18].
[7] Defra (2018). Multi-Agency Geographic Information for the Countryside mapping, [online]. Available at: https://magic.defra.gov.uk/MagicMap.aspx [Checked 23/08/18].
[8] North Somerset Council (2008). Strategic Flood Risk Assessment, [online]. Available at: https://www.n-somerset.gov.uk/my-services/planning-building-control/planningpolicy/supplementary-planning-advice/guidance/strategic-flood-risk-assessment/ [Checked 19/03/18].
[9] North Somerset Council (2011). Preliminary Flood Risk Assessment, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2017/04/North-Somerset-preliminary-flood-risk-assessment-report-2011.pdf [Checked 19/03/18].
[10] North Somerset Council (2011). Local Flood Risk Management Strategy, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2015/11/local-flood-risk-management-strategy.pdf [Checked 19/03/18].

2. Site description, development proposal and planning context

2.1 Site description

The application site

2.1.1 The application site is centred at Grid Reference ST 503 651 and is the current location of Bristol Airport. The application site is located to the immediate south-west of Lulsgate Bottom and 11km south-west of Bristol City Centre. The Bristol Airport ownership boundary covers a total area of 196ha (Figure 2.1). This land currently comprises large impermeable areas associated with the runway, taxiways and apron, and also buildings and large car parking areas. Remaining areas, including the land between and around the runway and taxiways is currently set to grass.

Topography

2.1.2 Bristol Airport is situated on a plateau which straddles three watercourse catchments (Figure 2.2). Based on Ordnance Survey (OS) 1:25k mapping, the highest point within Bristol Airport is located near the south-west boundary (196m AOD). Elevations are highest along the runway (around 185m AOD), with ground sloping towards the edges of the Bristol Airport, these being set at the following elevations: north-west (160m AOD), north-east (170mA OD) and southern edges (175mAOD). Broadly these areas form the upper part of the catchments of the River Moor, Winford Brook, and Kenn Moor.

2.1.3 The A38 forms the key access or egress route for Bristol Airport for all passengers and personnel. An area of the A38 is included in the Proposed Development, associated with proposed road improvements. This section stretches from Bristol Airport's northern access roundabout (set at 179m AOD) and slopes to the north, past the junction with Downside Road (around 167m AOD), to a topographic low point at the junction with West Lane (set at around 165m AOD).

2.1.4 With regards to the remainder of the adjacent A38, the realigned stretch between the northern and southern access roundabouts is set within a slight cutting, with the highpoint approximately halfway along. The land to the east of the A38 is set at higher elevations than the A38 and the Bristol Airport to the west, at around 190m AOD. Parts of the road are within a cutting around 2m deep. There is a small gradient from this point down to the two access roundabouts to Bristol Airport, with the southern roundabout being 184m AOD and the northern roundabout being at 179m AOD. To the south of Bristol Airport, the A38 slopes to the south-west to the topographic low at the Junction with New Road which is at 162m AOD.

Hydrology, drainage, hydrogeology and soils

Hydrology and drainage – catchment

2.1.5 The application site straddles three drainage catchments, as shown on Figure 2.2

2.1.6 The limestone bedrock and thin soils mean that the majority of rainfall infiltrates to ground. As shown on OS 1:25k mapping, watercourses are largely absent from the Broadfield Down plateau on which Bristol Airport is situated. The nearest watercourse is situated downslope of the application site and is supported by groundwater emergence from the limestone aquifer. During extreme periods of intense rainfall when the local infiltration capacity is exceeded, runoff will follow local topography collecting and draining as ephemeral flows along the adjacent 'dry valleys' (locally called combes) to downslope watercourses.

2.1.7 Runoff during extreme rainfall events from the southern half of the application site, (land south of the drainage divide, which runs west-east along the current runway), drains to the south and then west via the Goblin Combe dry valley which drains to the River Kenn, and then to the Bristol Channel at Clevedon via the Blind Yeo (both EA Main Rivers). The wider Kenn Moor area is managed by the North Somerset Internal Drainage Board.

2.1.8 Runoff during extreme rainfall events from the north-western part of application site, (land north-west of the runway), drains to the north and west towards Brockley Combe dry valley which also ultimately drains into the River Kenn.

2.1.9 Runoff during extreme rainfall events from the north-eastern area of the application site (land north-east of the runway) drains east via 'West Lane', towards the Winford Brook. This watercourse drains to the east, joining the River Chew in Chew Magna, which flows into the River Avon (all EA Main Rivers), which ultimately flows into the Bristol Channel.

2.1.10 The A38 part of the application site can be divided into three distinct sections based on drainage. Table 2.1 describes the drainage of each section of the A38. Parts of the A38 to the north and south of the sections covered here are outside of the catchments in which Bristol Airport is situated and have therefore not been appraised.

2.1.11 As the application site is located on a plateau, there are no areas of surface water originating off-site that run onto Bristol Airport.

2.1.12 No surface water bodies are present within the application site.

Table 2.1 A38 drainage adjacent to Bristol Airport

Section	Drainage Description
1 – New Road to Southern Airport Roundabout	From the southern Bristol Airport access roundabout, the A38 slopes to the south-west running perpendicular to contour lines until the low point at the junction with New Road. From here runoff will drain west via the Goblin Combe dry valley. Further details are provided in Figure 3.2.
2- A38 realignment between the two airport roundabouts	This section of the A38 is in situated in a road cutting that acts to intercept surface water draining from higher ground to the east. The highest point of the road is approximately mid-way between the two roundabouts, with the road having limited gradient to the north or south away from this point. An area of standing water is indicated on the EA risk of surface water flooding map (Figure 3.2). This section of road drains to a roadside French drain, which is currently heavily silted and overgrown.
3- Northern Airport Roundabout to Potters Hill	The low-point of this section of the A38 is just to the south of the junction with West Lane. Runoff drains to this point from sections of the A38 extending south to the northern airport roundabout and north up Potters Hill. Surface water flowpaths originating from the A38 to the south, Bristol Airport, and Downside Road or Lulsgate Bottom are shown to drain to the low-point. The flowpath crosses the A38 and trends to the east along West Lane, where a significant portion draining Lulsgate Quarry on the north side of the road. Runoff from West drains east towards the village of Winford.

Geology, hydrogeology and soils

2.1.13 The British Geological Society (BGS)[11] online 'Geology of Britain' mapping indicates that the bedrock geology beneath the majority of the application site is the Black Rock Limestone Subgroup. In the north-west and the very south and south-east the application site is underlain by Brockley Down Limestone. There are two small areas in the south that are underlain by the Westbury Formation and Cotham Member (undifferentiated) – Mudstone and Limestone, Interbedded. No superficial deposits are recorded. The bedrock geology beneath the site is shown on Figure 2.3.

2.1.14 Across the application site, the LANDIS soils database[12] indicates that freely draining loamy soils are present. However, Chapter 10 of the Environmental Statement (ES) indicates that large areas of Bristol Airport are underlain by made ground associated with historic development.

2.1.15 MAGIC mapping[13] indicates that the Black Rock Limestone Subgroup is classified as a 'Principal' aquifer, which is defined as having *"high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer"*[14]. The Brockley Down Limestone is classified as a 'Secondary A' Aquifer, which is defined as "*permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers"*. The Westbury Formation and Cotham Member (undifferentiated) is classified as a 'Secondary B' aquifer, which is defined as: *"predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers".* Groundwater vulnerability mapping indicates that the majority of the site, associated with the Principal Aquifer is Minor Aquifer (High), indicating that it is capable of rapidly transmitting pollutants. The area of the Secondary A Aquifer is considered to be a Minor Aquifer Intermediate and the Secondary B Aquifer is a Major Aquifer Intermediate, indicating that the whole site has the capability of transmitting pollutants.

2.1.16 Bristol Airport sits within Zone 2 of a groundwater Source Protection Zone (SPZ) (with the exception of the eastern area which lies beyond the zone boundary) (Figure 2.4). A second SPZ lies to the east of the application site. This has been defined for the surface water catchment to Bristol Water's Winford Brook (Chew Magna Reservoir) source. The definition of the surface water catchment reflects the potential for karst features to provide rapid fast pathways for pollution migration from sources to the receptor.

2.2 Development proposals

2.2.1 The Master Plan of the Proposed Development is included in Appendix A. The components of the Proposed Development are detailed in Table 2.2 which provides details of their consideration in this FRA. Table 2.2 is focussed on flood risk and surface water drainage implications. As well as this FRA, two Drainage Strategies have been prepared in support of the main Bristol Airport site (Appendix D), and the A38 highways improvements (Appendix E). It should be noted that a foul drainage strategy (Hydrock, Appendix D) has also being prepared to support the Proposed Development. This will ensure that the Bristol Airport's foul drainage system has suitable capacity

---

[11] BGS (2018). Geology of Britain, [online]. Available at: http://www.bgs.ac.uk/data/mapViewers/home.html [Checked 22/08/18].
[12] Cranfield Soil and Agrifood Institute (2018). Landis Soilscapes map, [online]. Available at: http://www.landis.org.uk/soilscapes/# [Checked 22/08/18].
[13] Department of Environment, Food and Rural Affairs (2018). MAGIC database, [online]. Available at: http://magic.defra.gov.uk/MagicMap.aspx [Checked 22/08/18].
[14] Environment Agency (2018). What's in your backyard Aquifer Designations, [online]. Available at: http://apps.environment-agency.gov.uk/wiyby/117020.aspx [Checked 22/08/18].

to manage foul flows from the increase in passenger numbers, and elements of the Proposed Development that would result in increased flows.

Table 2.2 Development components of the 12 mppa expansion - inclusion in the FRA

Area	Component	Full/Outline Planning permission	Assessed in FRA?
Flight Operations	Night flights/seasonal constraints	Full	No - since this is an operational proposal with no specific additional flood risk implications.
Northern	Expansion of the existing terminal Building and new terminal canopy	Full/Detailed	Yes
	Pier and Walkway	Outline	No - these works would be situated above existing areas of impermeable concrete apron already served by Bristol Airport's existing drainage system.
	Service Yard	Outline	Yes
	Multi-storey car park	Outline	Yes
	Gyratory road with internal surface car parking	Outline	Yes
Central	Eastern taxiway link	Outline	Yes
	Taxiway widening (and fillets)	Outline	Yes
	Aircraft stands 37 and 38	Full	No - since this is an operational proposal with no specific additional flood risk implications.
Southern	Operational extension to Silver Zone Car Park (Phase 1)	Full	No - car park already exists. This proposal concerns changes to season of usage only.
	Extension to the Silver Zone Car Park (Phase 2)	Outline	Yes
A38	Highway Improvements	Outline	Yes

2.3 Planning context

National Planning Policy Framework (NPPF)

2.3.1 The NPPF[2] acts as guidance for local planning authorities and decision-makers, both in drawing up plans and making decisions about planning applications. In terms of flood risk, the framework sets out the basis for the management of future development according to the risk of flooding, and the vulnerability or significance of the development.

National Planning Policy Framework - Planning Practice Guidance (PPG)

2.3.2 The supporting PPG provides guidance on the implementation of the NPPF. The flood risk guidance was published in 2014[15] and has not yet been updated following the 2018 NPPF. Providing additional relevant guidance on a range of issues, including the definition of flood zones, development vulnerability classifications, and compatibility of development types and flood zones. The PPG[15] makes reference to climate change allowances. Specific detail on the current allowances for the effects of climate change on flood risk being provided as a separate 'live' document online[16]. The flood risk and coastal change guidance sets out the climate change allowances to be used in FRAs for both peak river flows by river basin district and peak rainfall intensity, with values for three epochs up until 2115.

North Somerset Strategic Flood Risk Assessment (2008)

2.3.3 The *North Somerset Strategic Flood Risk Assessment* (SFRA)[17] provides a baseline understanding of flood risk across North Somerset, before focussing on the level of current and future flood risk to potential future residential development areas across North Somerset. Winford to the east is highlighted as a settlement at risk from fluvial flooding. The document provides limited information relevant to Bristol Airport. SFRA Figure 3.2 highlights several historic flood events along the A38 at Lulsgate Bottom, and along Downside Road.

North Somerset Preliminary Flood Risk Assessment (2011)

2.3.4 The *North Somerset Preliminary Flood Risk Assessment* (PFRA)[18] provides a baseline and 'with future climate change' understanding of flood risk from 'local' sources of flood risk (i.e. Ordinary Watercourses[19], surface water and groundwater) for which NSC is responsible for managing (as the LLFA). The study assesses flood risk from these sources to all types of development across North Somerset. Winford is highlighted as a settlement at risk from surface water flooding. The document provides limited information relevant to Bristol Airport part of the application site itself.

North Somerset - Local Flood Risk Management Strategy (2015)

2.3.5 The *North Somerset Local Flood Risk Management Strategy* (LFRMS)[20] builds on the PFRA to identify actions for key flooding hotspots where NSC as LLFA has responsibility. The study assesses flood risk management actions required to alleviate flooding in the 15 settlements judged to be most at risk of flooding. The only area included of relevance to the catchments in which Bristol Airport is situated is Claverham, situated immediately west of Brockley Combe, where flood risk is associated with surface water runoff from the hills east of Claverham, and groundwater emergence.

---

[15] Ministry of Housing, Communities and Local Government (2014). National Planning Practice Guidance, Flood risk and coastal change, [online]. Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change [Checked 21/08/18].
[16] Environment Agency (2017). Flood risk assessments: climate change allowances, [online]. Available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Checked 27/09/18].
[17] North Somerset Council (2008). Strategic Flood Risk Assessment, [online]. Available at: https://www.n-somerset.gov.uk/my-services/planning-building-control/planningpolicy/supplementary-planning-advice/guidance/strategic-flood-risk-assessment/ [Checked 19-03-18].
[18] North Somerset Council (2011). Preliminary Flood Risk Assessment, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2017/04/North-Somerset-preliminary-flood-risk-assessment-report-2011.pdf [Checked 19/03/18].
[19] These are all watercourses that are not classified as 'Main River' and overseen by the Environment Agency.
[20] North Somerset Council (2011). Local Flood Risk Management Strategy, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2015/11/local-flood-risk-management-strategy.pdf [Checked 19/03/18].

North Somerset 2012 Flood Investigations Report

2.3.6 This report[21] documents the areas of North Somerset most affected by the intense rainfall events experienced over summer 2012. Associated with the surface water flowpaths from the Bristol Airport plateau (Figure 2.5), Brockley, Claverham and Winford are highlighted as flooding hotspots. The report also details severe flooding of the A38 at Lulsgate Bottom adjacent to Bristol Airport (and the main access route from Bristol City). The report indicates that an under capacity, silted culvert collapsed, leading to surface water flooding up to 0.45m deep. Given the extensive area of road (~2km) draining to this low point and the intensity of the event, the report considers that flooding would have occurred regardless of the culvert failure.

2.4 Sequential test and exception test

Sequential test

2.4.1 The NPPF[2] and the accompanying Technical Guidance document[22] describe the principles of the Sequential Test, which aims to steer new development to areas with the lowest probability of flooding. The Sequential Test is a decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to areas at higher risk.

2.4.2 The EA's Flood Map for Planning[1] (Figure 2.6) shows the entire application site as being situated within Flood Zone 1. As such, the sequential test can be considered to be passed.

Exception test

2.4.3 The NPPF PPG on Flood risk and coastal change[3] states that the Exception Test is intended to ensure that a new development *"will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall"*

2.4.4 Table 3 of the guidance identifies that all vulnerabilities of development are compatible with a Flood Zone 1 location and that the Exception Test does not need to be applied. For this reason, the type of development proposed is considered to be appropriate for the application site, and therefore the Exception Test has not been considered further in this FRA.

[21] North Somerset Council (2012). North Somerset – 2012 Flood Investigations, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2016/03/North-Somerset-2012-flood-investigations.pdf [Checked 21/08/18].

[22] Ministry of Housing, Communities and Local Government (2014). National Planning Practice Guidance, Flood risk assessment for planning applications, [online]. Available at: https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications [Checked 11/10/18].

3. Flood risk appraisal

3.1 Summary of potential sources

3.1.1 Table 3.1 summarises the flood risk to the application site from various potential sources of flooding. These are then considered in the following sub-sections.

Table 3.1 Summary of potential flood risk sources

Source of Flood Risk	Risk Posed	Rationale
Tidal	Not applicable	As the application site is situated at elevations of 160m AOD and above, the risk of tidal flooding now and in future can be considered to be negligible. As such, it will not be considered further.
Fluvial	Low	The application site is entirely within EA Flood Zone 1 and as such, can be seen to be at low risk of fluvial flooding. Given the situation of the site this is expected to remain the case in future with climate change. Fluvial flood risk is only considered further in the context of Bristol Airport's potential to affect downslope areas currently at risk of flooding.
Surface water: run-on and run-off	Medium	EA surface water flood risk mapping shows that the majority of the application site is at very low risk of surface water flooding. There are a number of areas of surface water ponding associated with terminal buildings and concrete aprons. There is a high-risk surface water flowpath that crosses the A38 at a low-point by the Airport Tavern. Several other flowpaths originate on or near Bristol Airport. Being situated on a plateau there are no surface water flowpaths that run-on to the site. There are two sections of the adjacent A38 with recorded incidents of surface water flooding due to insufficient highway drainage capacity. The first is in the area between the airport roundabouts and the second is to the north of Bristol Airport, heading downslope along the road towards the Airport Tavern.
Surface water drainage system	Low	The area of impermeable surfaces on application site will increase as a result of the Proposed Development. Drainage Strategies have been prepared to detail how runoff will be managed and maintained at greenfield rates so as not to increase downstream flood risk. In addition, the development layout will be designed to manage for exceedance, such that roads and greenspace are used to route runoff in exceedance of the design event through the application site.
Groundwater	Low	Given the application site's elevation (>160m AOD) and topography (on top of a broad plateau), the risk of groundwater emergence can be considered to be low.
Foul sewers	Low	If any on-site foul sewers were to surcharge, it is likely that flows would be managed within roadways or areas of greenspace. Given the scale of the development in the context of the piped drainage network the risk from this source is minimal.

Source of Flood Risk	Risk Posed	Rationale
Artificial	Low	There are no canals or flood defences that pose a risk of flooding to the application site. There are no existing reservoirs, whose failure would cause the application site to flood.

3.2 Historic flooding

3.2.1 The *North Somerset 2012 Flood Investigations* report[21] states that there was significant flooding at Airport Tavern, Lulsgate bottom with the A38 flooding multiple times and pumping equipment was required to make the busy road safe. Depths were recorded as being in excess of 450mm and flooding was exacerbated by the pipe draining this low-lying section of highway collapsing under the retaining wall. However, the report states that even if the pipe had not collapsed the manhole in the field would have surcharged and flooded the area.

3.2.2 The *North Somerset Council Strategic Flood Risk Assessment*[17] indicates there has been historic surface water flooding to the A38 at Lulsgate Bottom immediately to the north-east of the application site.

3.2.3 Records of flooding provided through consultation with the LLFA (Appendix B) also include surface water flooding at the Airport Tavern in 2012 although note that work has been carried out by the highways authority on a soakaway in 2013 and there have been no records of flooding since. There are also records of surface water flooding on the A38 between Bristol Airport's northern and southern access roundabouts, which they note may be down to highway drainage issues.

3.2.4 The LLFA also note that there has been surface water flooding on the corner of Crooks Bridle Path and Downside Road, with includes both garden and highway flooding.

3.3 Fluvial flood risk

3.3.1 The EA's Flood Map for Planning[1] (Figure 2.6), shows that the application site is situated in Flood Zone 1 (the lowest flood risk area - less than 0.1% AEP). As such, the application site can be considered to be at low risk of fluvial flooding. Whilst the flood modelling underpinning the Flood Map for Planning typically only maps fluvial flood risk along floodplains in catchments greater than 3km^2, Bristol Airport's situation on a plateau with no upslope catchment limits the potential for fluvial flooding. The lack of surface watercourses due to the permeable thin soils and limestone geology below the application site further limit the risk of this source of flooding.

3.3.2 Fluvial flood risk at the application site is therefore considered to be negligible. Runoff pathways on and adjacent to the application site are discussed further in Section 3.4 (Surface Water flood risk).

3.3.3 With Bristol Airport being situated on a plateau on the watershed of three catchments, runoff drains in three broad directions. To the north-east, the nearest area of Flood Zones 2 and 3 (medium and high risk) is located approximately 4km from Bristol Airport, associated with the River Kenn. In the catchment to the east, the nearest area of Flood Zone 3 is located approximately 2.5km to the east in the settlement of Winford, associated with the Winford Brook. To the south-west, the nearest areas of Flood Zones 2 and 3 are associated with the River Yeo and located approximately 2.6km from Bristol Airport, near the settlement of Wrington. However, as shown on Figure 2.6, the Flood Zones around Wrington are outside of the catchments that the Bristol Airport part of the application site drains to, so this will not be affected by the Proposed Development. It should be noted that all of these areas of flooding are located at elevations significantly below the Bristol

Airport part of the application site and therefore are not considered to pose a risk to the application site.

3.3.4 Since Bristol Airport is situated in Flood Zone 1, the Proposed Development's only potential means of increasing downstream flood risk would be either changes to runoff rates from the application site, or the concentration of runoff from a large proportion of the application site and infiltration at points where rapid downslope emergence may occur. These are considered further in Section 3.4 (Surface Water flood risk) and in the DS. Therefore, fluvial flood risk is therefore not considered further.

3.4 Surface water flood risk: run-on and runoff

3.4.1 The EA's Flood Risk from Surface Water mapping[5] (Figure 2.5) shows that the majority of the application site is at 'very low' (less than 0.1% AEP) risk of surface water (rain and runoff) flooding. There are however, significant areas of surface water ponding associated with low points between the runway and taxiways. On the south side of terminal buildings areas of surface water flooding are shown extending across the concrete aprons where runoff draining northwards is shown to pond against these buildings. However, it should be noted that several of the areas south (upslope) of the piers do not reflect the 'bridge' sections of the piers, which would allow surface water to pass under and continue draining northwards rather than ponding on the upslope apron. To the west of the terminal building, a large area of ponded surface water is shown, although this is associated with a former service yard, which has now been built over as part of the previous western terminal extension. The areas of ponding contain areas at low, medium, and high risk of surface water flooding (0.1% AEP to 1% AEP, 1% AEP to 3.33% AEP, and greater than 3.33% AEP respectively).

3.4.2 There are also a number of notable surface water flowpaths that originate on the application site. To the north-east a flowpath issues towards Downside Road and trends towards West Lane, across the A38 and drains into the quarry. There are also flowpaths issuing from Bristol Airport to the south, west and east. These follow the routes of the dry valleys of the upper Winford Brook, Goblin Combe (draining to the River Kenn catchment) and Brockley Combe (draining to the Kenn Moor SSSI catchment). These flowpaths extend away from the application site to areas of downslope settlements which are also at risk from surface water flooding (Felton and Winford in the east, Brockley and Cleeve in the west). These flow paths are classified as low, medium and high surface water flood risk areas along the valley bottoms.

3.4.3 NSC as LLFA have provided details of three areas of historic surface water flooding. All of these areas match with the EA surface water flood risk mapping. The areas are:

- On the corner of Cook's Bridle Path and Downside Road, which includes both garden and highway flooding;
- On the A38 between the airport roundabouts; and
- At the Airport Tavern, Lulsgate Bottom in 2012.

3.4.4 Current (2016) climate change guidance (Table 2)[23] indicates that rainfall intensity could increase by up to 40% by 2115. This would result in the areas shown as being at 'High' risk (i.e. most frequent surface water flooding), extending into areas shown as being at 'Medium' risk, and so on for the other risk classes.

[23] Environment Agency (2017). Flood risk assessments; climate change allowances, [online]. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2 [Checked 21/08/18].

3.4.5 On this basis, current and future surface water flood risk is considered significant at and adjacent to Bristol Airport. Further consideration is provided in Section 5.

3.5 Surface water drainage system

3.5.1 Details of the existing surface drainage network arrangements at Bristol Airport are provided in the Hydrock Drainage Strategy (Appendix D). Similarly, details of the A38 surface water drainage are provided in the C-TAS Drainage Strategy (Appendix E).

3.5.2 Bristol Airport's drainage system collects runoff onsite passing this through interceptors to capture contaminants before discharge to ground. The existing drainage systems ensure that runoff from Bristol Airport's buildings, runway or taxiways and aprons, roads and associated impermeable or semi-impermeable areas is managed within the Bristol Airport site. Existing drainage systems have a range of design standards, with those supporting more recent development elements being designed to the 1% AEP with climate change event as required by current guidance. This manages the risk of the development exacerbating or increasing off-site flood risk. Broadly, the existing Drainage Strategy prepared by Hydrock (Appendix D) includes:

North Side: new and old terminal buildings, access roads, surface and multi-storey car parking, hotel) - runoff routed to multiple soakaways located within the surface car parking area. A bund running along the northern and eastern Bristol Airport site boundary acts to retain runoff during extreme events for on-site infiltration;

Air Side: Runway, taxiway and aprons - runoff routed to multiple soakaways; and

South Side: impermeable arrivals or collection car parking - routed to multiple soakaways. Silver Zone Car Park extension (Phase 1) - infiltration via drainage blanket formed by the car park's aggregate surfacing. A bund running along the southern and eastern boundary of Bristol Airport acts to retain runoff during extreme events for on-site infiltration.

3.5.3 With regards to the A38, a separate Drainage Strategy (Appendix E) has been prepared by C-TAS, this indicates that:

Realigned A38 (between South Side and North Side access roundabouts): drainage provided by a roadside filter drain with infiltration to ground; and

A38 North Side access roundabout to Lulsgate Bottom: traditional road edge gullies and piped system. Various discharge routes to adjacent fields/ditches/soakaways.

3.5.4 On this basis, current and future flood risk associated with the drainage system at Bristol Airport is considered significant. Further consideration is provided in Section 4 and Section 5 and the Proposed Development's Drainage Strategy (for the main airport site (Appendix D) and the A38 highway improvements (Appendix E).

3.6 Groundwater flood risk

3.6.1 BGS geological mapping indicates that Bristol Airport is underlain by the Black Rock and Clifton Down limestone formations solid geology and no superficial geology is indicated. Given Bristol Airport's elevated location (160m AOD and above), the risks of groundwater emergence are limited. OS mapping indicates springs at around 20m AOD in the west near Claverham and Brockley, and 120m AOD in the east at Winford. The 2017 EnviroCheck report (see Appendix 12D of the ES) contains information on groundwater flood risk, indicating that Bristol Airport is in a low risk area, with the bottoms of the off-site dry-valleys being at higher risk. This suggests the risk at the application site is limited, although isolated perched aquifers could be encountered during below ground construction works for foundations and basement areas.

3.6.2 The Landmark Information Group Envirocheck report (Appendix 12D of the ES) indicates that the BGS groundwater susceptibility mapping shows the application site overlies geology classed as being in the lowest category of risk from potential groundwater flooding. Notable areas of risk nearby are confined to the deeper combes and valley bottoms.

3.6.3 The LLFA stated that they had no records of groundwater flooding at the application site (Appendix B).

3.6.4 On this basis, current and future flood risk associated with groundwater flood risk at Bristol Airport is not considered further. With regards to infiltration, further details are provided in Section 4 and Section 5 and in the Proposed Development's Drainage Strategy (for the main airport site (Appendix D) and the A38 highway improvements (Appendix E).

3.7 Foul sewer flood risk

3.7.1 Due to the application site's location on top of a plateau with no upslope catchment, the risk from sewer flooding from surrounding areas running on to the application site can be considered to be negligible. Were any on-site sewers to surcharge, it is likely that the small quantities of flood water would be contained within areas laid to roads, hardstanding and green space, or dissipate into the on-site drainage system. Given the scale of the development in relation to the limited quantity of surcharge possible from foul drainage systems, flood risk from this source is considered to be negligible, and is not considered further.

3.7.2 Further details of the foul drainage proposals are provided in Section 4 and in the Drainage Strategy for the main airport site (Appendix D).

3.8 Flood risk from canals, reservoirs and other artificial sources

3.8.1 The EA's reservoir flood risk mapping indicates no areas of risk on or adjacent to the application site. There are also no canals present in the vicinity that would pose a risk to the application site.

3.9 Existing flood defence structures

3.9.1 The EA's Flood Map for Planning[1] indicates there are no flood defence structures in the area.

4. Drainage Strategy

4.1 Existing surface water drainage

4.1.1 The existing surface water drainage network for the application site is summarised in Section 3.5 of this report. Broadly, runoff is collected, passed through interceptors and then infiltrated into the limestone bedrock beneath the site at multiple soakaway structures located across the application site. Further details are provided in the 'Existing Drainage' section of the Drainage strategies prepared for the Proposed Development (for the main airport site (Appendix D) and for the A38 highway improvements (Appendix E)).

4.2 Drainage Strategy

National Planning Policy Framework

4.2.1 The NPPF[2] requires that the volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development (unless specific off-site arrangements are made and result in the same net effect). Wherever possible, rainfall should be retained on site and allowed to infiltrate into the ground. Typically, runoff volumes generated during a storm will have to be stored for the duration of the storm and released slowly afterwards to meet the required discharge rate.

4.2.2 The NPPF[2] further advises that planning authorities should promote the use of SuDS principles in the management of surface water runoff from new developments. There is a presumption for the use of SuDS within any development, except in rare instances that it can be demonstrated that SuDS principles cannot feasibly be incorporated within a development, as agreed with the LLFA or Internal Drainage Board (IDB).

4.2.3 In the case of the Proposed Development at Bristol Airport, it is proposed to locally upgrade or construct new drainage systems to suit each element of the development (Table 2.2). This approach has been taken given that the development elements will occur on discrete areas of land within the application site, and the timescales differ for the construction of each element. This will ensure that runoff rates are not increased above baseline levels. In some areas, where the new development results in an upgrade to drainage systems designed to older, lower design standards the new drainage system will deliver a betterment over the baseline situation.

Flood and water management act, 2010

4.2.4 Under the *Flood and Water Management Act 2010*[24], the NSC are designated as the LLFA and therefore act as the 'approving body' for sustainable drainage systems. At the detailed design stage, BAL (or their contractors) will be required to submit their drainage design to the LLFA for approval. The act also recognises the roles played by district councils, internal drainage boards, highways authorities and water companies. These bodies, together with the EA, are identified as flood risk management authorities.

[24] The Flood and Water Management Act 2010, [online]. Available at: https://www.legislation.gov.uk/ukpga/2010/29/contents [Checked 13/08/2018].

CIRIA SuDS manual (C753), 2015

4.2.5 The CIRIA SuDS[4] (C753) is the most up-to-date industry standard containing revised principles and technical advice for the planning, design, construction, management and maintenance of effective SuDS. This document replaces the original CIRIA SuDS Manual (C697). NSC as the LLFA, will expect all new development to be designed to align with the revised (C753) manual.

DEFRA non-statutory technical standards for sustainable drainage systems, 2015[25]

4.2.6 The non-statutory technical standards for sustainable drainage systems is a national guidance document that provides a set of standards to be applied when designing SuDS systems for any development. Standards include controls on peak flow and volume of run-off and flood risk internal to the development and downstream. Specifically, Standards S7, S8 and S9 state:

S7 – "the drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the Site for a 3.3% AEP rainfall event";

S8 – "the drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1% AEP rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development"; and

S9 – "The design of the Site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1% AEP rainfall event are managed in exceedance routes that minimise the risks to people and property".

West of England sustainable development developer guide, 2015[26]

4.2.7 The guide signposts to existing policy and guidance to support the delivery of a sustainable approach to the drainage of new development in the West of England. In particular it details the requirements for the management of water quality of runoff generated by developments, although CIRIA C753[4] has now superseded some of the recommendations provided within. The design of the existing Bristol Airport Silver Zone valet car parking drainage (permeable surfacing) is noted as an example of good design[27].

Sewers for adoption, 2012[28]

4.2.8 The guidance is intended for use by developers when planning, designing and constructing conventional foul and surface water gravity sewers and lateral drains for developments.

[25] Department for Environment, Food and Rural Affairs (2015). Non-statutory technical standards for sustainable drainage systems, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf [Checked 11/10/18].

[26] West of England Partnership (2015). West of England Sustainable Drainage Developer Guide, [online]. Available at: https://www.bristol.gov.uk/documents/20182/34524/West+of+England+sustainable+drainage+developer+guide+section+1/864fe0d2-45bf-4240-95e2-a9d1962a0df9 [Checked 18/07/18].

[27] Bristol City Council (2015). Sustainable Drainage Case Studies, Case Study 05 Bristol Airport Car Park, [online]. Available at: https://www.bristol.gov.uk/documents/20182/34524/WoE+SuDS+Case+Study+05+-+Bristol+Airport+carpark+SuDS.pdf/0053a9b0-d14f-4ca7-b019-7476beedce1a [Checked 06/09/18].

[28] WRc (2012). Sewers for Adoption - A Design & Construction Guide for Developers: 7th Edition, [online]. Available at: http://sfa.wrcplc.co.uk/home.aspx [Checked 28/08/18].

4.3 North Somerset Council (LLFA) SuDS policy

4.3.1 The North Somerset adopted *Core Strategy*[29] states that SuDS are the preferred option for dealing with surface water runoff, and all major developments should explore the possibilities for SuDS, especially as part of multi-functional green infrastructure.

4.3.2 As part of the consultation with NSC as LLFA (Appendix B), a number of requirements for the application site were provided. These were:

Sustainable drainage principles should be applied to the application site;

Infiltration may be possible, though this should be confirmed with BRE-365 infiltration tests in the location of any proposed soakaways;

Due to the source protection zone beneath the application site, pollution control may be required;

Any watercourse or rhyne network should remain open and allow easy access for maintenance and inspections;

There must be no interruption to the surface water drainage system of the surrounding land as a result of operations on the application site; and

Provisions must be made to ensure that all existing drainage systems continue to operate effectively and that land owners upstream and downstream of the site are not adversely affected.

4.4 Climate change

4.4.1 NPPF's[2] accompanying climate change guidance[30] specifies climate change allowances for peak rainfall intensity. Table 2 in NPPF's climate change guidance[30] provides a range of allowances dictated by the design life of the Proposed Development and an assessment of the application of either the Central or Upper End banding as appropriate. In the case of the scheme being considered, it is unlikely that it will remain unchanged beyond a period of 50 years. This would place the development lifetime on the cusp between the 2040 to 2069 and 2070 to 2115 periods for which rainfall increases are specified. For the 2070 to 2115 period, a value of +40% is required if the 'Upper end' allowance is used, or +20% if the 'Central' allowance is used. CIRIA SUSDRAIN[31] guidance[32] indicates that the +20% allowance can be used if runoff in excess of this drainage system design standard up to the +40% standard can be managed safely within suitable areas of the site for each element of the Proposed Development. However, for this assessment, in order to ensure that there is sufficient contingency within the design, a figure of +30% has been used to size soakaways and piped drainage. Final climate change allowances (whether +20%, +30% or +40%) would be selected based on subsequent detailed drainage design and available surface storage in each development area.

[29] North Somerset Council (2017). Core Strategy, [online]. Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2015/11/Core-Strategy-adopted-version.pdf [Checked 16/04/18].
[30] Environment Agency (2017). Flood risk assessments; climate change allowances, [online]. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2 [Checked 21/08/18].
[31] Ciria (2018) Susdrain - Applying climate change allowances to SuDS design, [online]. Available at: https://www.susdrain.org/files/resources/fact_sheets/applying_climate_change_allowances_to_suds_design_draft.pdf [Checked 13/11/18].
[32] HR Wallingford (2018). "What is Interception?", [online]. Available at: http://www.uksuds.com/FAQRetrieve.aspx?ID=55020 [Checked 08/11/18].

4.4.2 This ensures that the drainage design complies with the requirements of NPPF with regards to climate change to ensure that the Proposed Development appropriately manages surface water runoff both now and in the future over its lifetime.

4.5 Infiltration and drainage hierarchy

4.5.1 The existing development directs all surface water runoff to a series of soakaways located within the current Bristol Airport site boundary. The Drainage Strategy prepared for components of the Proposed Development located at Bristol Airport adopts the same strategy of continued discharge of all surface water runoff to ground via infiltration, with drainage proposals included for appropriate upsizing or new soakaways as required to suit the development proposals.

4.5.2 With regards to the A38 highway improvements, the proposed drainage scheme (see: Appendix E) will direct all runoff from the net new impermeable area to a soakaway for infiltration to ground. Additionally, due to the layout of the road and drainage pipe runs, there will be a diversion of some of the existing road catchment area away from the current soakaway to the new soakaway facility. Drainage from the remainder of the road will continue to drain to the existing A38 soakaway located beside the Airport Tavern.

4.5.3 As such the Proposed Development proposals comply with the 'drainage hierarchy', which seeks to ensure runoff is managed by the most sustainable means as close to the source as possible. This ensures that the SuDS proposals mimic the natural hydrological cycle as closely as possible by managing runoff rates and volumes on site and allowing infiltrated flows to supplement river baseflows via recharge to the limestone aquifer. No discharge of surface water runoff to less sustainable options in the SuDS hierarchy (watercourses, surface water sewers, combined sewers) is proposed.

4.5.4 For the Bristol Airport:

The locations of existing soakaways and infiltration areas are shown in the Drainage Strategy (Appendix D - see Appendix C therein); and

The locations of proposed or upgraded soakaways and infiltration areas are shown in the Drainage Strategy (Appendix D - see Appendices D to J therein).

4.5.5 For the A38 highway improvements:

The locations of existing soakaway and connections to the highways drainage network are provided in Appendix E; and

The locations of proposed or upgraded soakaways and connections to the highways drainage network are provided in the A38 Drainage Strategy (Appendix E, see Appendix E therein).

4.5.6 The design of infiltration systems has been supported by infiltration test data, undertaken for previous developments at Bristol Airport, undertaken to the BRE-365 methodology. Details of the tests are provided at Section 3.1.2 of the Hydrock Drainage Strategy (Appendix D).

4.6 Water quality

4.6.1 The Proposed Development's drainage system will be designed to incorporate suitable water quality recommendations as detailed in CIRIA C753[4] (The SuDS Manual, Section 26.8 therein). To maintain a suitable quality of surface water runoff, a suitable 'management train' will be incorporated into the design by selecting appropriate elements for the drainage system to ensure the capture and removal of a significant proportion of the typical contaminants in surface water runoff.

4.6.2 However, the following constraints are relevant to the selection of SuDS elements to ensure a suitable water management train to meet quality objectives:

The operational nature of the Bristol Airport:

Open-air SuDS features are unsuitable due to the risk of attracting birds;

Air-side surfaces such as taxiways and aprons need to be designed to aviation standards, necessitating the use of sealed heavy-duty tarmac or concrete surfaces (limiting the options for permeable types of paving); and

The aquifer within the limestone geology beneath the application site is classified as an SPZ (Zone 2). Whilst a considerable thickness of unsaturated strata is present between the surface and water table, the nature of the development and use of infiltration as the sole means of surface water disposal means that a risk assessment will be required to inform the subsequent detailed design of the drainage system, so as to include appropriate pollution control measures.

4.6.3 Broadly the drainage proposals incorporate the following measures:

Main site, northern and southern site areas:

Where possible, the first flush (i.e. runoff from the first 5 to 10mm of rainfall) will be retained within the SuDS, typically this will be achieved via the surface dressing of open car-parking areas with permeable, graded crushed stone to form a 'drainage blanket';

For the other development elements situated within the northern zone:

- Roof runoff (as relatively clean water) will be directed directly into the surface water drainage pipe network. Flows will then pass to soakaways for infiltration into the ground;
- Runoff from potentially contaminated areas (hardstanding, road surfaces) will be collected within trapped gullies before passing into the piped surface water drainage system via a Class 1 interceptor. Flows will then pass to soakaways for infiltration into the ground;

Main site, central air-side area:

Runoff will be collected via trapped gullies to collect entrained sediment, before passing through a suitable Class 1 interceptor device. Flows will then pass to soakaways for infiltration into the ground; and

A38 highway improvement:

The detailed road drainage design will be prepared in accordance with the Design Manual for Roads and Bridges (DMRB)[33]. The design will incorporate trapped gullies with runoff routed to a Class 1 interceptor before directing to via the piped drainage system to the proposed new soakaway.

4.6.4 With regards to the risk assessment to inform the detailed design of Bristol Airport's drainage system, CIRIA C753[4] Section 26 (in particular Section 26.7) details the requirements for assessing

[33] Highways Agency, Transport Scotland, Welsh Assembly Government, The Department for Regional Development Northern Ireland (2009). The Design Manual for Road and Bridges, Volume II Section 3 Road Drainage and the Water Environment, [online]. Available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf [Checked 27/09/18].

the suitability of proposed SuDS elements to ensure the effectiveness of SuDS elements in providing water quality treatment, and in minimising the risk of groundwater pollution. The guidance will be used during detailed design to undertake a risk assessment of the risk of contaminants entering and passing through the drainage system for each element of the Proposed Development. This will enable the inclusion of suitable treatment measures to be incorporated in the SuDS management train.

4.6.5 It should be noted that Bristol Airport is situated on top of a considerable thickness of unsaturated rock (well in excess of the minimum of 1m unsaturated depth specified by CIRIA C753[4]) between the infiltration features and the water table. This provides a significant buffer for further capture, degradation and dispersion of any contaminants remaining in water infiltrated to ground.

4.6.6 Pollution control valves will also be incorporated in the drainage system for use during emergency incidents and spillages. These will be clearly sign-posted, detailed in operational manuals or staff training, and along with the other elements of the drainage system subject to regular maintenance.

4.7 SuDS strategy

4.7.1 Table 4.1 summarises the SuDS proposals for the Proposed Development elements. Further detail is provided in the respective section of the associated Drainage Strategy.

Table 4.1 Drainage Strategy summary

Area	Component	Level of drainage design	Summary of Drainage Strategy proposals
Main Airport Site - Surface Water Drainage Strategy - Hydrock (Appendix D)			
Northern	Expansion of the existing terminal Building and new terminal canopy and new service yard	Outline	See main airport DS (Appendix D - see section 3.2 and Appendix D therein). Runoff routed to new cellular soakaway located to immediate north. Associated reconfiguration of the drainage system associated with remaining parts of the set-down and pick up car park, control tower, access roads and west apron area to drain to new soakaways. This allows the abandonment of the current soakaways beneath the footprint of the proposed multi-storey car park 3. Overall system designed to 1% AEP + CC allowance standard - this represents a betterment to the drainage system of existing development in this area.
	Multi-storey carpark 2 and transport interchange	*Permitted Development*	*Included for information - this development will occur in the near future and result in a change to the 'existing' surface water drainage network before construction of the adjacent developments covered by this application. Details are provided with regards to how the existing drainage will be reconfigured to enable this and the adjacent elements of the 12 mppa application development.*
	Multi-storey car park 3	Outline	See main airport DS (Appendix D - see section 3.4 and Appendix F therein). Runoff routed to new cellular soakaway located to immediate north. Existing drainage infrastructure under footprint will be removed and re-sited (see details above under 'expansion of existing terminal building' section). Overall system designed to 1% AEP + CC allowance standard - this represents a betterment to the drainage system of existing development in this area.

Area	Component	Level of drainage design	Summary of Drainage Strategy proposals
	Gyratory road with internal surface car parking	Outline	See main airport DS (Appendix D - see section 3.5 and Appendix G therein). A new piped drainage system serving the new road layout will be constructed, draining to a series of soakaways constructed from concrete rings. Associated reconfiguration of the drainage system associated with the remaining part of the existing long and short stay surface car parking (situated within the gyratory system) will enable this to continue to drain to the existing soakaway that serves this area. Overall system designed to 1% AEP + CC allowance standard - this represents a betterment to the drainage system of existing development in this area.
	Northern surface parking reconfiguration	*Permitted Development*	*Included for information - this development will occur in the near future and result in a change to the 'existing' surface water drainage network before construction of the adjacent developments covered by this application. Provided to confirm minor changes to the drainage network required to ensure that remaining areas of the northern surface car park are suitably drained following construction of the multi-storey car park (3) and gyratory road system.*
Central	Eastern taxiway link and taxiway widening (fillets)	Outline	See main airport DS (Appendix D - see section 3.9 and Appendix J therein). New East taxiway link: runoff routed to new piped drainage system and series of concrete ring soakaways. Taxiway widening (fillets): runoff from both new areas of impermeable <u>and</u> the existing hardstanding areas that drain to the area of proposed widening will be routed to new taxiway parallel infiltration trenches. Overall the completed system will be designed to 1% AEP + climate change allowance standard - since design includes for the upgrade of parts of the existing hardstanding drainage, this represents a betterment over existing conditions.
Southern	Extension to the Silver Zone Car Park (Phase 2)	Outline	See main airport DS (Appendix D - see section 3.7 and Appendix I therein). Runoff from the plot's new internal access road and search lanes (tarmac) to drain to adjacent parking plots. Parking plots surfaced with graded gravel laid within an open-cell gravel retention plastic grid over granular fill with a high void ratio. Additional contour parallel infiltration trenches incorporated within this drainage blanket to provide additional storage and infiltration. Bunds to be constructed around the west, south and east perimeter to retain all runoff up to the 1% AEP + 40% climate change allowance standard on site.
Main Airport Site - Foul Drainage Strategy - Hydrock (Appendix D)			
All	All foul flow generating development components of the 12 mppa planning application	Outline	See main airport site DS (Appendix D) section 4 and 5.2. Modifications to the foul drainage network have been designed to meet the expected needs of Bristol Airport's increase to 12 mppa using guidance in 'Sewers for Adoption[28]'. Appropriate capacity has been confirmed with Wessex Water.
A38 Highways Improvements - Surface Water Drainage Strategy - C-TAS (Appendix E)			

Area	Component	Level of drainage design	Summary of Drainage Strategy proposals
A38	Highway Improvements	Outline	See A38 DS (Appendix E). Runoff collected from net new impermeable, plus a proportion of existing road catchment and routed to a new soakaway located in the former quarry between Downside Road and the A38. Overall system designed to 1% AEP + climate change allowance standard. The direction of some of the existing impermeable area to the new soakaway provides a betterment over existing conditions.

Table 4.1 is based on Table 2.2, excluding development elements that have no associated flood risk or drainage implications. Text in italics is has been included to provide further information

4.7.2 With regards to the LLFA's requirements (Section 4.3) it is considered that requirements 1, 2, 3, 5 and 6 are met. No watercourses or rhynes are present within or adjacent to the boundary of the Proposed Development, so requirement 4 is not considered relevant to address. However, all drainage systems have been designed to allow appropriate access for maintenance.

4.7.3 With regards to infiltration to ground, either existing Environmental Permits will be altered and agreed with the EA, or new permits obtained for new soakaway features.

4.8 Surface water exceedance pathways

4.8.1 The proposed soakaways and piped drainage systems have been designed to the 1% AEP event with a 30% climate change allowance, this ensures they meet the required design standards both now and in future with climate change. The detailed drainage design stage would be used to confirm that runoff up to the 1% AEP + 40% climate change allowance standard can be managed on the surface of suitable areas within each element of the Proposed Development (i.e. depressions, bunded areas of surface car parking). Where this is not possible, the piped element and soakaway capacity design would be adjusted to provide a + 40% allowance rather than the + 30% allowance used at this outline stage.

4.8.2 Where the capacity of individual drainage elements is temporarily exceeded during peak rainfall, measures to retain surface water runoff within the site have been included. This includes the use of low-bunding around the downslope edges to hold back water and allow subsequent, capture and treatment within the drainage system before infiltration to ground. These features are included within the Northern surface parking, and in the south, at the Silver Zone extension car parking, and are shown in Appendices H and I respectively of the main airport site Drainage Strategy (Appendix D).

4.8.3 Runoff for rainfall events in excess of the 1% AEP + 40% climate change allowance design standard will pass off-site via existing surface water flowpaths (as shown on Figure 2.5), as is the case under the baseline pre-development situation. For extreme rainfall events with intensities above the design event, all surfaces typically function to shed runoff, such that the excess runoff from developed areas in these extreme events that is not captured by the drainage system will have a negligible effect on increasing flood risk. Comparison of the proposed development (see Appendix A) with Figure 2.5 indicates that in general no significant development is proposed that could interact with existing flowpaths. The exceptions being:

- Western terminal extension and additional multi-storey car park - these could block surface water runoff pathways draining northwards following the site's topography;
- Taxiway fillets; and

A38 at low-point mid-way between Downside Road and West Lane.

4.8.4 For the Western terminal extension and taxiway fillets, suitable flow routes will be incorporated in the design via the grading of adjacent land to ensure that existing flowpaths are managed and are not concentrated or diverted such that downslope flood risk would be increased. Opportunities will be taken to retain these flows on-site for capture and infiltration within the wider network of soakaways.

4.8.5 With regards to the A38, the key source area for surface water flooding is the land (not in BAL's control) to the west of the A38-West Lane junction (see Figure 2.5). The existing Bristol Airport development includes perimeter bunds along the northern edge of the Northern surface car parking and infiltration systems which act to retain and manage runoff on site, that would otherwise reach the A38. The Proposed Development elements within the north side of Bristol Airport include for new or upgraded drainage elements designed to the 1% AEP + climate change allowance design event, which represents a betterment over existing. These will therefore further reduce the quantities of runoff reaching the Downside Road or A38 area under extreme rainfall conditions. The A38 drainage proposals (Appendix E) include for directing all new impermeable road area, plus a proportion of existing impermeable road area to a new soakaway designed to the 1% AEP + climate change allowance standard. The detailed design will check that the quarry void can also contain the 1% AEP + 40% climate change allowance event. This again will contribute to reducing the current level of surface water flood risk to the A38 between Downside Road and West Lane.

4.9 Long term SuDS management and adoption

4.9.1 Schedule 3 of the *Flood and Water Management Act 2010*[24] states that as LLFA and SuDS Approving Body, NSC adopt SuDS drainage systems provided that they are constructed as approved and are compliant with national standards. The key proposals are:

- All drainage within Bristol Airport's operational boundary will be owned and maintained by BAL; and
- Only the drainage system associated with the upgraded section of the A38 will be adopted by the Highways Authority (HA), in this case NSC.

4.9.2 The drainage proposals for components of the Proposed Development at Bristol Airport are detailed in the Drainage Strategy (Appendix D). The drainage proposals for the A38 are detailed in a separate Drainage Strategy (Appendix E). These are compliant with all of the planning and drainage design guidance detailed in Section 4.2 and Section 4.3, and therefore, should be suitable for approval and where appropriate adoption by the LLFA and HA.

4.9.3 Table 2.2 details the type of planning permission sought for the elements of the Proposed Development. All elements of the application with hydrological implications are at this stage being submitted for 'outline' permission only. Drainage proposals submitted as 'outline' planning permission will need to be further developed, agreed with and approved by the LLFA at the detailed design stage to discharge the relevant planning condition(s).

5. Flood risk management measures

5.1 Flood risk

5.1.1 Analysis of the EA's Flood map for Planning[1] has indicated the entire site is in Flood Zone 1 (Figure 2.6), with negligible potential for this classification to change due to climate change. For this reason, fluvial and tidal flood risk are not considered further. The risks from groundwater, foul sewers and artificial sources of flooding have also been assessed as negligible.

5.1.2 Whilst the EA's surface water flood mapping[1] indicates that the majority of the application site is currently at a very low risk of surface water flooding (less than 0.1% AEP), there are several areas at low (1% to 0.1% AEP) or greater risk of surface water flooding (Figure 2.5). Further consideration of surface water flood risk is therefore required.

Sequential and exception tests

5.1.3 As the application site is located in Flood Zone 1, these are considered met and are not considered further. With regards to the sequential layout of the development in order to direct development to the lowest areas of flood risk, the locations of the individual elements of the Proposed Development is dictated by the existing infrastructure layout. This limits the ability to avoid the mapped areas of surface water flood risk. Instead, recommendations on suitable mitigations are provided.

Design levels and exceedance flows

5.1.4 To mitigate the risk from surface water flooding within the application site, several standard mitigation measures are proposed:

1. Finished Floor Levels (FFLs) of the ground floor of new buildings should be set so as to provide an additional level of freeboard within the application site. To manage the risk of flooding following intense rainfall events, a threshold of at least 150mm is recommended. Where new development is proposed near areas of mapped surface water flood risk consideration to further raising will be given, this will be based on balancing the need to provide suitable access and the operational consequences if flooding was to occur. This is on the basis of the significant impermeable areas adjacent to buildings;

2. In specific areas of surface water flood risk, additional localised ground profiling, walls and bunds may be required (i.e. to protect access points to any basement or service areas, and utility or plant rooms and ducts); and

3. Exceedance pathways should be maintained and not blocked or concentrated so as to increase flood risk to existing development located on and off-site. Exceedance flows should be managed on site, by routing flows to the least sensitive areas (i.e. on site this would be greenspace, car parking areas).

5.1.5 Table 5.1 provides a comparison of the location of the development proposals. Figure 5.1 shows the key elements of the Proposed Development with the EA's surface water flood risk mapping overlain.

Table 5.1 Surface water flood risk management measures

Area	Component	Full/outline planning permission	Level of surface water flood risk and proposed mitigation measures
Northern	Expansion of the existing terminal Building	Full/Detailed	• Surface water flow pathways or ponding (high/medium/low risk) are shown in this area, to the south of the existing building, and passing from the apron and pier area around the western and eastern ends of the existing terminal building. • Mitigations: apply 1, 2 and 3.
	Service Yard	Outline	• Surface water flow pathways (high/medium/low risk) are shown in this area, passing from the apron and pier area around the western edge of the terminal building. • Mitigations: apply 1, 2 and 3.
	Multi-storey car park	Outline	• Located in an area of 'very low' risk of surface water flooding. Asset of limited sensitivity to surface water flooding. • Mitigations: N/A
	Gyratory road with internal surface car parking	Outline	• To the north east of this component, there are areas of surface water flooding (low risk) that drain from north to south.
Central	Eastern taxiway link	Outline	• Located in an area of 'very low' risk of surface water flooding. Asset of limited sensitivity to surface water flooding. • Mitigations: N/A
	Taxiway widening (and fillets)	Outline	• Includes three areas of widening, two are in an area at 'very low' risk of surface water flooding. The section between taxiways Delta and Foxtrot passes through an area at high/medium/low risk. • Mitigations: existing surface water accumulation would be managed either by diverting this water to the adjacent surface water drainage system, or if feasible ground reprofiling to re-provide storage.
Southern	Extension to the Silver Zone Car Park (Phase 2)	Full	• Located in an area of 'very low' risk of surface water flooding. Asset of limited sensitivity to surface water flooding. • Mitigations: N/A
A38 highways improvements			
A38	Highway improvements	Full	• Existing flow pathway from north-east corner of Bristol Airport and Downside Road plus runoff from this section of the A38 itself ponds and drains towards Lulsgate Quarry and Winford. • Mitigations: where possible 3, although the existing situation will largely remain as it reflects runoff accumulating from a much wider area. Betterment provided via directing an area in excess of the net new impermeable to a new soakaway constructed to the 1% AEP + climate change allowance standard.

Table 5.1 is based on Table 2.2, excluding development elements excluded as having no flood risk/drainage implications.

Surface water flood risk bands: High: greater than 3.33% AEP; Medium: between 3.33% and 1% AEP; Low: between 1% and 0.1% AEP; and Very Low: less than 0.1% AEP.

5.2 Surface water drainage and SuDS

5.2.1 Given the scale of the application site and the individual components of the Proposed Development, the management of surface water runoff is a key requirement to ensure that flood risk is managed so as not to increase both on-site flood risk (to existing and Proposed Development) and to existing development located off-site.

5.2.2 Section 4 and the associated Drainage Strategies (for Bristol Airport see Appendix D and for the A38 see Appendix E) detail the proposed surface water drainage arrangements. All new drainage systems will be designed to manage runoff to the 1% AEP event + climate change allowance and incorporate sustainable drainage principles. The drainage proposals include for the management of exceedance flows (Section 4.8), and water quality (Section 4.6). Adherence to, and incorporation of these design principles, will ensure that the risk of flooding from additional runoff and the associated drainage system and SuDS is managed in accordance with the requirements of the NPPF[2].

5.2.3 Overall, where elements of existing drainage systems are upgraded this will provide a betterment over existing arrangements, as the future drainage system in these areas will be designed to higher standards, holding back more runoff and slowly releasing this to ground, compared to the existing drainage system in these areas.

6. Conclusions and recommendations

6.1.1 The following conclusions are made:

The application site has been demonstrated to be situated within EA Flood Zone 1. All development will therefore be located within Flood Zone 1. The location meets the aims of the NPPF[2] Sequential Test;

An assessment of tidal, fluvial, artificial and groundwater flood risk has shown that the application site is at a very low to low risk of flooding from these sources;

The majority of the application site is also shown to be at very low risk of surface water flooding. However, there are several areas of the application site where surface water flood risk is classified as low, medium or high. Appropriate design mitigations have been identified (Section 5) for the elements of the Proposed Development that interact with these areas. Incorporation of these measures will ensure that flood risk from this source is appropriately managed;

SuDS, incorporating SuDS principles have been designed to support both components of the Proposed Development located at Bristol Airport, and the adjacent A38 highway improvements (Section 4). All runoff will be managed on-site via infiltration. This will ensure that the Proposed Development mimics the natural hydrological cycle as closely as possible, and runoff rates leaving the site are kept at or below greenfield rates and volumes. These have been designed to the 1% AEP + climate change allowance event as required by NPPF. The design proposals also include suitable measures for the management of water quality and exceedance flows. The drainage system designs are considered to comply with the guidance provided in CIRIA C753[4], and the *West of England Sustainable Drainage Developer Guide*[26]. Appropriate detail had been incorporated in the designs commensurate with the type of planning permission sought (outline). Full details are provided in the associated Drainage Strategies (for Bristol Airport (Appendix D) and for the A38 highway improvements (Appendix E));

A suitable foul drainage system (see Appendix D) has been designed with the required capacity to meet the expected foul flows associated with the growth of Bristol Airport. Agreement has been reached with Wessex Water with regards to the discharge rates; and

With the incorporation of these measures, flood risk will be suitably managed both on and off-site, both currently and with future climate change.

6.1.2 The following key recommendations are made:

The final detailed drainage designs will need to include for sufficient water quality measures to manage the risk of pollution to the limestone aquifer beneath the application site. The designs should be compliant with the requirements of C753[4], as outlined in Section 4.6 of this FRA;

The detailed design of each element of the Proposed Development and associated drainage system should include for the principles of designing for exceedance to utilise greenspace and roads or car parking to convey and store exceedance flows;

Where identified as a requirement (see Table 5.1), appropriate raising of FFLs and localised land reprofiling should also be included to aid the management of risk from surface water flooding;

The proposed drainage systems will need to be confirmed as acceptable by the LLFA (NSC) in terms of compliance with design guidance and standards. As the soakaways will require Environmental Permits (either for existing soakaways, or construction of additional soakaways) for the discharge to the aquifer beneath the site, the EA will also need to approve the proposals;

For elements of the Proposed Development for which outline planning permission is sought, detailed design information will need to be subsequently developed to discharge the relevant future planning conditions before the start of construction;

Drainage systems on-site will be owned and maintained by BAL. Operating procedures will be updated to include for the briefing of staff on emergency procedures (in the case of accidents or spillages), and to include for the future maintenance of these assets;

Provisions for the adoption and maintenance of the drainage systems associated with the A38 highway improvements will need to be agreed with the HA and LLFA - NSC; and

Additional location specific infiltration testing will be required to inform the final design and sizing of the proposed soakaways.

Appendix A Proposed Development Masterplan

Rev no:	Date:	Amendment:	Drwn by:	Chk'd by:

TODD ARCHITECTS
2ND FLOOR TITANIC HOUSE,
6 QUEENS ROAD, BELFAST
BT3 9DT,
T +44 (0) 28 9024 5587,
E INFO@TODDARCH.CO.UK

TODD

Status: PLANNING	Client: BRISTOL AIRPORT
Date: 05/12/2018	Project Name: **12 MPPA PLANNING APPLICATION**
Dwn by: EH / Ckd by: SF	Drawing Title: PROPOSED SITE PLAN
Scale: 1:2500 / Page: A0	Drawing No: **17090-00-100-407** / Revision: **00**

TODD ARCHITECTS
2ND FLOOR TITANIC HOUSE,
6 QUEENS ROAD, BELFAST
BT3 9DT,
T +44 (0) 28 9024 5587,
E INFO@TODDARCH.CO.UK

Rev no:	Date:	Amendment:	Drwn by:	Chk'd by:

Status: PLANNING	Client: BRISTOL AIRPORT
Date: 05/12/2018	Project Name: **12 MPPA PLANNING APPLICATION**
Dwn by: DJA / Ckd by: EH	Drawing Title: PROPOSED SITE PLAN - NORTH
Scale: 1:1250 / Page: A0	Drawing No: **17090-00-100-408** / Revision: **00**

0 50m 100m 200m

EXISTING BUILDINGS

EXISTING APRON / HARD STANDING

PROPOSED IMPROVEMENTS TO RUNWAYS / TAXIWAYS

LANDSCAPING - REFER TO THE INTEGRATED / EMBEDDED LANDSCAPE, VISUAL & ECOLOGY MASTERPLAN

PLANNING APPLICATION BOUNDARY

Rev no:	Date:	Amendment:	Drwn by:	Chk'd by:

TODD ARCHITECTS
2ND FLOOR TITANIC HOUSE,
6 QUEENS ROAD, BELFAST
BT3 9DT,
T +44 (0) 28 9024 5587,
E INFO@TODDARCH.CO.UK

Status: PLANNING		Client: BRISTOL AIRPORT	
Date: 05/12/2018		Project Name: **12 MPPA PLANNING APPLICATION**	
Dwn by: DJA	Ckd by: EH	Drawing Title: PROPOSED SITE PLAN - CENTRAL	
Scale: 1:1250	Page: A0	Drawing No: **17090-00-100-409**	Revision: **00**

DISCLAIMER:
TODD ARCHITECTS CONFIRM THAT RECIPIENTS CAN ONLY RELY ON APPROVED CONTROLLED DOCUMENT FORMATS IN CONSTRUCTION PROJECTS. CONTROLLED DOCUMENT FORMATS INCLUDE ORIGINAL HARD COPY DRAWINGS ISSUED BY TODD ARCHITECTS, OR UNPRINTED PDF/DWF IMAGES OF DRAWINGS RECEIVED FROM TODD ARCHITECTS. TODD ARCHITECTS CANNOT ENSURE THE ACCURACY OF DRAWINGS, USED IN AN UNCONTROLLED DOCUMENT FORMAT WHICH MAY BE ALTERED OR MISINTERPRETED AS A RESULT OF HUMAN ERROR ON THE PART OF THE RECIPIENT, OR AS A RESULT OF THE INCOMPATIBILITY OF COMPUTER SYSTEMS WHEN OPENING OR PRINTING COMPUTER AIDED DRAWINGS. UNCONTROLLED DOCUMENT FORMATS INCLUDE; COMPUTER AIDED DESIGN FILES, PRINTS WHICH HAVE BEEN CREATED BY THE RECIPIENT FROM NON-CONTROLLED FILE FORMATS, PHOTOCOPIES OF ORIGINAL HARD COPY DRAWINGS FROM TODD ARCHITECTS, DRAFT DRAWINGS SUPPLIED BY TODD ARCHITECTS FOR INFORMATION PURPOSES ONLY. TODD ARCHITECTS ACCEPT NO RESPONSIBILITY FOR ANY LOSS OR DAMAGE ARISING AS A RESULT OF RELIANCE BY THE RECIPIENT OR ANY THIRD PARTY ON UNCONTROLLED DOCUMENT FORMATS, RELIANCE UPON WHICH WILL BE ENTIRELY AT THE RISK OF THE RECIPIENT.

CONTRACTORS ARE RESPONSIBLE FOR THE VERIFICATION OF ALL DIMENSIONS ON SITE AND THE ARCHITECT IS TO BE INFORMED OF ANY DISCREPANCY. DO NOT SCALE FROM THIS DRAWING. USE FIGURED DIMENSIONS ONLY.

Rev no:	Date	Amendment	Drwn by:	Chk'd by:

TODD ARCHITECTS
2ND FLOOR TITANIC HOUSE,
6 QUEENS ROAD, BELFAST
BT3 9DT,
T +44 (0) 28 9024 5587,
E INFO@TODDARCH.CO.UK

TODD

Status: PLANNING	Client: BRISTOL AIRPORT
Date: 05/12/2018	Project Name: **12 MPPA PLANNING APPLICATION**
Dwn by: DJA / Ckd by: EH	Drawing Title: PROPOSED SITE PLAN - SOUTH
Scale: 1:1250 / Page: A0	Drawing No: **17090-00-100-410** / Revision: **00**

Appendix B Lead Local Flood Authority Consultation

INTERNAL MEMORANDUM

FROM: Flood Risk Management Team

Date: 11 July 2018

Application: Environmental Scoping Opinion to determine the scope of an Environmental Impact Assessment for a future application for the proposed expansion of the airport to accommodate 12 million passengers per annum.

Reference Number: 18/P/3502/EA2

Location: Bristol International Airport, North Side Road, Felton, Bristol

---

Formal comments regarding the above.
The Flood Risk Management (Drainage) Team comments are advisory as this is an EIA screening opinion

Advisory:
The site lies within an Environment Agency Source Protection Zone 2, and a low risk area for ground water flooding. The surface water flood maps show flooding at 1 in 30 on Downside Road and A38.

The LLFA only records of flooding in the area are at the following locations

- On the corner of Cooks Bridle Path and Downside Road, which includes both garden and highway flooding
- On the A38 between the airport roundabouts – this may be due to highway drainage capacity issues
- At the Airport Tavern Lulsgate Bottom in 2012 – although work was carryout by the highways authority to a soakaway in 2013 and we have no records since
- We have no records of groundwater or other sources of flooding

Sustainable drainage principles should be applied to the site and we are aware that soakaways are already used within the airport complex. British Geological Survey infiltration map suggests that that infiltration will be possible, however due to the source protection zone pollution control may be required, this should be confirmed with BRE 365 infiltration tests in the location of any proposed soakaways.

Our guidance document on sustainable drainage should be followed and we recommend that where possible drainage is integrated into the green infrastructure spaces https://www.n-somerset.gov.uk/wp-content/uploads/2015/12/West-of-England-sustainable-drainage-developer-guide.pdf

Any watercourse (rhyne) network should remain open and allow easy access for maintenance and inspections, any EIA should assess the environment in and around the network.

There must be no interruption to the surface water drainage system of the surrounding land as a result of the operations on the site. Provisions must be made to ensure that all existing drainage systems continue to operate effectively and that land owners upstream and downstream of the site are not adversely affected, therefore any EIA should assess the influence flooding might have on the environment both on site and on neighbouring land.

Appendix C Environment Agency Consultation

Mr N Underhay
North Somerset Council
Development Control
Town Hall
Walliscote Grove Road
Weston-super-Mare
North Somerset
BS23 1UJ

Our ref: WX/2018/131849/01-L01
Your ref: 18/P/3502/EA2

Date: 06 July 2018

Dear Mr Underhay

ENVIRONMENTAL SCOPING OPINION TO DETERMINE THE SCOPE OF AN ENVIRONMENTAL IMPACT ASSESSMENT FOR A FUTURE APPLICATION FOR THE PROPOSED EXPANSION OF THE AIRPORT TO ACCOMMODATE 12 MILLION PASSENGERS PER ANNUM AT BRISTOL INTERNATIONAL AIRPORT, NORTH SIDE ROAD, FELTON, BRISTOL

Thank you for referring the above Environmental Scoping Report, which was received on 20 June 2018.

The Environment Agency can now make the following comments:

GROUNDWATER PROTECTION

Chapter 10; Despite there being no surface water courses within close proximity to the airport, streams at the edge of Broadfield Down are maintained by groundwater base flow. Any development at the airport has the potential to impact on groundwater quality, which in turn could impact on surface waters. A statement to this effect should be included and the risk appropriately determined in Section 11.

11.5.23 & 11.5.26. Please clarify the basis of there being no private water supplies within 2km. Has a water interest survey historically been undertaken across the area to determine this? If not, it cannot be assumed that there are no such interests. The Local Authority records should be checked as they will be complete and list all such sources. Where the risk associated with current and future activities justify, it, a Water Interest Survey should be undertaken to determine if such interests exist.

General Points:

The key theme or pillar of future planned development at the airport, should be to reduce the Environmental impact of the airport. This should consider:

1. The objective of reducing the environmental impact of the airport on the environment & making this more sustainable:

- Reduced transport.
- Reduced environmental risk from parking.
- Reduced environmental risk from fuel & chemical storage, transportation and use across the airport.
- Reducing the risk in line with Water Framework Directive objectives.

2. Remediating land impacted by historic contamination:

- Updating risk assessments to ensure a desk survey has been undertaken to assess the potential contamination risks that may result in ALL potential development areas.
- Prior to any areas being developed to undertake appropriate site investigations, where appropriate to intrusively prove the presence or absence of contamination.

3. The Airports should be designed so as to reduce the risk to water resources, where possible using sustainable urban drainage together with appropriate pollution prevention mechanisms such as appropriate designed interceptors etc.

4. The airport should be designed so as to reduce the risk from foul drainage. This may result in the need for further treatment at nearby STW to reduce the risk to groundwater body and associated receptors.

5. The airport design and infrastructure should be resilient to climate change. This may require the upgrade of soakaways, interceptor capacity etc. to reflect any changes in rainfall run-off etc.

WASTE

The scope should consider waste arisings from the development and how these will be managed. Any contaminated land must identified. The scope needs to consider waste management options with aims to minimise waste arisings. The scope should consider if any permits or exemptions will be required during the development.

SURFACE WATER DRAINAGE

The Lead Local Flood Authority should be consulted to ensure their interests are not adversely affected.

We have sent a copy of this letter to the applicant for information.

Please quote the Agency's reference on any future correspondence regarding this matter.

Yours faithfully

Richard Bull
Sustainable Places - Planning Advisor
Direct dial 02030 250287
Direct fax 01278 452985
Direct e-mail nwx.sp@environment-agency.gov.uk

End

Appendix D Hydrock Drainage Strategy (main airport site)

Hydrock

Bristol Airport 12mppa Expansion

Foul and Surface Water Drainage Strategy

For Bristol Airport

Date: *6 December 2018*

Doc ref: *BAE-HYD-XX-XX-RP-D-5001*

DOCUMENT CONTROL SHEET

Issued by	Hydrock Consultants Limited Over Court Barns Over Lane Almondsbury Bristol BS32 4DF	Tel: 01454 619533 Fax: 01454 614125 www.hydrock.com
Client	Bristol Airport	
Project name	Bristol Airport 12mppa Expansion	
Title	Foul and Surface Water Drainage Strategy	
Doc ref	BAE-HYD-XX-XX-RP-D-5001	
Project no.	C-09194	
Status	S2 - For Information	
Date	06/12/2018	

Document Production Record		
Issue Number	P05	Name
Prepared by		Richard Hughes Eng Tech TMICE
Checked by		
Approved by		

Document Revision Record			
Issue Number	Status	Date	Revision Details
P02	S2	02/10/2018	Taxiway areas added.
P03	S2	24/10/2018	MSCP/Interchange & Northern Parking excluded from 12 mppa proposals.
P04	S2	16/11/2018	Amended to Client comments.
P05	S2	05/12/2018	Updated masterplan.

Hydrock Consultants Limited has prepared this report in accordance with the instructions of the above named client for their sole and specific use. Any third parties who may use the information contained herein do so at their own risk.

CONTENTS

Appendices

1. INTRODUCTION

This report has been prepared by Hydrock on behalf of Bristol Airport in support of a Planning Application to be submitted to North Somerset Council for the proposed interim 12 mppa (million passengers per annum) expansion scheme of Bristol Airport.

This report sets out the foul and surface water drainage strategies that will draw upon historic and current information with a view to utilising existing systems where possible whilst ensuring that the final proposals meet current day standards.

2. SITE INFORMATION

2.1 Location and Setting

Bristol Airport is located approximately 4 miles to the south-west of Bristol, adjacent to the A38.

The airport is situated on the top of a plateau of high ground called Broadfield Down and is surrounded by predominantly open, rural, undulating countryside with extensive woodland areas to the west and open farmland. There are a number of small residential settlements immediately to the north and east of the site.

The site is bounded by Downside Road to the north, with agricultural / pasture use fields beyond; small woodland areas to the northeast and northwest; and, residential properties to all other boundaries.

A site location plan is included in Appendix A.

2.2 Topography

The site has a high point of 190m AOD towards the western end of the main runway and falls generally to the north-west and south-east.

2.3 Existing Site Features

The airport site is characterised by areas that ae described as either being 'landside' or airside'.

'Landside' features generally comprise the main terminal building, car parks, with both permeable and impermeable surfacing, access roads, a multi-storey car park, various outbuildings, a hotel, an administration block and landscaping.

'Airside' features include impermeable surfaces in the form of runways, taxiways, aircraft aprons, access roads, the main terminal buildings, a fuel farm, control tower and associated infrastructure buildings.

2.4 Proposed Development

The proposal is for an Interim Planning Application for works to enable expansion of the capacity of the airport in order to be able to cater for up to 12 million passengers per annum, (12 mppa).

The proposed works will include, inter alia, the following elements;

- West Terminal Extension (Phases 2 and 2A)
- New Service Yard
- Transport Interchange and Multi-Storey Car Park (MSCP2)
- Multi-Storey Car Park (MSCP3)
- New Gyratory Road
- Northern Surface Parking

- Surface Parking to Cogloop 2 Land
- South Terminal Extension / New Arrivals VCC (Bussing)
- Taxiway Extensions
- Walkway to East Pier

It should be noted that the Transport Interchange/MSCP2 and Northern Surface Parking works are not part of the 12 mppa application but have previously been approved under the earlier 10 mppa application. However, they have been included in this report as the works will have been completed prior to the current proposals coming forward and therefore will be a change to existing baseline conditions.

A proposed layout plan is included in Appendix B.

3. DRAINAGE STRATEGY – SURFACE WATER

3.1 Surface Water

3.1.1 Site Wide Pre-Development

The site is served by an entirely private drainage systems which is owned and maintained by Bristol Airport.

Currently, surface water runoff from both 'landside' and 'airside' features is collected via a series of gulleys, drainage channels and roof drainage systems into a positive piped network. Ultimately, all runoff discharges to soakaway features located throughout the site and are variously of either perforated ring construction, tanks or filter trenches. Where appropriate, water is passed through petrol/oil interceptors before discharging to the soakaways.

The drainage system has been added to, amended, or abandoned over time as various parts of the site have been redeveloped. Not all of these works have been recorded and therefore there is no definitive, overall record plan of the current drainage network. It should also be borne in mind that there is a more or less continuous phase of improvement works being carried out which affect and alter the drainage network. It is intended to produce a definitive record of the drainage systems as part of these works.

Various historical record plans have been collated and amalgamated into a single drawing. A copy of the plan showing the combined existing drainage information, drawing no. BAE-HYD-XX-XX-DR-D-2001, is included in Appendix C.

A more detailed description and assessment of the existing drainage for each of the specific application areas is set out in the relevant sections below.

3.1.2 Site Wide Post-Development

In accordance with the Sustainable Drainage Systems (SUDS) management train[1], rainfall run-off should be reused, infiltrated to ground, discharged to local watercourses or discharged to a local sewer network (in that order of priority). This approach is supported by Building Regulations Part H and Paragraph 080 of NPPG.

From previous work on the airport site, the strategy will be to infiltrate all surface water runoff from the proposed application works to ground following the principles that have been established to date.

Due to the nature of the site, the provision of open water features such as ponds or swales is not encouraged in order to reduce the potential risk from bird strikes. For this reason these types of SuDS features ae not included in the proposals and water quality will be addressed through the provision of filtration devices and oil interceptors, as appropriate.

Infiltration testing has previously been undertaken across the site as part of previous planning applications and detailed designs. Across the northern section of the airport site an average infiltration value of 4.2×10^{-5} m/s was found for the area in the vicinity of the Set Down/Pick Up Car Park and Hotel area and an average value of 5.13×10^{-5} m/s was established across the surface car parks. Previous infiltration testing has been undertaken for the 'Cogloop 1' parking area to the south of the runway

[1] CIRIA (2015) CIRIA C753 The SuDS Manual

established an average infiltration rate of 3.35 x 10^{-5} m/s. This value has been used for the initial assessment of the proposed Cogloop 2 parking extension.

Additional site testing will be carried out at the specific soakaway locations prior to construction and the design details amended as necessary.

All soakaways will be designed to cater, as a minimum, for the 1 in 30 year storm event and will be tested for the 1 in 100 year event plus an allowance of +30% for climate change in order to assess the performance of the structure. The figure of +30% has been selected in accordance with the advice set out in the DEFRA guidance note, "Flood risk assessments: climate change allowances". Table 2 of this document provides a range of allowances dictated by the design life of the scheme and an assessment of the application of either the Central or Upper End banding as appropriate. In the case of the scheme being considered, it is unlikely that it will remain unchanged beyond a period of 50 years. This would place the development lifetime on the cusp between the 2040 to 2069 and 2070 to 2115 periods for which rainfall increases are specified. For the 2070 to 2115 period, a value of +40% is required if the 'Upper end' allowance is used, or +20% if the 'Central' allowance is used. CIRIA SUSDRAIN guidance* indicates that the +20% allowance can be used if runoff in excess of this drainage system design standard up to the +40% standard can be managed safely within suitable areas of the site. However, for this assessment in order to ensure that there is sufficient contingency within the design, a figure of +30% has been used for sizing soakaways/piped drainage. Final climate change allowances (whether +20%, +30% or +40%) would be selected based on subsequent detailed drainage design and available surface storage in each development area.

All soakaway structures shall be located a minimum of 5m from any building.

A detailed assessment of each application element is set out below.

3.2 West Terminal Extension (Phases 2 & 2A), Terminal Canopy and Service Yard

3.2.1 Description

The proposal is for an extension to the western end of the existing terminal building, a new canopy to the northern side of the terminal and the provision of a new Service Yard immediately to the west of the building.

The area of the proposed works is currently occupied by an existing service yard, car parking, buildings (Gate Gourmet), pedestrian areas and an access road.

3.2.2 Existing Site Area and Drainage

As noted above, the area of the proposed terminal building extension, canopy and service yard is currently given over to impermeable areas for car parking, service yards, buildings and roadways.

The existing surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2003.

**https://www.susdrain.org/files/resources/fact_sheets/applying_climate_change_allowances_to_suds_design_draft.pdf*

The site is currently 100% impermeable and is already drained to existing on-site surface water drainage systems. The western end of the Terminal Building currently drains north to point 'A' on the above drawing, ultimately discharging to a soakaway located to the north of MSCP1.

The runoff from the West Apron, Control Tower, Western Walkway, MT Building and associated access roads drain to an oil interceptor located at point 'B' on the plan and then subsequently discharge to a soakaway located under the future MSCP3.

The existing Service Yard and Pick Up/Set Down Car Park and Terminal building frontage are drained by a separate drainage system to point 'C' on the plan. This then discharges to the existing soakaways located in the vicinity of the MSCP1 site.

3.2.3 Development Proposals

The proposal is to extend the western part of the existing terminal building and provide a new canopy to the northern side of the building, thus increasing the amount of roof area. A new Service Yard is also to be provided immediately to the west of the terminal building.

The gross area of the terminal extension is approximately 4,585m^2 (0.459 ha), the canopy 3,330m^2 (0.333 ha) and for the Service Yard is 3,561m^2 (0.356 ha) resulting in total area of 11,476m^2 (1.148 ha).

The provision of the new Service Yard will also result in alterations to the existing Set Down/Pick Up Car Park area.

All areas will require positive drainage systems to be provided.

3.2.4 Drainage Proposals

As described above, the current development area is already 100% impermeable and is drained by an existing surface water system. The opportunity will be taken to remove the need to drain runoff from the Terminal Building, West Apron, Control Tower and surrounding areas north to soakaways that are currently located in the northern car park areas, which will be affected by the proposed Multi-Storey Car Park proposals. New soakaway units will be installed immediately to the north and west of the Terminal Building.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2004.

Previous site investigations within this area of the Airport site have shown an average infiltration value of 4.2×10^{-5} m/s and this value has been used in the calculations for the soakaways described below.

The eastern part of the West Apron will be intercepted by the new drainage systems to serve the Terminal Building extension and Service Yard thus removing some of the impermeable area currently draining to point 'B'. In view of this reduction, it is proposed to retain the existing oil interceptor in this location. Point 'B' will therefore drain to a new cellular soakaway tank, (Soakaway 1), to the south-west of the hotel complex.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. In the latter event, the storage capacity will be exceeded and the additional volume will be accommodated with the combination of an overflow pipe and allowing for a maximum flooded volume of 52m^3 at the soakaway location, which equates to a depth of 100mm. The overflow pipe will discharge to two new linked soakaways constructed along the western boundary of the airport site, (Soakaways 1A and 1B).

The proposed Service Yard and West Terminal Extension will be drained via a new surface water system. This will flow northwards and discharge to a new cellular soakaway tank, (Soakaway 2), located to the east of the Hotel complex as shown on the above mentioned plan. Any existing rainwater pipes and internal surface water drainage points that are being retained will be connected to the new system at appropriate points.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. In the latter event, the storage capacity will be exceeded and the additional volume will be accommodated by allowing for a maximum flooded volume of 176m^3 at the soakaway location, which equates to a depth of 300mm.

In all of the above cases, the flooded volumes will not affect any critical assets.

The existing Set Down/Pick Up Car Park which is being retained and a section of North Side Road immediately to the south of the Hotel complex will continue to drain towards point ‘C’ on the plan. It is proposed that these areas drain to a new soakaway located in the verge immediately south of MSCP3, (Soakaway 3). This soakaway will also cater for the existing highway drainage to the west and north-west of the Hotel complex. It will be necessary to reconfigure the existing highway drainage connections to accommodate changes in sewer alignment and level.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario.

The area under canopy to the northern side of the building is currently pedestrianised and drains to point ‘D’. The provision of a new canopy will extend the impermeable area and it is proposed that this is drained to a new soakaway located immediately to the north.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario.

3.3 Transport Interchange and Multi-Storey Car park (MSCP2)

3.3.1 Description

The proposal is for the construction of a new Transport Interchange and Multi-Storey Car Park (MSCP2) located to the north of the main Terminal Building and to the east of MSCP1.

A new access road will also be constructed immediately to the south and will be served by a revised gyratory system to the east.

It should be noted that these elements are not part of the 12 mmpa application but have been approved under the previous 10 mppa approval. The proposals are however included here as they represent changes that will occur to the existing drainage baseline.

3.3.2 Existing Site Area and Drainage

The Interchange will be built on the site of an existing surface car park.

The existing surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2007.

The site is currently occupied by surface parking comprising Premier Parking, long stay and short stay parking. The former is asphalt paving and is 100% impermeable, the remaining areas are a permeable surfacing.

3.3.3 Development Proposals

The proposal is to provide a new Transport Interchange multi-storey car park, with associated access roads, which will form a direct link to the main Terminal Building.

The gross area of the new car park is 16,730m^2 (1.673 ha) and the access road to the south is 1,531m^2 (0.153 ha).

All areas will require positive drainage systems to be provided.

3.3.4 Drainage Proposals

Approximately 85% of the area of the Interchange site is currently Premier Parking which is fully paved and is positively drained to an existing soakaway, (Soakaway 7) located immediately to the north west which also caters for the existing MSCP1. This soakaway also accommodates the existing runoff from the western part of the Terminal Building, the western service yard and the main access road fronting the Terminal Building. As described in separate sections of this report, that part of the Terminal Building and service yard will be drained to a new soakaway (Soakaway 2). The main access road will also be removed and therefore a significant part of the drained area currently contributing to existing Soakaway 7 will be removed in the redevelopment proposals. Consequently, it is proposed that the western half of Interchange is drained to the existing soakaway as there will be a net decrease in contributing area.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2008.

Previous site investigations within this area of the Airport site have shown an average infiltration value of 5.13×10^{-5} m/s and this value has been used in the calculations for the soakaways described below.

The runoff from the eastern part of the multi-storey car park will be collected via a new piped system and directed to a new cellular soakaway unit, (Soakaway 6), located in the surface car park area immediately to the north-east of the building.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. No flooding will occur in this latter event.

The proposed access road immediately to the south of the Interchange will be drained via a series of road gulleys to a collector pipe flowing west to east in the verge. This will discharge to a new cellular soakaway unit, (Soakaway 8), located in the proposed verge to the south.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. No flooding will occur in this latter event.

3.4 Multi-Storey Car Park (MSCP3)

3.4.1 Description

The proposal is for the construction of a new multi-storey car park located in the north-west corner of the airport site. The car park will effectively form an extension of the adjacent MSCP1.

A new access road will also be constructed immediately to the south.

3.4.2 Existing Site Area and Drainage

The MSCP will be built on the site of an existing surface car park.

The existing surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2005.

The site is currently a mixture of permeable surfacing and asphalt roadways which drain to various soakaway systems.

The site area also includes a number of soakaways that serve the western terminal building, the West Apron, Control Tower area and Set Down/Pick Up area. In order to allow the construction of the MSCP it will be necessary to remove these existing drainage systems and this work has been described elsewhere under the relevant application elements.

3.4.3 Development Proposals

The proposal is to provide a new multi-storey car park with associated access roads which will effectively form an extension to the MSCP1.

The gross area of the new car park is 11,135m^2 (1.114 ha) and the access road to the south is 1,475m^2 (0.175 ha).

All areas will require positive drainage systems to be provided.

3.4.4 Drainage Proposals

In order to allow construction of the MSCP3, it will be necessary to remove the existing soakaways serving the Terminal Building, West Apron, Control Tower and surrounding areas. New soakaway units will be installed immediately to the north and west of the Terminal Building and are described in more detail int the relevant sections for these areas.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2006.

Previous site investigations within this area of the Airport site have shown an average infiltration value of 5.13 x 10^{-5} m/s and this value has been used in the calculations for the soakaways described below.

The runoff from the multi-storey car park will be collected via a new piped system and directed to a new cellular soakaway unit, (Soakaway 4), located on the northern side of the building.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. In the latter event, the storage capacity will be exceeded and the maximum flooded volume of 40m^3 will be accommodated in the surface car park in and around the soakaway area. The existing bund along the northern boundary of the airport boundary will prevent any flood water escaping from the site. The flooded volumes will not affect any critical assets.

The proposed access road immediately to the south of the MSCP3 will be drained via a series of road gulleys to a collector pipe flowing west to east in the verge. This will discharge to a new cellular soakaway unit, (Soakaway 5), located in the proposed verge to the south of the existing MSCP1.

The soakaway has been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. No flooding will occur in this latter event.

3.5 New Gyratory Road System

3.5.1 Description

A new gyratory road system is to be constructed in order to provide access to the proposed Transport Interchange and the reconfigured surface car a parking. This highway network will also include the main revised access into the airport from the A38.

3.5.2 Existing Site Area and Drainage

The area of the proposed gyratory road system is currently occupied by long stay and short stay car parks, nearly all of which are permeable surfaces.

There are no positive drainage systems serving the car parks however, the area does include soakaways and a petrol interceptor which cater for the main access road into the airport, the eastern part of the Terminal Building and the airside aprons.

The works will also include realignment of the main access road which is currently drained by a positive drainage system discharging to soakaways within the existing car park areas.

The existing surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2009.

3.5.3 Development Proposals

The proposed gyratory roads will be constructed with an impermeable asphalt surface and will allow circulatory access to the various surface car parks and the transport Interchange.

3.5.4 Drainage Proposals

As noted above, there a number of existing soakaways and a petrol interceptor which cater for surface water runoff from the existing Terminal Building and aircraft apron areas. These will be retained but, in the case of the units to the north of the proposed gyratory road system will need to be relocated in order to remove them from lying immediately below the new road surface.

The proposed road surface will be drained via gulleys and a positive piped drainage system ultimately discharging to a series of soakaway units.

The approach roads from the east will drain to multiple perforated concrete ring soakaways. For the purposes of preparing a drainage strategy, it has been assumed that each soakaway will cater for approximately $800m^2$ drained area each. These soakaways will be redesigned individually at the detailed design stage when road levels and gulley positions have been fixed. The purpose of this strategy is to identify the approximate locations and numbers of soakaways.

The soakaways have been designed to accommodate the 1 in 30 year storm event and tested against the 1 in 100 year plus 30% climate change scenario. No flooding will occur in this latter event.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2010.

3.6 Northern Surface Car Parking

3.6.1 Description

The existing long and short stay car parks are to be reconfigured, where required, in order to accommodate the proposed works that are planned in the immediate area, i.e. Multi-Storey Car Park, Transport Interchange and Gyratory Road System.

It should be noted that these elements are not part of the 12 mmpa application but have been approved under the previous 10 mppa approval. The proposals are however included here as they represent changes that will occur to the existing drainage baseline.

3.6.2 Existing Site and Drainage

The existing car parks are constructed with permeable surfaces and asphalt search lanes.

There are no positive drainage systems serving the car parks however, the area does include soakaways and a petrol interceptor which cater for the main access road into the airport, the eastern part of the Terminal Building and the airside aprons.

The existing surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2011.

3.6.3 Development Proposals

The existing parking will be reconfigured to suit the other development proposals in the immediate vicinity.

Search lanes will be formed in an impermeable asphalt construction whilst the parking bays will be formed with a permeable surfacing of reinforced grass/gravel.

3.6.4 Drainage Proposals

The impermeable search lanes will be crossfalled in order to shed runoff towards the permeable parking bays.

During frequent storm events runoff will drain through the permeable surfacing and infiltrate naturally to ground. In addition, infiltration trenches will be provided running in a west-east direction in order to cater for more intense rainfall events thus providing further storage volume.

An existing landscape bund to the northern perimeter of the site will provide a containment feature preventing exceedance flows from leaving the site.

The drainage system will be designed such that there will be no flooding up to and including the 1 in 30 year event. The system will also be modelled for the 1 in 100 year event with an allowance of +30% for climate change in order to check the performance of the network and to identify the locations and degree of any flooding. For the purposes of this strategy, a 120m long drainage length has been assumed.

Previous geotechnical investigations have shown an infiltration value of 5.13×10^{-5} m/s through the site.

Lateral infiltration trenches will be provided in an east-west axis in order to intercept water shedding across the parking areas generally in a south-north direction.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2012.

3.7 Surface Parking to Cogloop 2 Land

3.7.1 Description

The proposal is for an extension to the existing Silverzone Cogloop 1 car park area on the southern side of the airport site.

The current car park areas consist of asphalt search lanes with porous gravel parking bays draining direct to ground.

It is intended that the Cogloop 2 proposals will follow those previously employed on Cogloop 1.

3.7.2 *Existing Site and Drainage*

Cogloop 2 is currently a grassed agricultural field. The site geology generally consists of a reddish brown clayey slightly sandy gravel, overlying jointed limestone bedrock.

The gross area is approximately 4.9 hectares and slopes generally from north to south with an average fall of 1 in 20 with a central band where the fall increase to 1 in 10.

As the site is currently undeveloped it is unlikely that there are any existing drainage systems present.

3.7.3 *Development Proposals*

The proposal is to provide some 2,700 car parking spaces with associated search lanes. Access will be formed through the existing landscaping bund on the northern boundary of the site from the Cogloop 1 car park.

Search lanes will be formed in an impermeable asphalt construction whilst the parking bays will be formed with a permeable surfacing of reinforced grass/gravel.

3.7.4 *Drainage Proposals*

The impermeable search lanes will be crossfalled in order to shed runoff towards the permeable parking bays.

During frequent storm events runoff will drain through the permeable surfacing and infiltrate naturally to ground. In addition, infiltration trenches will be provided running in a west-east direction in order to cater for more intense rainfall events thus providing further storage volume.

A 2m high landscape bund will be provided around the perimeter of the site and the section of the southern boundary will therefore provide a containment feature preventing exceedance flows from leaving the site.

The drainage system will be designed such that there will be no flooding up to and including the 1 in 30 year event. The system will also be modelled for the 1 in 100 year event with an allowance of +30% for climate change in order to check the performance of the network and to identify the locations and degree of any flooding. No flooding is predicted to occur in this event.

Previous geotechnical investigations have shown infiltration values ranging between 1.73×10^{-5} and 4.19×10^{-5} m/s immediately to the north of the site. Further site specific testing will be carried out at the detailed design stage however, for the purposes of this assessment, the average value of the range will be taken, (3.35×10^{-5} m/s).

Lateral infiltration trenches will be provided in an east-west axis in order to intercept water shedding across the parking areas generally in a north-south direction.

The proposed surface water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2002.

3.8 South Terminal Extension / New Arrivals VCC (Bussing)

3.8.1 Description

The proposal is to extend the southern terminal building and include for additional 'new arrivals' facilities.

3.8.2 Existing Site and Drainage

The area of the site is currently 100% paved being occupied by access roads and pedestrian areas. Runoff from these areas currently drain to existing positive drainage systems and discharge to the east and north of the Terminal building, ultimately draining to soakaways located in the northern surface car parks.

3.8.3 Development Proposals

The proposals will extend the Terminal building footprint by approximately 2,000m^2 (0.200 ha) to the south and include new bussing units.

3.8.4 Drainage Proposals

As noted above, the area of the proposed extension works is already occupied by impermeable, drained areas. There will therefore be no increase in runoff resulting from the proposed works. It is proposed that the outfall drainage is retained and that connections to the system are amended to suit.

3.9 Taxiway Extensions

3.9.1 Description

The proposal is to provide extensions to existing taxiway areas on the northern and eastern sections of the current runway/taxiway hardstanding areas.

3.9.2 Existing Site and Drainage

The areas over which the extensions will be built are currently grassed. They are immediately adjacent to existing taxiways which shed surface water runoff to the edges of the hardstanding areas. Surface water is collected via infiltration trenches running parallel with the edge of the hardstandings.

3.9.3 Development Proposals

The proposals comprise extension fillets to the edges of the northern taxiway at five separate locations, references T1 to T5 as shown on drawing no BAE-HYD-XX-XX-DR-D-2016 and a further East Taxiway extension immediately to the east of taxiway Alpha as shown on drawing no. BAE-HYD-XX-XX-DR-D-2015.

The total area of the extensions is 22,546m^2 (2.255 ha), for the northern taxiway and 7,151m^2 (0.715 ha) for the east taxiway.

3.9.4 Drainage Proposals

As described above, the existing taxiways currently shed water to the edge of the impermeable areas where the runoff then discharges to existing infiltration trenches.

The development proposals will increase the amount of hardstanding and therefore additional soakaway features will be required in order to cater for the additional run-off. For areas T2, T3 and T4 it is proposed to construct new infiltration trenches which will accommodate both the existing taxiway runoff and that resulting from the extension areas.

The infiltration trenches will be designed such that there will be no flooding up to and including the 1 in 30 year event. The system will also be modelled for the 1 in 100 year event with an allowance of +30% for climate change in order to check the performance of the network and to identify the locations and degree of any flooding.

There are no geotechnical investigations for the runway/taxiway areas due to the proximity of air traffic and therefore the minimum infiltration value of 2.5 x 10^{-5} the north of the site has been used. Further site specific testing will be carried out at the detailed design stage to confirm the actual values.

The calculations are included in Appendix J and show that flooding will occur in the Q100 +30% event in infiltration trenches T2, T3, T4 and T5 with a volumes of 20^3, 27m^3, 37m^3 and 30m^3 respectively. In all cases the flooded volume will naturally fall towards the grassed infield between the taxiway and the runway. The extent of the available area results in negligible depth of standing water even assuming that no natural infiltration will take place across the infield with no adverse impacts on the airfield infrastructure.

The extreme western taxiway extension (T1) and the East taxiway extension will both be served by multiple precast concrete soakaway rings installed in stone filled pits, as shown on drawing nos. BAE-HYD-XX-XX-DR-D-2015 and 2016. These soakaways have been design using the same criteria as for the infiltration trenches discussed above however there is no flooding for the T1 units in the Q100 +30% event and nor for the East extension. These volumes can be readily accommodated in the adjacent grassed areas with no adverse impacts on the airfield infrastructure.

3.10 Walkway to East Pier

3.10.1 Description

The proposal is to provide a new elevated walkway as access to the proposed East Pier.

3.10.2 Existing Site and Drainage

The area of the site is currently 100% paved being occupied by access roads, parking areas, buildings and pedestrian areas. Runoff from these areas currently drain to existing positive drainage systems and discharge to the east of the Terminal building, ultimately draining to soakaways located in the immediate area and the northern surface car parks.

3.10.3 Development Proposals

The proposals will be to provide a covered, elevated walkway form the eastern side of the Terminal Building.

3.10.4 Drainage Proposals

As noted above, the area of the proposed extension works is already occupied by impermeable, drained areas. There will therefore be no increase in runoff resulting from the proposed works. It is proposed that the outfall drainage is retained and that connections to the system are amended to suit.

4. DRAINAGE STRATEGY -FOUL WATER

4.1 Description

The majority of the application elements do not have foul drainage implications. The exception to this are the Terminal Building extension proposals and therefore the following sections relate to this part of the development.

4.2 Existing Site and Drainage

The existing foul water drainage network for the airport is split between two catchments, one to the south of the runway and the other to the north.

The southern catchment is pumped north, and discharges into the northern systems near the north-east corner of the airport site at which point the flows are discharged, via a pump, to an existing public foul sewer in Downside Road at Wessex Water manhole reference ST 51650604. The public sewer is then routed out to the A38 and then flows via the villages of Felton, Winford ultimately discharging to the Wessex Water sewage treatment works (STW) at Chew Stoke, Wessex Water STW reference 13058.

The Environment Agency currently lists the treatment works as being due for an upgrade in 2019 however, Wessex Water have confirmed that the works have now been assessed for investment in their next business plan period (2020-2025) with a low probability of development occurring. No major works are planned at this time. It has also been noted that approximately 60% of the biological load received at the STW is generated by the airport site.

As far as can be established, the foul and surface water drainage systems are separate and therefore rainfall events should not have any effect on flows within the foul systems.

Wessex Water have a current restriction of a maximum discharge rate from the airport site of 12 l/s and, under the previous 10 mppa application, it was established that a storage tank was to be provided in order that peak flows exceeding this value could be retained for discharge at off-peak times.

The existing foul water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2013.

4.3 Development Proposals

The application proposals which will impact on the foul drainage system are as follows;

- Western extension to main Terminal Building
- Southern extension to Terminal Building
- Removal of existing Administration Block to southern catchment
- Removal of 'Gourmet Gateway' building (anticipated early 2019)

The remainder of the application proposals will not have any foul drainage implications.

4.4 Drainage Proposals

As noted above, increased flows will be generated by the extension of the Terminal Building but will be partially offset by the removal of the Administration Block and the 'Gourmet Gateway' building.

The Administration Building and Fire Station are being relocated to the southern catchment which is served by an existing pumping station. The pumping rate will be maintained at the current value and therefore there will be no material change to flow rates arising from these changes.

The revised flow discharge rates for the proposed development will therefore be as follows;

Main Terminal Building

The planning application is for a passenger capacity of 12 million per annum.

The peak month for passenger numbers is August and previous analysis carried out for the 10 mppa application has established that this is approximately 11% of the yearly capacity. On this basis, the peak number of passengers per day, for the peak month will be,

$$\frac{12{,}000{,}000 \times 11\%}{31} = 42{,}581$$

Foul flows have been calculated using the British Water Code of Practice 'Flows and Loads – 4: Sizing Criteria, Treatment Capacity for Sewage Treatment Systems'. As there is no specific information available for airport passengers, the following activities have been used in the flow calculations and assumptions have been made with regard to the number of passengers who will take part in each activity.

Per Capita Loadings Average	% of Passengers	Passengers/day	Flow litres/person/day	Flow (m^3/day)
Toilet Blocks (per use)	75	31,936	10	319
Toilet (urinal) per use	25	10,465	5	53
Full meal	5	2,129	25	53
Snack Bar	15	6,387	15	96
Fast Food	10	4,258	12	51
Bar Drinker	10	4,258	12	51

Assuming a peaking factor of 3, the peak flow rate will be,

$$\frac{623 \times 10^3 \times 3}{24 \times 60 \times 60} = \mathbf{21.6\ l/s}$$

Existing Hotel

The existing hotel in the north-west part of the site is a 201 room 3*/4* facility with anticipated future expansion up to 251 rooms.

Using the British Water Code of Practice 'Flows and Loads – 4: Sizing Criteria, Treatment Capacity for Sewage Treatment Systems', the allowance is 250 litres/head day and assuming a maximum occupancy rate of 2 persons/room and a peaking factor of 3, the flow generated will be,

$$\frac{251 \times 2 \times 250 \times 3}{24 \times 60 \times 60} = \mathbf{4.4\ l/s}$$

Flows from Southside Pumping Station

Referring to an AECOM Technical Note dated December 2010, the rising main diameter is 100mm and, therefore, assuming that the velocity lies within the recommended range of 0.75 m/s to 1.8 m/s, the minimum and maximum delivery rates will be 5.9 l/s to 14.1 l/s.

An average value if **10 l/s** has therefore been assumed.

NB: It should be noted that this will not be a constant rate throughout the whole day but will be a series of peaks, as determined by the fill time of the sump. The AECOM Technical Note dated March 2011 noted an estimated fill time of 43 mins and a pump run time of 2.6 minutes.

Aircraft Foul Systems

Reference has been made to an AECOM Technical Note dated December 2010, which notes that the maximum capacity of the system is 2,000 litres which can be emptied in approximately 10 minutes. This equates to an average flow rate of **3.3l/s**.

The AECOM Technical Note also states that this operation happens on average 3.5 times a day therefore this figure is discarded from the following calculations due to the relatively infrequent occurrence.

The total peak discharge rate from the airport will therefore be;

21.6 + 4.4 + 10.0 = 36.0 l/s.

Assume a 3 hour storage period in order to allow discharge outside of peak periods, in accordance with the current operation of the foul system. On this basis, the storage requirement will be the difference between the total inflow and outflow during this period.

$$\text{Total inflow} = \frac{36.0 \times 3 \times 60 \times 60}{1000} = 389m^3$$

$$\text{Total outflow} = \frac{12.0 \times 3 \times 60 \times 60}{1000} = 129.6m^3$$

Therefore storage required = 389 – 129.6 = 259.4m^3

Storage already provided under previous scheme = 98m^3

Additional storage therefore required under this application, = 259.4 – 98 = 161.4m^3.

Due to the volume of storage required, it is likely that some form of chemical dosing will be required in order to prevent issues with septicity and this should be discussed with a suitable specialist contractor.

General

The provision of the new Western and Southern Extensions and the Transport Interchange/MSCP2 will require the diversion of existing foul drainage runs and the provision of new sewers.

The proposed foul water drainage systems are shown on Hydrock drawing no. BAE-HYD-XX-XX-DR-D-2014.

5. CONCLUSIONS

5.1 SURFACE WATER

All existing surface water from the airport site currently discharges to ground via numerous infiltration systems. There is no discharge to public sewers or watercourses.

The proposed redevelopment of various elements of the airport infrastructure will alter existing systems and introduce additional areas of surface water runoff.

The proposed drainage strategy described in this report continues and extends the use of infiltration systems to serve the proposed works. As for the baseline condition, no surface water will be discharged off site.

All infiltration systems have been designed for the 1 in 30 year return period event and tested for the 100 year event plus an allowance for climate change. Under no circumstances will flooding be permitted to occur for the 1 in 30 year event and, where the drainage system has been shown to flood, the volume of water has been determined and the location and depth identified.

The off-site risk from surface water flooding following the implementation of the proposed development will therefore not be increased.

5.2 Foul Water

All foul drainage from the site drains via both gravity and pumped systems to the north-east corner of the airport site at which point flows are discharged to a public foul sewer in Downside Road.

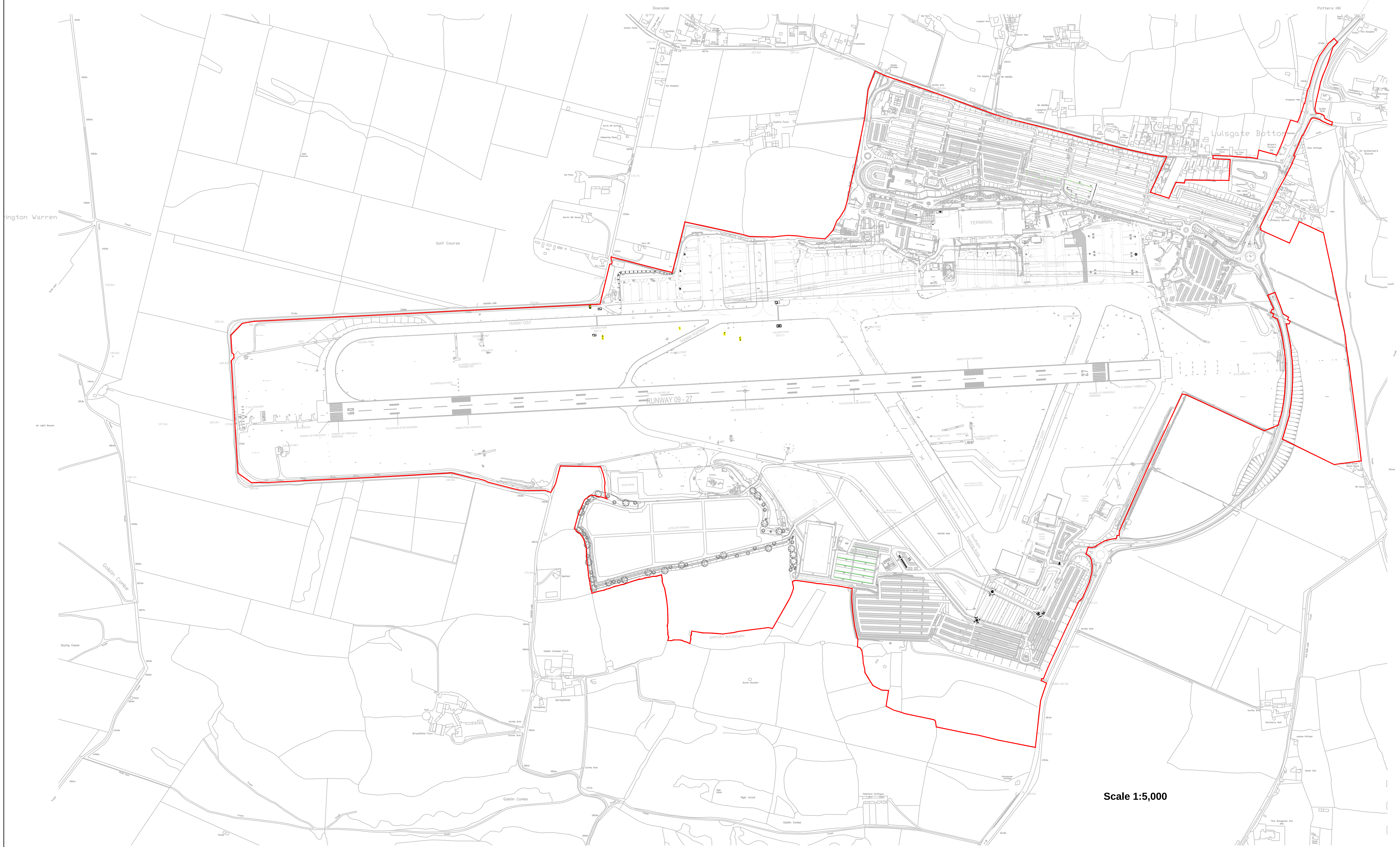
Wessex Water currently restrict the maximum flow rate from the airport site to 12 l/s. This rate is restricted by the capacity of the Chew Magna sewage treatment works. Wessex Water have confirmed that there is no short-term intention to upgrade these works at present.

The increase of the airport capacity to 12 million passengers per annum will give rise to an increase in foul flows. Given that Wessex Water have no intention to carry out works to the sewage treatment works to increase capacity, then the current 12 l/s restriction will remain in place. In order to cater for the increased flows, it will be necessary to extend the existing on-site storage tanks.

The provision of additional storage and maintaining the current discharge ate from the site will ensure that there is no detrimental impact on the off-site public sewer network.

Appendix A

Reference	Title
BAE-HYD-XX-XX-DR-D-2000-P02	Site Location Plan



Scale 1:5,000

NOTES

REVISIONS

Rev	Date	Description	By	Ckd	App
P02	05/12/18	Site boundary updated.	RJH		
P01	24/09/18	First Issue.	RJH		

Hydrock
OVER COURT BARNS
OVER LANE
ALMONDSBURY
BRISTOL
BS32 4DF
t: +44 (0) 1454 619533
e: bristol@hydrock.com

CLIENT
BRISTOL AIRPORT

PROJECT
BRISTOL AIRPORT
12mppa EXPANSION SCHEME

TITLE
SITE LOCATION PLAN

HYDROCK PROJECT NO.	SCALE @ A1
C-09194-C	As Shown
STATUS DESCRIPTION	STATUS
INFORMATION	S2
DRAWING NO. (PROJECT CODE-ORIGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER)	REVISION
BAE-HYD-XX-XX-DR-D-2000	P02

Appendix B – Proposed Masterplan

Reference	Title
T17090-00-100-407-00	Proposed Site Plan

Rev	Date	Amendment	Drwn by:	Chk'd by:

TODD ARCHITECTS
2ND FLOOR TITANIC HOUSE,
6 QUEENS ROAD, BELFAST
BT3 9DT,
T +44 (0) 28 9024 5587,
E INFO@TODDARCH.CO.UK

TODD

Status: PLANNING	Client: BRISTOL AIRPORT
Date: 05/12/2018	Project Name: **12 MPPA PLANNING APPLICATION**
Dwn by: EH / Ckd by: SF	Drawing Title: PROPOSED SITE PLAN
Scale: 1:2500 / Page: A0	Drawing No: **17090-00-100-407** / Revision: **00**

Appendix C – Existing Drainage Plan

Reference	Title
BAE-HYD-XX-XX-DR-D-2001-P02	Existing Drainage Plan

KEY

- - - - Existing storm drainage
Existing tank soakaway
Existing manhole soakaway
Existing petrol interceptor

NOTES

NOTES *(CONTINUED)*

NOTES *(CONTINUED)*

NOTES *(CONTINUED)*

NOTES *(CONTINUED)*

REVISIONS *(CONTINUED)*

REVISIONS

Rev	Date	Description	By	Ckd	App
P02	16/11/18	Additional drainage information.	RJH		
P01	07/08/18	First Issue.	RJH		

Hydrock
OVER COURT BARNS
OVER LANE
ALMONDSBURY
BRISTOL
BS32 4DF
t: +44 (0) 1454 619533
e: bristol@hydrock.com

CLIENT
BRISTOL AIRPORT

PROJECT
BRISTOL AIRPORT
12mppa EXPANSION SCHEME

TITLE
EXISTING FOUL AND SURFACE WATER DRAINAGE LAYOUT

HYDROCK PROJECT NO.
C-09194-C

SCALE @ AO
1 : 2,500

STATUS DESCRIPTION
FOR APPROVAL

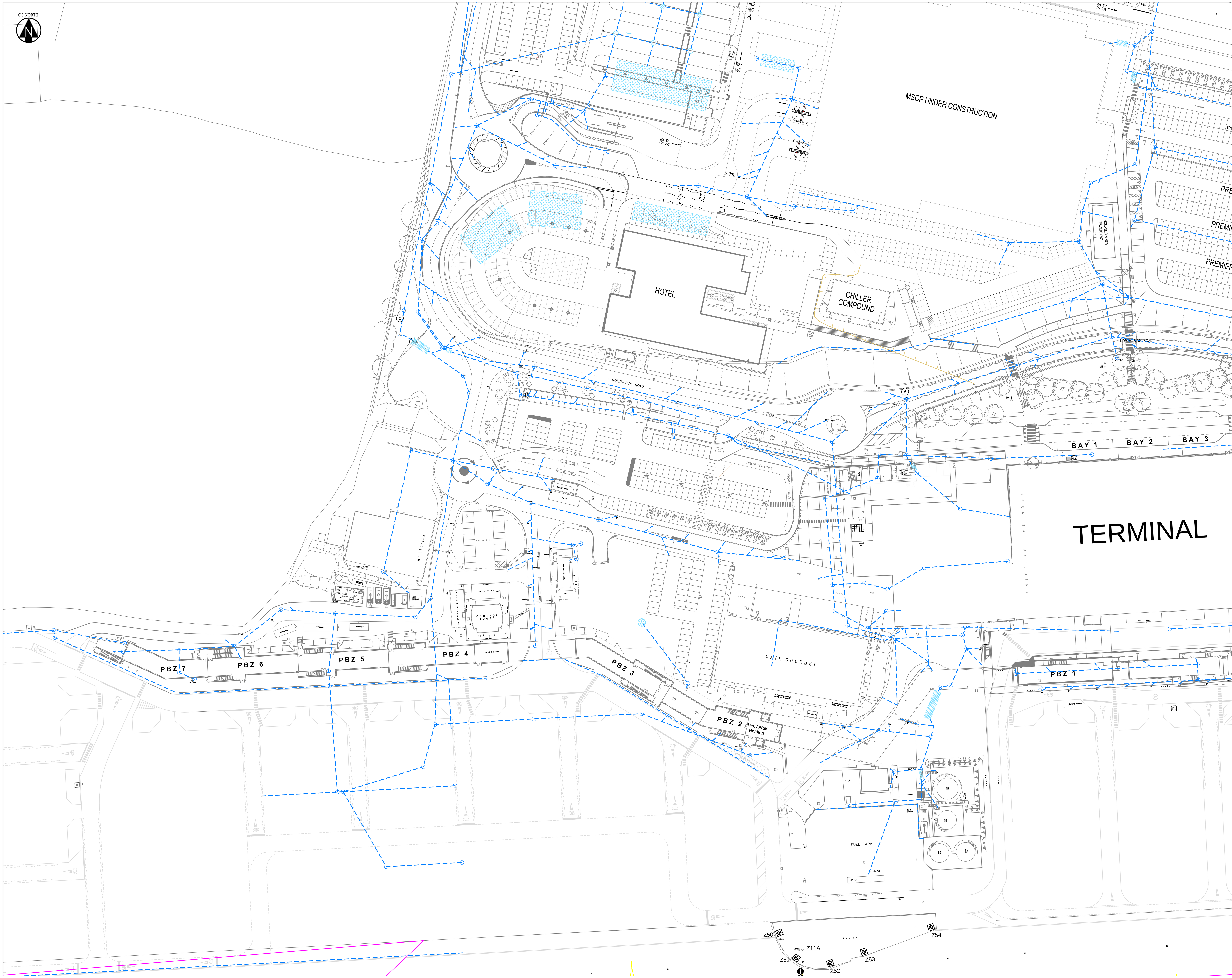
STATUS
S2

DRAWING NO. (PROJECT CODE-ORGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER)
BAE-HYD-XX-XX-DR-D-2001

REVISION
P02

Appendix D – West Terminal Extension, Terminal Canopy and New Service yard

Reference	Title
BAE-HYD-XX-XX-DR-D-2003-P02	Existing Surface Water Drainage
BAE-HYD-XX-XX-DR-D-2004-P03	Proposed Surface Water Plan
Ex West Apron Replan.SRCX	Existing West Apron Replan Soakaway 1 - Q30
Ex West Apron Replan.SRCX	Existing West Apron Replan Soakaway 1 – Q100 +30%
Soak1 Overflow.SRCX	Soakaways 1A & 1B – Q30
Soak1 Overflow.SRCX	Soakaways 1A & 1B – Q100 +30%
Ex Terminal Replan.SRCX	Existing Terminal Replan Soakaway 2 - Q30
Ex Terminal Replan.SRCX	Existing Terminal Replan Soakaway 2 – Q100 +30%
Point C + Ex Hways.SRCX	Soakaway 3 - Q30
Point C + Ex Hways.SRCX	Soakaway 3 – Q100 +30%
Terminal Canopy.SRCX	Terminal Canopy Soakaway 10 - Q30
Terminal Canopy.SRCX	Terminal Canopy Soakaway 10 – Q100 +30%



KEY

- Existing surface water drain
- Existing tank soakaway
- Existing manhole soakaway
- Existing petrol interceptor

REVISIONS

Rev	Date	Description	By	Ckd	App
P02	16/11/18	Additional existing drainage.	RJH		
P01	11/09/18	First Issue.	RJH		

Hydrock
OVER COURT BARNS
OVER LANE
ALMONDSBURY
BRISTOL
BS32 4DF
t: +44 (0) 1454 619533
e: bristol@hydrock.com

CLIENT
BRISTOL AIRPORT

PROJECT
BRISTOL AIRPORT
12mppa EXPANSION SCHEME

TITLE
WEST TERMINAL EXTENSION, SERVICE YARD
and TERMINAL CANOPY
EXISTING SURFACE WATER DRAINAGE

HYDROCK PROJECT NO. C-09194-C

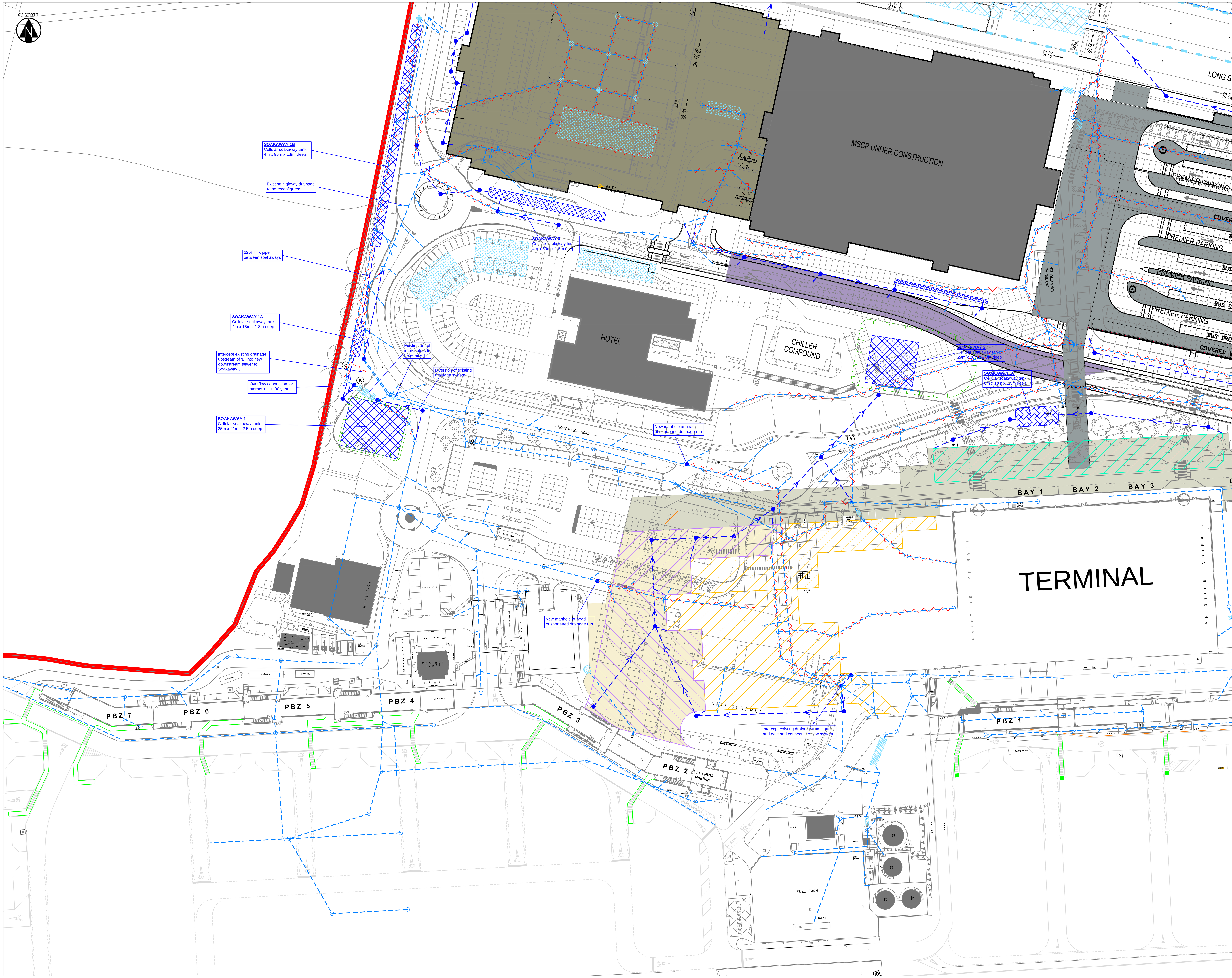
SCALE @ A0 1:500

STATUS DESCRIPTION FOR APPROVAL

STATUS S2

DRAWING NO. (PROJECT CODE-ORGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER) BAE-HYD-XX-XX-DR-D-2003

REVISION P02



KEY

- Existing surface water drain
- Existing petrol interceptor
- Existing tank soakaway
- Existing manhole soakaway
- Proposed surface water drain
- Proposed petrol interceptor
- Proposed cellular soakaway unit
- Existing surface water drain to be abandoned
- Proposed Service Yard Area
- Proposed West Terminal Extension
- Proposed New Terminal Canopy

REVISIONS

Rev	Date	Description	By	Ckd	App
P03	05/12/18	Masterplan updated.	RJH		
P02	16/11/18	Drainage updated.	RJH		
P01	24/09/18	First Issue.	RJH		

Hydrock
OVER COURT BARNS
OVER LANE
ALMONDSBURY
BRISTOL
BS32 4DF
t: +44 (0) 1454 619533
e: bristol@hydrock.com

CLIENT
BRISTOL AIRPORT

PROJECT
BRISTOL AIRPORT
12mppa EXPANSION SCHEME

TITLE
WEST TERMINAL EXTENSION, SERVICE YARD and TERMINAL CANOPY PROPOSED SURFACE WATER DRAINAGE

HYDROCK PROJECT NO.	SCALE @ A0
C-09194-C	1:500

STATUS DESCRIPTION	STATUS
FOR APPROVAL	S2

DRAWING NO. (PROJECT CODE-ORGINATOR-ZONE-LEVEL-TYPE-ROLE-NUMBER)	REVISION
BAE-HYD-XX-XX-DR-D-2004	P03

Summary of Results for 30 year Return Period

Half Drain Time : 657 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	7.834	0.834	12.6	0.0	12.6	415.9	O K
30 min Summer	8.103	1.103	13.1	0.0	13.1	550.3	O K
60 min Summer	8.376	1.376	13.7	0.0	13.7	686.1	O K
120 min Summer	8.629	1.629	14.2	0.0	14.2	812.6	O K
180 min Summer	8.752	1.752	14.4	0.0	14.4	873.6	O K
240 min Summer	8.816	1.816	14.5	0.0	14.5	905.7	O K
360 min Summer	8.873	1.873	14.6	0.0	14.6	934.3	O K
480 min Summer	8.876	1.876	14.6	0.0	14.6	935.6	O K
600 min Summer	8.854	1.854	14.6	0.0	14.6	924.5	O K
720 min Summer	8.827	1.827	14.5	0.0	14.5	911.2	O K
960 min Summer	8.770	1.770	14.4	0.0	14.4	882.7	O K
1440 min Summer	8.666	1.666	14.2	0.0	14.2	831.1	O K
2160 min Summer	8.520	1.520	13.9	0.0	13.9	758.1	O K
2880 min Summer	8.378	1.378	13.7	0.0	13.7	687.3	O K
4320 min Summer	8.114	1.114	13.2	0.0	13.2	555.4	O K
5760 min Summer	7.881	0.881	12.7	0.0	12.7	439.4	O K
7200 min Summer	7.682	0.682	12.3	0.0	12.3	340.0	O K
8640 min Summer	7.515	0.515	12.0	0.0	12.0	256.9	O K
10080 min Summer	7.378	0.378	11.7	0.0	11.7	188.6	O K
15 min Winter	7.941	0.941	12.8	0.0	12.8	469.2	O K
30 min Winter	8.244	1.244	13.4	0.0	13.4	620.6	O K
60 min Winter	8.554	1.554	14.0	0.0	14.0	775.0	O K
120 min Winter	8.848	1.848	14.6	0.0	14.6	921.9	O K
180 min Winter	8.996	1.996	14.9	0.0	14.9	995.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	74.059	0.0	0.0	52
30 min Summer	48.833	0.0	0.0	66
60 min Summer	30.811	0.0	0.0	92
120 min Summer	18.860	0.0	0.0	148
180 min Summer	13.992	0.0	0.0	202
240 min Summer	11.265	0.0	0.0	258
360 min Summer	8.299	0.0	0.0	370
480 min Summer	6.674	0.0	0.0	482
600 min Summer	5.632	0.0	0.0	546
720 min Summer	4.901	0.0	0.0	608
960 min Summer	3.933	0.0	0.0	734
1440 min Summer	2.881	0.0	0.0	1004
2160 min Summer	2.107	0.0	0.0	1416
2880 min Summer	1.687	0.0	0.0	1824
4320 min Summer	1.231	0.0	0.0	2616
5760 min Summer	0.984	0.0	0.0	3376
7200 min Summer	0.827	0.0	0.0	4120
8640 min Summer	0.717	0.0	0.0	4840
10080 min Summer	0.636	0.0	0.0	5544
15 min Winter	74.059	0.0	0.0	52
30 min Winter	48.833	0.0	0.0	66
60 min Winter	30.811	0.0	0.0	92
120 min Winter	18.860	0.0	0.0	146
180 min Winter	13.992	0.0	0.0	202

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
240 min Winter	9.079	2.079	15.0	0.0	15.0	1037.1	O K
360 min Winter	9.166	2.166	15.2	0.0	15.2	1080.2	O K
480 min Winter	9.190	2.190	15.2	0.0	15.2	1092.1	O K
600 min Winter	9.179	2.179	15.2	0.0	15.2	1086.8	O K
720 min Winter	9.148	2.148	15.2	0.0	15.2	1071.5	O K
960 min Winter	9.075	2.075	15.0	0.0	15.0	1035.1	O K
1440 min Winter	8.927	1.927	14.7	0.0	14.7	961.2	O K
2160 min Winter	8.707	1.707	14.3	0.0	14.3	851.6	O K
2880 min Winter	8.490	1.490	13.9	0.0	13.9	743.0	O K
4320 min Winter	8.092	1.092	13.1	0.0	13.1	544.7	O K
5760 min Winter	7.756	0.756	12.5	0.0	12.5	377.2	O K
7200 min Winter	7.482	0.482	11.9	0.0	11.9	240.2	O K
8640 min Winter	7.266	0.266	11.5	0.0	11.5	132.8	O K
10080 min Winter	7.114	0.114	11.2	0.0	11.2	56.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
240 min Winter	11.265	0.0	0.0	256
360 min Winter	8.299	0.0	0.0	366
480 min Winter	6.674	0.0	0.0	478
600 min Winter	5.632	0.0	0.0	584
720 min Winter	4.901	0.0	0.0	684
960 min Winter	3.933	0.0	0.0	776
1440 min Winter	2.881	0.0	0.0	1084
2160 min Winter	2.107	0.0	0.0	1536
2880 min Winter	1.687	0.0	0.0	1972
4320 min Winter	1.231	0.0	0.0	2792
5760 min Winter	0.984	0.0	0.0	3568
7200 min Winter	0.827	0.0	0.0	4272
8640 min Winter	0.717	0.0	0.0	4936
10080 min Winter	0.636	0.0	0.0	5472

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.370	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 3.234

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.323	8	12	0.323	16	20	0.323	24	28	0.324	32	36	0.324
4	8	0.323	12	16	0.323	20	24	0.323	28	32	0.324	36	40	0.324

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Model Details

Storage is Online Cover Level (m) 11.000

Cellular Storage Structure

Invert Level (m) 7.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15100 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.15100

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	525.0	525.0	2.500	525.0	755.0	2.600	0.0	755.0

Pipe Overflow Control

Diameter (m) 0.300 Roughness k (mm) 0.600 Upstream Invert Level (m) 9.200
Slope (1:X) 100.0 Entry Loss Coefficient 0.500
Length (m) 50.000 Coefficient of Contraction 0.600

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 803 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.445	1.445	13.8	0.0	13.8	720.8	O K
30 min Summer	8.925	1.925	14.7	0.0	14.7	960.2	O K
60 min Summer	9.376	2.376	15.6	25.7	41.3	1184.9	O K
120 min Summer	10.269	3.269	15.8	151.0	166.9	1264.2	O K
180 min Summer	11.003	4.003	15.8	190.0	205.8	1268.4	FLOOD
240 min Summer	11.003	4.003	15.8	190.0	205.8	1267.9	FLOOD
360 min Summer	11.003	4.003	15.8	190.0	205.8	1268.0	FLOOD
480 min Summer	10.736	3.736	15.8	176.8	192.6	1264.6	Flood Risk
600 min Summer	10.418	3.418	15.8	159.7	175.5	1264.3	O K
720 min Summer	9.884	2.884	15.8	126.0	141.8	1263.8	O K
960 min Summer	9.611	2.611	15.8	93.7	109.5	1263.5	O K
1440 min Summer	9.490	2.490	15.8	55.3	71.2	1242.1	O K
2160 min Summer	9.424	2.424	15.7	36.4	52.1	1208.8	O K
2880 min Summer	9.377	2.377	15.6	26.1	41.7	1185.5	O K
4320 min Summer	9.316	2.316	15.5	10.9	26.4	1155.0	O K
5760 min Summer	9.213	2.213	15.3	0.2	15.4	1103.5	O K
7200 min Summer	8.927	1.927	14.7	0.0	14.7	961.0	O K
8640 min Summer	8.670	1.670	14.2	0.0	14.2	833.0	O K
10080 min Summer	8.443	1.443	13.8	0.0	13.8	719.6	O K
15 min Winter	8.626	1.626	14.1	0.0	14.1	811.0	O K
30 min Winter	9.166	2.166	15.2	0.0	15.2	1080.3	O K
60 min Winter	10.962	3.962	15.8	188.0	203.8	1264.9	Flood Risk
120 min Winter	11.051	4.051	15.8	192.2	208.1	1316.0	FLOOD
180 min Winter	11.051	4.051	15.8	192.2	208.0	1315.4	FLOOD

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	124.836	0.0	0.0	53
30 min Summer	83.061	0.0	0.0	67
60 min Summer	52.662	0.0	51.2	88
120 min Summer	32.210	0.0	278.9	110
180 min Summer	23.799	4.9	406.0	136
240 min Summer	19.065	4.4	482.3	166
360 min Summer	13.962	4.5	579.6	228
480 min Summer	11.178	0.0	629.0	292
600 min Summer	9.399	0.0	651.9	356
720 min Summer	8.153	0.0	657.7	420
960 min Summer	6.510	0.0	638.1	558
1440 min Summer	4.731	0.0	552.1	838
2160 min Summer	3.432	0.0	433.3	1244
2880 min Summer	2.730	0.0	332.4	1648
4320 min Summer	1.973	0.0	150.0	2524
5760 min Summer	1.566	0.0	0.8	3528
7200 min Summer	1.308	0.0	0.0	4328
8640 min Summer	1.129	0.0	0.0	5096
10080 min Summer	0.998	0.0	0.0	5856
15 min Winter	124.836	0.0	0.0	53
30 min Winter	83.061	0.0	0.0	67
60 min Winter	52.662	0.0	186.6	76
120 min Winter	32.210	52.5	465.3	110
180 min Winter	23.799	51.9	612.8	142

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
240 min Winter	11.043	4.043	15.8	191.9	207.7	1308.3	FLOOD
360 min Winter	11.013	4.013	15.8	190.4	206.3	1277.5	FLOOD
480 min Winter	11.003	4.003	15.8	190.0	205.8	1268.0	FLOOD
600 min Winter	10.254	3.254	15.8	150.2	166.0	1264.2	O K
720 min Winter	9.995	2.995	15.8	133.7	149.5	1263.9	O K
960 min Winter	9.661	2.661	15.8	104.8	120.6	1263.6	O K
1440 min Winter	9.508	2.508	15.8	60.8	76.7	1250.3	O K
2160 min Winter	9.437	2.437	15.7	39.4	55.1	1215.5	O K
2880 min Winter	9.386	2.386	15.6	28.1	43.7	1190.1	O K
4320 min Winter	9.329	2.329	15.5	13.2	28.7	1161.7	O K
5760 min Winter	9.252	2.252	15.4	2.3	17.6	1123.0	O K
7200 min Winter	8.882	1.882	14.6	0.0	14.6	938.7	O K
8640 min Winter	8.525	1.525	14.0	0.0	14.0	760.4	O K
10080 min Winter	8.213	1.213	13.4	0.0	13.4	604.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
240 min Winter	19.065	44.8	703.0	174
360 min Winter	13.962	14.0	822.9	230
480 min Winter	11.178	4.5	890.7	284
600 min Winter	9.399	0.0	927.2	346
720 min Winter	8.153	0.0	944.4	410
960 min Winter	6.510	0.0	942.2	544
1440 min Winter	4.731	0.0	860.9	836
2160 min Winter	3.432	0.0	695.4	1248
2880 min Winter	2.730	0.0	551.2	1660
4320 min Winter	1.973	0.0	277.4	2568
5760 min Winter	1.566	0.0	32.5	3664
7200 min Winter	1.308	0.0	0.0	4576
8640 min Winter	1.129	0.0	0.0	5376
10080 min Winter	0.998	0.0	0.0	6152

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.370	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 3.234

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.323	8	12	0.323	16	20	0.323	24	28	0.324	32	36	0.324
4	8	0.323	12	16	0.323	20	24	0.323	28	32	0.324	36	40	0.324

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Model Details

Storage is Online Cover Level (m) 11.000

Cellular Storage Structure

Invert Level (m) 7.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15100 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.15100

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	525.0	525.0	2.500	525.0	755.0	2.600	0.0	755.0

Pipe Overflow Control

Diameter (m) 0.300 Roughness k (mm) 0.600 Upstream Invert Level (m) 9.200
Slope (1:X) 100.0 Entry Loss Coefficient 0.500
Length (m) 50.000 Coefficient of Contraction 0.600

Summary of Results for 30 year Return Period

Half Drain Time : 418 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	8.562	1.562	16.7	652.9	O K
30 min Summer	8.562	1.562	16.7	652.9	O K
60 min Summer	8.562	1.562	16.7	652.9	O K
120 min Summer	8.562	1.562	16.7	652.9	O K
180 min Summer	8.562	1.562	16.7	652.9	O K
240 min Summer	8.562	1.562	16.7	652.9	O K
360 min Summer	8.562	1.562	16.7	652.9	O K
480 min Summer	8.562	1.562	16.7	652.9	O K
600 min Summer	8.562	1.562	16.7	652.9	O K
720 min Summer	8.562	1.562	16.7	652.9	O K
960 min Summer	8.562	1.562	16.7	652.9	O K
1440 min Summer	8.562	1.562	16.7	652.9	O K
2160 min Summer	8.587	1.587	16.8	663.6	O K
2880 min Summer	8.587	1.587	16.8	663.6	O K
4320 min Summer	8.587	1.587	16.8	663.6	O K
5760 min Summer	8.532	1.532	16.6	640.2	O K
7200 min Summer	8.532	1.532	16.6	640.2	O K
8640 min Summer	8.532	1.532	16.6	640.2	O K
10080 min Summer	8.532	1.532	16.6	640.2	O K
15 min Winter	8.562	1.562	16.7	652.9	O K
30 min Winter	8.562	1.562	16.7	652.9	O K
60 min Winter	8.562	1.562	16.7	652.9	O K
120 min Winter	8.562	1.562	16.7	652.9	O K
180 min Winter	8.562	1.562	16.7	652.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	74.059	0.0	226
30 min Summer	48.833	0.0	226
60 min Summer	30.811	0.0	226
120 min Summer	18.860	0.0	226
180 min Summer	13.992	0.0	226
240 min Summer	11.265	0.0	226
360 min Summer	8.299	0.0	226
480 min Summer	6.674	0.0	226
600 min Summer	5.632	0.0	226
720 min Summer	4.901	0.0	226
960 min Summer	3.933	0.0	226
1440 min Summer	2.881	0.0	226
2160 min Summer	2.107	0.0	228
2880 min Summer	1.687	0.0	228
4320 min Summer	1.231	0.0	228
5760 min Summer	0.984	0.0	224
7200 min Summer	0.827	0.0	224
8640 min Summer	0.717	0.0	224
10080 min Summer	0.636	0.0	224
15 min Winter	74.059	0.0	226
30 min Winter	48.833	0.0	226
60 min Winter	30.811	0.0	226
120 min Winter	18.860	0.0	226
180 min Winter	13.992	0.0	226

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
240 min Winter	8.562	1.562	16.7	652.9	O K
360 min Winter	8.562	1.562	16.7	652.9	O K
480 min Winter	8.562	1.562	16.7	652.9	O K
600 min Winter	8.562	1.562	16.7	652.9	O K
720 min Winter	8.562	1.562	16.7	652.9	O K
960 min Winter	8.562	1.562	16.7	652.9	O K
1440 min Winter	8.562	1.562	16.7	652.9	O K
2160 min Winter	8.587	1.587	16.8	663.6	O K
2880 min Winter	8.587	1.587	16.8	663.6	O K
4320 min Winter	8.587	1.587	16.8	663.6	O K
5760 min Winter	8.532	1.532	16.6	640.2	O K
7200 min Winter	8.532	1.532	16.6	640.2	O K
8640 min Winter	8.532	1.532	16.6	640.2	O K
10080 min Winter	8.532	1.532	16.6	640.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
240 min Winter	11.265	0.0	226
360 min Winter	8.299	0.0	226
480 min Winter	6.674	0.0	226
600 min Winter	5.632	0.0	226
720 min Winter	4.901	0.0	226
960 min Winter	3.933	0.0	226
1440 min Winter	2.881	0.0	226
2160 min Winter	2.107	0.0	228
2880 min Winter	1.687	0.0	228
4320 min Winter	1.231	0.0	228
5760 min Winter	0.984	0.0	224
7200 min Winter	0.827	0.0	224
8640 min Winter	0.717	0.0	224
10080 min Winter	0.636	0.0	224

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.370	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Model Details

Storage is Online Cover Level (m) 11.000

Cellular Storage Structure

Invert Level (m) 7.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15100 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.15100

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	440.0	440.0	1.800	440.0	850.4	1.900	0.0	850.4

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 418 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	8.562	1.562	16.7	652.9	O K
30 min Summer	8.562	1.562	16.7	652.9	O K
60 min Summer	8.562	1.562	16.7	652.9	O K
120 min Summer	8.562	1.562	16.7	652.9	O K
180 min Summer	8.562	1.562	16.7	652.9	O K
240 min Summer	8.562	1.562	16.7	652.9	O K
360 min Summer	8.562	1.562	16.7	652.9	O K
480 min Summer	8.562	1.562	16.7	652.9	O K
600 min Summer	8.562	1.562	16.7	652.9	O K
720 min Summer	8.562	1.562	16.7	652.9	O K
960 min Summer	8.562	1.562	16.7	652.9	O K
1440 min Summer	8.562	1.562	16.7	652.9	O K
2160 min Summer	8.587	1.587	16.8	663.6	O K
2880 min Summer	8.587	1.587	16.8	663.6	O K
4320 min Summer	8.587	1.587	16.8	663.6	O K
5760 min Summer	8.532	1.532	16.6	640.2	O K
7200 min Summer	8.532	1.532	16.6	640.2	O K
8640 min Summer	8.532	1.532	16.6	640.2	O K
10080 min Summer	8.532	1.532	16.6	640.2	O K
15 min Winter	8.562	1.562	16.7	652.9	O K
30 min Winter	8.562	1.562	16.7	652.9	O K
60 min Winter	8.562	1.562	16.7	652.9	O K
120 min Winter	8.562	1.562	16.7	652.9	O K
180 min Winter	8.562	1.562	16.7	652.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	124.836	0.0	226
30 min Summer	83.061	0.0	226
60 min Summer	52.662	0.0	226
120 min Summer	32.210	0.0	226
180 min Summer	23.799	0.0	226
240 min Summer	19.065	0.0	226
360 min Summer	13.962	0.0	226
480 min Summer	11.178	0.0	226
600 min Summer	9.399	0.0	226
720 min Summer	8.153	0.0	226
960 min Summer	6.510	0.0	226
1440 min Summer	4.731	0.0	226
2160 min Summer	3.432	0.0	228
2880 min Summer	2.730	0.0	228
4320 min Summer	1.973	0.0	228
5760 min Summer	1.566	0.0	224
7200 min Summer	1.308	0.0	224
8640 min Summer	1.129	0.0	224
10080 min Summer	0.998	0.0	224
15 min Winter	124.836	0.0	226
30 min Winter	83.061	0.0	226
60 min Winter	52.662	0.0	226
120 min Winter	32.210	0.0	226
180 min Winter	23.799	0.0	226

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
240 min Winter	8.562	1.562	16.7	652.9	O K
360 min Winter	8.562	1.562	16.7	652.9	O K
480 min Winter	8.562	1.562	16.7	652.9	O K
600 min Winter	8.562	1.562	16.7	652.9	O K
720 min Winter	8.562	1.562	16.7	652.9	O K
960 min Winter	8.562	1.562	16.7	652.9	O K
1440 min Winter	8.562	1.562	16.7	652.9	O K
2160 min Winter	8.587	1.587	16.8	663.6	O K
2880 min Winter	8.587	1.587	16.8	663.6	O K
4320 min Winter	8.587	1.587	16.8	663.6	O K
5760 min Winter	8.532	1.532	16.6	640.2	O K
7200 min Winter	8.532	1.532	16.6	640.2	O K
8640 min Winter	8.532	1.532	16.6	640.2	O K
10080 min Winter	8.532	1.532	16.6	640.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
240 min Winter	19.065	0.0	226
360 min Winter	13.962	0.0	226
480 min Winter	11.178	0.0	226
600 min Winter	9.399	0.0	226
720 min Winter	8.153	0.0	226
960 min Winter	6.510	0.0	226
1440 min Winter	4.731	0.0	226
2160 min Winter	3.432	0.0	228
2880 min Winter	2.730	0.0	228
4320 min Winter	1.973	0.0	228
5760 min Winter	1.566	0.0	224
7200 min Winter	1.308	0.0	224
8640 min Winter	1.129	0.0	224
10080 min Winter	0.998	0.0	224

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.370	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Time Area Diagram

Total Area (ha) 0.000

Time From:	(mins) To:	Area (ha)
0	4	0.000

Model Details

Storage is Online Cover Level (m) 11.000

Cellular Storage Structure

Invert Level (m) 7.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15100 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.15100

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	440.0	440.0	1.800	440.0	850.4	1.900	0.0	850.4

Summary of Results for 30 year Return Period

Half Drain Time : 398 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	7.541	0.541	9.5	205.6	O K
30 min Summer	7.718	0.718	9.9	272.9	O K
60 min Summer	7.892	0.892	10.3	338.9	O K
120 min Summer	8.041	1.041	10.6	395.5	O K
180 min Summer	8.100	1.100	10.7	418.1	O K
240 min Summer	8.121	1.121	10.7	425.8	O K
360 min Summer	8.116	1.116	10.7	424.3	O K
480 min Summer	8.095	1.095	10.7	416.0	O K
600 min Summer	8.070	1.070	10.6	406.5	O K
720 min Summer	8.045	1.045	10.6	397.2	O K
960 min Summer	7.997	0.997	10.5	379.0	O K
1440 min Summer	7.903	0.903	10.3	343.3	O K
2160 min Summer	7.768	0.768	10.0	291.8	O K
2880 min Summer	7.643	0.643	9.7	244.3	O K
4320 min Summer	7.432	0.432	9.3	164.2	O K
5760 min Summer	7.274	0.274	9.0	104.0	O K
7200 min Summer	7.161	0.161	8.7	61.0	O K
8640 min Summer	7.088	0.088	8.6	33.5	O K
10080 min Summer	7.052	0.052	8.5	19.7	O K
15 min Winter	7.612	0.612	9.7	232.7	O K
30 min Winter	7.812	0.812	10.1	308.6	O K
60 min Winter	8.010	1.010	10.5	383.9	O K
120 min Winter	8.186	1.186	10.9	450.8	O K
180 min Winter	8.263	1.263	11.0	479.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	74.059	0.0	51
30 min Summer	48.833	0.0	64
60 min Summer	30.811	0.0	90
120 min Summer	18.860	0.0	142
180 min Summer	13.992	0.0	194
240 min Summer	11.265	0.0	248
360 min Summer	8.299	0.0	342
480 min Summer	6.674	0.0	402
600 min Summer	5.632	0.0	466
720 min Summer	4.901	0.0	532
960 min Summer	3.933	0.0	670
1440 min Summer	2.881	0.0	944
2160 min Summer	2.107	0.0	1348
2880 min Summer	1.687	0.0	1736
4320 min Summer	1.231	0.0	2480
5760 min Summer	0.984	0.0	3184
7200 min Summer	0.827	0.0	3848
8640 min Summer	0.717	0.0	4504
10080 min Summer	0.636	0.0	5144
15 min Winter	74.059	0.0	52
30 min Winter	48.833	0.0	64
60 min Winter	30.811	0.0	90
120 min Winter	18.860	0.0	142
180 min Winter	13.992	0.0	196

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
240 min Winter	8.295	1.295	11.1	492.2	O K
360 min Winter	8.308	1.308	11.1	496.9	O K
480 min Winter	8.282	1.282	11.1	487.0	O K
600 min Winter	8.250	1.250	11.0	475.0	O K
720 min Winter	8.217	1.217	10.9	462.3	O K
960 min Winter	8.148	1.148	10.8	436.1	O K
1440 min Winter	8.004	1.004	10.5	381.7	O K
2160 min Winter	7.796	0.796	10.1	302.6	O K
2880 min Winter	7.610	0.610	9.7	231.8	O K
4320 min Winter	7.311	0.311	9.0	118.3	O K
5760 min Winter	7.113	0.113	8.6	42.9	O K
7200 min Winter	7.048	0.048	8.1	18.1	O K
8640 min Winter	7.041	0.041	7.0	15.6	O K
10080 min Winter	7.037	0.037	6.2	13.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
240 min Winter	11.265	0.0	250
360 min Winter	8.299	0.0	356
480 min Winter	6.674	0.0	452
600 min Winter	5.632	0.0	494
720 min Winter	4.901	0.0	570
960 min Winter	3.933	0.0	724
1440 min Winter	2.881	0.0	1024
2160 min Winter	2.107	0.0	1448
2880 min Winter	1.687	0.0	1848
4320 min Winter	1.231	0.0	2580
5760 min Winter	0.984	0.0	3192
7200 min Winter	0.827	0.0	3648
8640 min Winter	0.717	0.0	4400
10080 min Winter	0.636	0.0	5136

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.370	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 1.656

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.166	8	12	0.166	16	20	0.166	24	28	0.165	32	36	0.165
4	8	0.166	12	16	0.166	20	24	0.166	28	32	0.165	36	40	0.165

Time Area Diagram

Total Area (ha) 0.000

Time (mins) From:	To:	Area (ha)
0	4	0.000