Luton Rising
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November 2023

London Luton Airport Expansion

Planning Inspectorate Scheme Ref: TR020001

Volume 5 Environmental Statement and Related Documents

5.02 Appendix 20.6 Hydrogeological Risk Assessment - Drainage

Application Document Ref: TR020001/APP/5.02
APFP Regulation: 5(2)(a)

The Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

London Luton Airport Expansion Development Consent Order 202x

5.02 ENVIRONMENTAL STATEMENT APPENDIX 20.6 HYDROGEOLOGICAL RISK ASSESSMENT - DRAINAGE

Regulation number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference:	TR020001
Document Reference:	TR020001/APP/5.02
Author:	Luton Rising

Version	**Date**	**Status of Version**
Issue 01	February 2023	Application issue
Revision 01	November 2023	Additional submission - Deadline 4

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1 INTRODUCTION

1.1 Report context

1.1.1 This report is part of a suite of documents prepared to support the application for development consent for the expansion of London Luton Airport (‘the airport'). Specifically, this Hydrogeological Risk Assessment Report (HRA) is a technical appendix supporting **Chapter 20 Water Resources and Flood Risk of the Environmental Statement (ES) [TR2000/APP/5.01]**.

1.1.2 This report provides a hydrogeological risk assessment to assess the acceptability of discharge of treated wastewater and surface runoff to ground from the proposed infiltration tanks in terms of the potential impact on groundwater quality.

1.1.3 The proposed drainage infrastructure comprises the construction of a water treatment plant (WTP) and two infiltration tanks for the discharge of surface water runoff to ground. The potential for discharge of treated contaminated surface water runoff and foul effluent to ground is also considered, however it is considered likely that this will be discharged to the Thames Water (TW) sewage network, as discussed in the revised Drainage Design Statement (DDS) provided as **Appendix 20.4** of the ES **[TR2000/APP/5.02]**.

1.1.4 The proposed drainage infrastructure is to be installed at a future date coinciding with the construction of an additional terminal (Terminal 2) and therefore this risk assessment will need to be revised to account for the final detailed drainage design and to support an application to the Environment Agency for an Environmental Permit to discharge, closer to the time of construction.

1.1.5 This HRA has been updated for Deadline 4 of the DCO Examination in response to comments and ongoing engagement with the Environment Agency and to reflect changes to the proposed drainage design as a result of ongoing discussion with statutory stakeholders. The report has been prepared based on hydrogeological data and the revised drainage strategy at conceptual drainage design stage, as described in the DDS provided as **Appendix 20.4** of the ES **[TR2000/APP/5.02]** which has also been updated for Deadline 4. The change relates to the preferred option for treatment and discharge of foul water and contaminated surface water from the Proposed Development to discharge to the TW network.

2 PROPOSED DEVELOPMENT

2.1 Summary

2.1.1 An overview of the Proposed Development and the site and surroundings in which it is proposed is provided in **Chapter 2** Site and Surroundings of the ES **[TR02000/APP/5.01]**. A detailed description of the Proposed Development is provided in **Chapter 4 The Proposed Development** of the ES **[TR02000/APP/5.01]**. A summary of those elements of the Proposed Development relevant to this assessment is provided below:

a. extension and remodelling of the existing passenger terminal (Terminal 1) to increase the capacity;
b. new passenger terminal building and boarding piers (Terminal 2);
c. earthworks to create an extension to the current airfield platform; the vast majority of material for these earthworks would be generated on site;
d. airside facilities including new taxiways and aprons, together with relocated engine run-up bay and fire training facility;
e. landside facilities, including buildings which support the operational, energy and servicing needs of the airport;
f. enhancement of the existing surface access network, including a new dual carriageway road accessed via a new junction on the existing New Airport Way (A1081) to the new passenger terminal along with the provision of forecourt and car parking facilities;
g. extension of the Luton Direct Air to Rail Transit (Luton DART) with a station serving the new passenger terminal;
h. landscape and ecological improvements, including the replacement of existing open space; and
i. further infrastructure enhancements and initiatives to support the target of achieving zero emission ground operations by 2040[1], with interventions to support carbon neutrality being delivered sooner including facilities for greater public transport usage, improved thermal efficiency, electric vehicle charging, on-site energy generation and storage, new aircraft fuel pipeline connection and storage facilities and sustainable surface and foul water management installations.

2.1.2 The Proposed Development will be delivered incrementally to increase capacity of the existing airport in response to forecast passenger demand. For the purposes of assessment, three assessment Phases 1, 2a and 2b are considered as defined in **Chapter 4** of the ES **[TR02000/APP/5.01].**

[1] This is a Government target, for which the precise definition will be subject to further consultation following the *Jet Zero Strategy*, and which will require further mitigations beyond those secured under the Development Consent Order.

2.2 Proposed Drainage Strategy

2.2.1 As part of the Proposed Development, drainage systems would manage surface water runoff and discharge to ground, via a combination of two infiltration tanks, after treatment as described in the DDS which is provided in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**.

Assessment Phase 1

2.2.2 The existing drainage at the airport discharges into a combination of soakaways and the Thames Water (TW) sewage network. As detailed in the DDS **[TR020001/APP/5.02]**, during the assessment Phase 1 construction works the drainage strategy aims to use the existing airport drainage infrastructure, with flows balanced using rainwater harvesting, attenuation tanks below aprons and landside storage.

2.2.3 Surface runoff from the new aprons will discharge into the existing central soakaway. Live monitoring of contaminants within the drainage system is proposed and any contaminated water will be diverted to the attenuation tanks. Water stored in the tanks will be discharged into the TW foul sewer at an agreed discharge rate.

Assessment Phases 2a and 2b

2.2.4 The main drainage infrastructure for the Proposed Development will be incorporated during assessment Phases 2a and 2b and will include the installation of a new Water Treatment Plant (WTP), attenuation tanks and infiltration tanks. The proposed locations are shown in **Inset 1**.

2.2.5 The new Infiltration Tank 2 in the east of the site will be used for the discharge of uncontaminated (clean) surface water runoff to ground.

2.2.6 The WTP will treat contaminated runoff to discharge to ground via Infiltration Tank 3, and tanker sludge off-site for treatment. A storage tank (Tank 1) will be used to contain runoff prior to discharge to the WTP for treatment. The WTP will also treat harvested surface water run-off to greywater standards and discharge to Terminal 2.

2.2.7 As detailed in the DDS **[TR020001/APP/5.02]**, TW assessment of the network and capacity to accept discharges from the Proposed Development are ongoing and therefore the DDS considers a preferred and reserve option for the drainage.

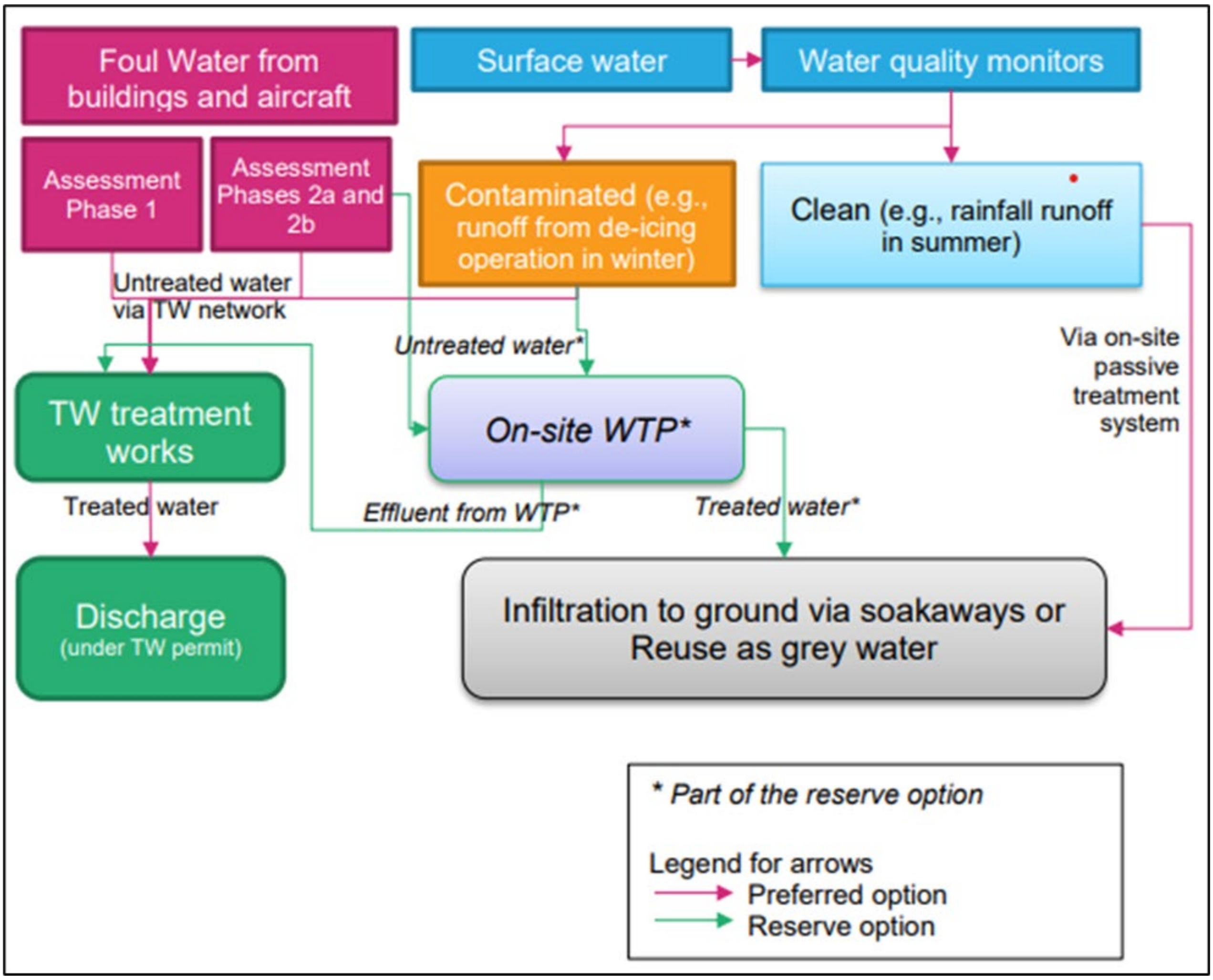
2.2.8 The preferred option is to direct all contaminated discharges from assessment Phases 2a and 2b of the Proposed Development (including foul water from buildings, aircraft blue water and contaminated surface water runoff) to the TW drainage and treatment systems. Non-contaminated (clean) surface water runoff would continue to be directed to groundwater by infiltration or reused as grey water.

2.2.9 The reserve option is for infiltration to ground for treated foul water and contaminated surface water. This ensures a viable option exists for the treatment of contaminated discharges from assessment Phases 2a and 2b of the Proposed Development, should the preferred option prove not to be viable.

2.2.10 The preferred and reserve options are summarised on **Inset 2**.

Inset 1: Location of proposed infiltration tanks and WTP

Inset 2: Preferred and reserved treatment options (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)



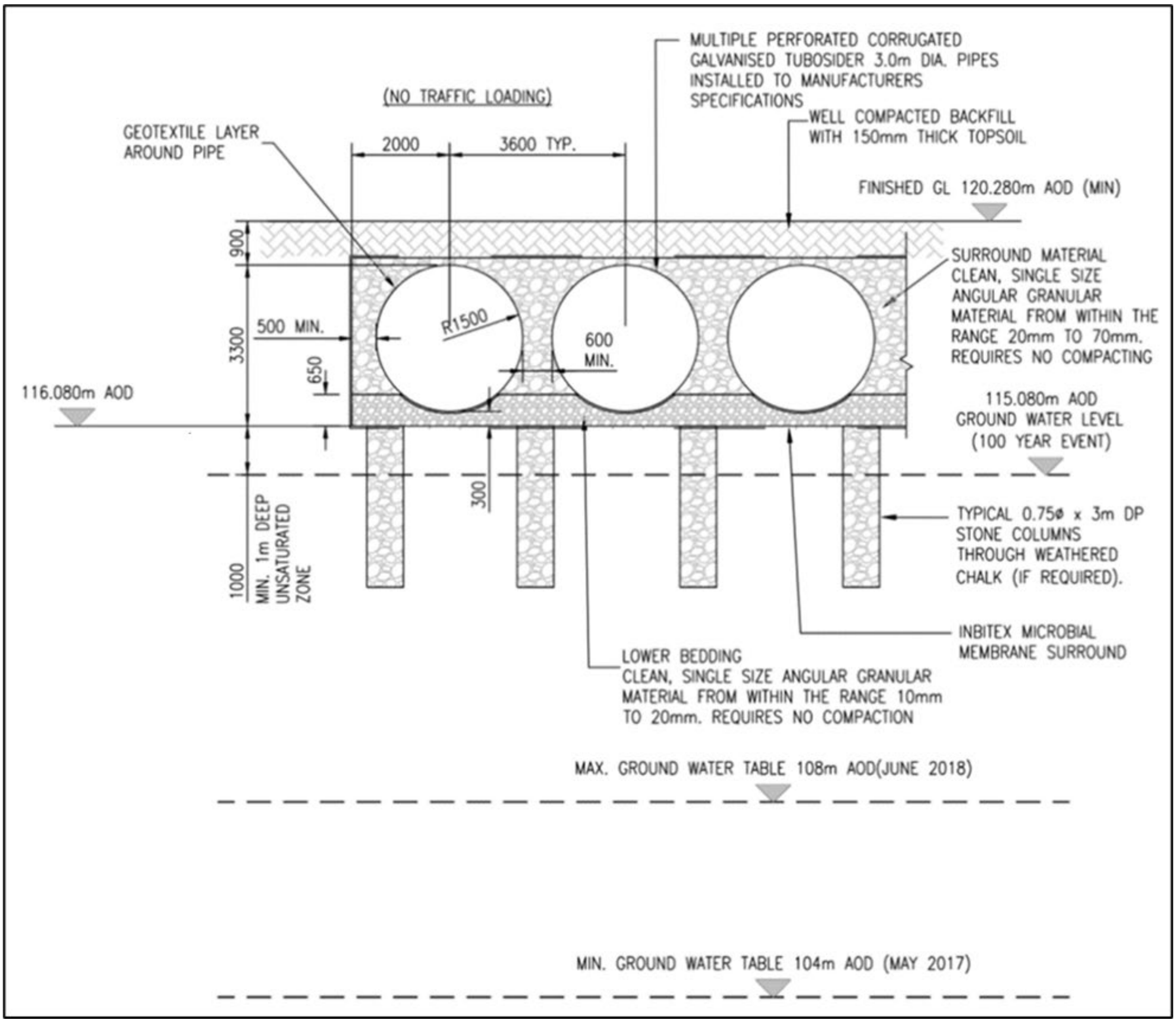
2.3 Proposed Infiltration Tank Design

2.3.1 Two new infiltration tanks would be constructed, the proposed locations of these are shown in **Inset 1**. Both tanks would be underground, removing the requirement for open water at surface, which is necessary to minimise the risk of bird strikes.

2.3.2 The larger of the two infiltration tanks, from hereon named the 'Infiltration Tank 2', would be located to the east and down hydraulic gradient of the runway. This tank would be approximately 260m in length by 120m in width. The design of the tank includes 75,000m^3 of storage capacity and is shown in **Inset 3**.

2.3.3 A 300mm granular drainage layer would be provided at the base of the tank which is proposed to be installed directly onto the underlying chalk bedrock. As shown in **Inset 3** stone columns to provide structural support to the tank may be constructed through the weathered chalk if required. This this will be defined during detailed design.

Inset 3: Preliminary design of Infiltration Tank 2 (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)

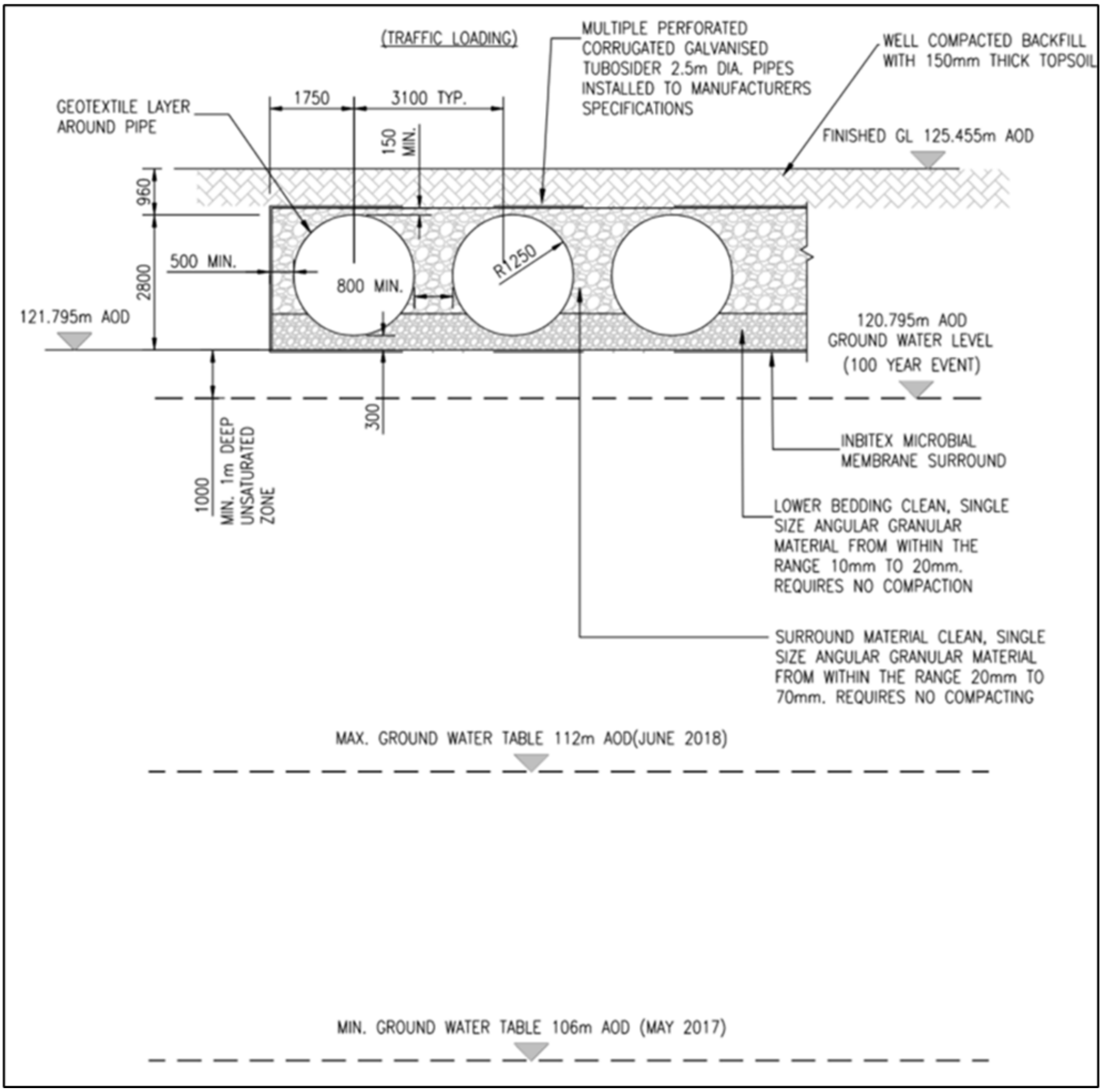


2.3.4 The smaller infiltration tank, from hereon named the 'Infiltration Tank 3', would be located to the east of the proposed new terminal (T2). The tank is approximately 120m in length by 60m in width.

2.3.5 This tank would be used for the discharge of treated effluent from the WTP. The design of the tank includes 7,000m^3 of storage capacity and is shown in **Inset 4**.

2.3.6 A 300mm granular drainage layer would be provided at the base of the tank which is proposed to be installed directly onto the underlying chalk bedrock.

Inset 4: Preliminary design of Infiltration Tank 3 (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)



2.3.7 A WTP would be provided close to Infiltration Tank 3. The WTP includes a large underground storage tank system of 70,900m^3 volume (Tank 1) which is designed to contain a two hour 1 in 100-year storm event.

2.3.8 All underground tanks (storage and infiltration) have been designed with the bottom of the tanks at least 1m above the inferred 1 in 100-year groundwater level.

2.3.9 The construction details and operation of the infiltration tanks will be confirmed during detailed design.

2.3.10 The infiltration tanks have been designed to an infiltration rate of 0.085m/hr, which corresponds to the hydraulic conductivity in the top 20m of the Chalk, acquired from on-site permeability testing during ground investigation undertaken across the wider airport area (discussed in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**). Actual infiltration rates and permeability testing would be confirmed following a detailed investigation that includes soakage tests at the infiltration tank base level which will be undertaken as part of the detailed design as set out in the Design Principles [TR020001/APP/7.09].

2.3.11 The volume of water discharged to the infiltration tanks will vary depending on seasonal and weather conditions and how much water is used for greywater reuse.

2.4 Drainage catchment areas

2.4.1 The indicative drainage catchment areas for the Proposed Development are shown in **Inset 5.** The catchments are split between landside and airside areas and the activities which will be undertaken in these areas will have potential to introduce contaminants into the drainage system.

2.4.2 The landside catchment comprises Terminal 2 and other landside development, surface car parks, access roads, and small areas of soft landscaping.

2.4.3 The airside catchment incorporates the aircraft stands, taxiways, and runways. There are areas of soft landscaping (predominantly grass) adjacent to the runway and taxiways.

2.4.4 The Proposed Development will include a new fire training ground. The drainage associated with the training ground will be self-contained and surface runoff will not be discharged to the main assessment Phase 2b drainage system. During training operations, water will be contained and transported off site for treatment and disposal. Therefore, the drainage related to the fire training ground is not considered in this assessment as it will not be discharged to ground via the proposed infiltration tanks.

2.4.5 Based on the catchment areas, three drainage types have been identified as follows:

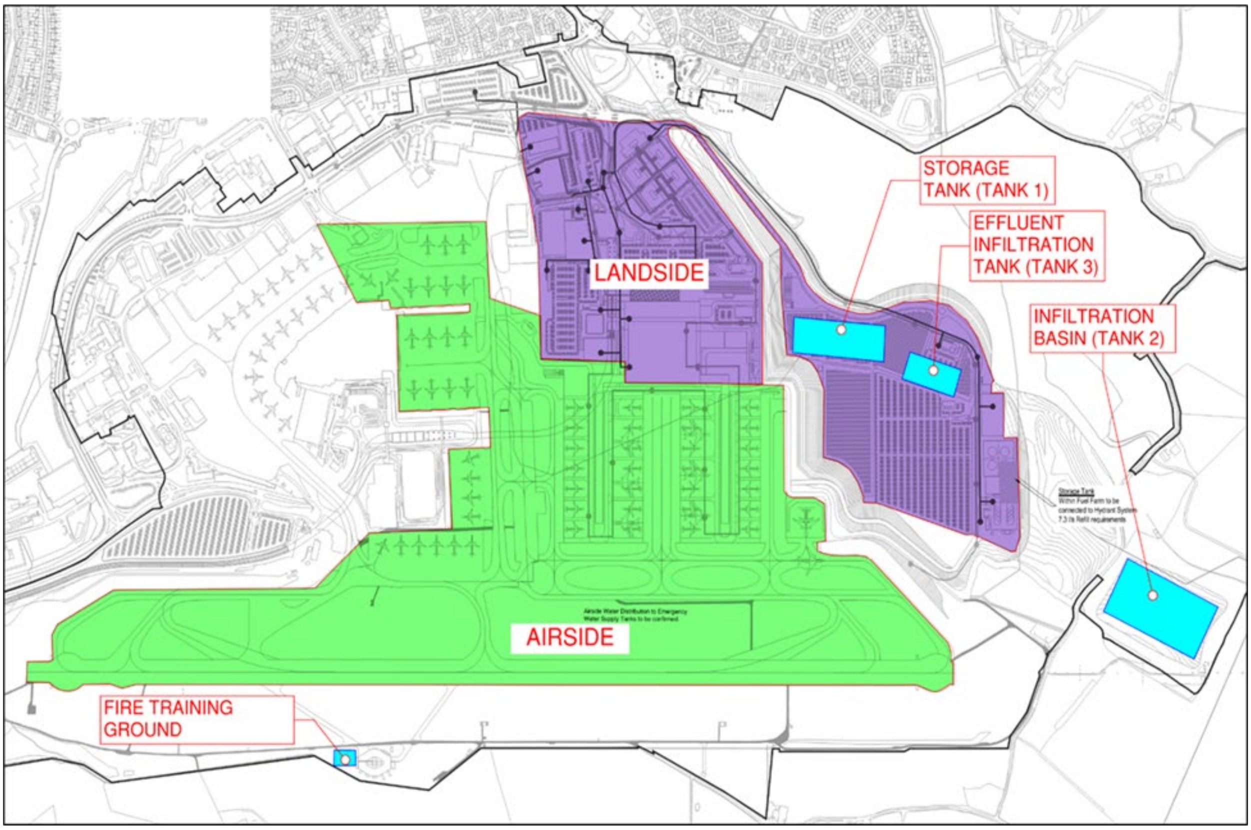
a. surface water runoff from airside areas;

a. surface water runoff from landside areas; and

b. foul water from T2 and landside development.

2.4.6 The activities at the airport where contaminants have the potential to enter each of these drainage streams is summarised in the following section.

Inset 5: Airside and landside drainage catchment (from DDS, **Appendix 20.4** of the ES **[TR020001/APP/5.02]**)



2.5 Airside surface runoff

2.5.1 The key activities within airside areas which have the potential to introduce contaminants into the drainage system are:

a. Aircraft de-icing/anti-icing;
b. Hard surface de-icing;
c. Aircraft and vehicle refuelling;
d. Wear of airplanes, vehicles and infrastructure;
e. Application of herbicides to soft-landscaping; and
f. Emergency incidents (e.g. fires, large spills).

De-icing and anti-icing

2.5.2 The cold weather operations at the airport consist roughly of three operations:

a. De-icing of aircraft prior to take-off;
b. Anti-icing of aircraft prior to take-off;
c. Treatment of hard surfaces such as runways, taxiways and aprons to melt and prevent the formation of ice.

2.5.3 During the winter period (typically November to April), in line with Civil Aviation Authority (CAA) regulatory requirements, it is necessary to prevent the build-up of ice on aircraft and hard surfaces (anti-icing) or remove any ice already present (de-icing). For this report, the term de-icing is used to cover both de-icing and anti-icing.

2.5.4 De-icing and anti-icing of aircraft is carried out using glycol-based fluids. Propylene glycol is the main de-icing agent currently in use. It is non-toxic but can lead to oxygen depletion in water bodies due to the ease with which it biodegrades. It is noted that ethylene glycol is not used at Luton airport.

2.5.5 Anti-icing is a tacky mix of glycol which may shear off the plane as it gains speed and thus it may be found in other areas of the airport, especially on the runway.

2.5.6 The treatment of hard surfaces is carried out using potassium formates, potassium acetates and sodium formate granules. Like propylene glycol, these are not toxic and are easily biodegradable which may lead to oxygen depletion in receiving water bodies.

2.5.7 Efforts are currently being made at the airport to reduce areas where de-icing products are applied and introduce improved recovery systems to collect product from hard surfaces. De-icing operations at the airport are increasing in effectiveness, and, while the use of de-icer can vary each season depending on weather conditions, the latest de-icing consumption figures show a year on year reduction in product use. It is anticipated that the trend of reduced consumption, increased off-site recycling and decreased discharge will continue.

2.5.8 Measures that will be implemented to mitigate pollution of the surface runoff during de-icing activities will include:

a. Improved control and management of the application of ground de-icers (e.g. bunds, vacuum pumps to tankers and off-site recycling);
b. De-icing of aircraft will be carried out in dedicated bays where improved controls and management can be implemented, such as collection of residual fluids by vacuum sweeper.

2.5.9 Any residual fluids containing de-icing products entering the drainage system would be stored in the polluted storage tank (Tank 1) and discharged to the WTP for treatment.

2.5.10 Outside of the winter period, surface runoff will not be affected by de-icing products.

Aircraft and vehicle refuelling

2.5.11 Refuelling and other associated aircraft activities has the potential for accidental spills of fuels, lubricating oils and hydraulic fluids which could enter the drainage system.

2.5.12 BTEX (benzene, toluene, ethylbenzene, and xylene) and naphthalene are the primary component of jet fuel and oils and are highly mobile in the water environment.

2.5.13 Fuel spillage management includes booms to contain flow and rubber mats to cover gully gratings. In the event of larger fuel spills other mitigation would be deployed, for example temporary bunds and vacuum pumps to cylinder tanks that are then exported from site and re-cycled.

2.5.14 Class 1 oil separators will be installed within all areas where there is potential of a fuel spillage.

2.5.15 Surface runoff containing elevated concentrations of oil entering the drainage system would be stored in the polluted storage tank (Tank 1) and discharged to the WTP for treatment.

Wear of aircraft, vehicles, and infrastructure

2.5.16 Wear and corrosion particles from aircraft, vehicles, and other infrastructure have the potential to introduce heavy metals into the surface runoff. These can include zinc, nickel, copper, cadmium, and chromium.

2.5.1 It is noted that that LLAOL have advised that technical aircraft washing is not undertaken in the operation of the airport.

2.5.2 Gullies with silt traps and/or filter drains adjacent to runways and parallel taxiways will act as a first stage separation stage for the main areas where heavy metals may be present.

2.5.3 As a result, significant quantities of metals are not anticipated and metals concentrations entering the drainage system are likely to be in trace amounts. This has been observed in existing water monitoring data from the airport (Ref. 17) where low concentrations of metals have been recorded.

Application of herbicides to soft landscaping areas

2.5.4 There is potential that herbicides could be applied to areas of soft landscaping to prevent weed growth.

2.5.5 The exact products and quantities that could be applied is uncertain. However, it is assumed that they would be applied in low quantities and, as they would be applied to landscaped areas, the risk of runoff containing herbicides will be minimal.

Emergency incidents

2.5.6 Potential emergency incidents that could occur include fires and large-scale fuel spills. Key contaminants are likely to include fuels, oils, and firefighting foams. No firefighting foams which contain per- and polyfluoroalkyl substances (PFAS) are in use at the airport.

2.5.7 Releases because of any emergency incidents would be dealt with as part of the airport's emergency management plan. Typically, any runoff will be contained, and the drainage system isolated for disposal.

2.6 Landside surface runoff

2.6.1 The key activities within landside areas which have the potential to introduce contaminants into the drainage system are:

a. Surface car park and access roads;
b. Application of herbicides to soft-landscaping; and
c. Emergency incidents (e.g. fires, large spills).

Car park and access roads

2.6.2 Wear and corrosion particles from vehicles infrastructure have the potential to introduce heavy metals into the surface runoff. These can include zinc, nickel, copper, cadmium, and chromium.

2.6.3 Silt traps and/or filter drains will act as a first stage separation stage. As a result, significant quantities of metals are not anticipated and metals concentrations entering the drainage system are likely to be in trace amounts.

2.6.4 There is potential for minor fuel leaks from vehicles which could result fuel (containing contaminants such as BTEX and naphthalene) being present in the surface runoff. The likelihood of significant fuel leaks is considered to be rare and significant concentrations within the surface drainage are not anticipated.

Application of herbicides to soft landscaping areas

2.6.5 There is potential that herbicides could be applied to areas of soft landscaping to prevent weed growth.

2.6.6 The exact products and quantities that could be applied is uncertain. However, it is assumed that they would be applied in low quantities and, as they would be applied to landscaped areas, the risk of runoff will be minimal.

Emergency incidents

2.6.7 Potential emergency incidents that could occur include fires and large-scale fuel spills. Key contaminants are likely to include fuels, oils, and firefighting foams. No firefighting foams which contain per- and polyfluoroalkyl substances (PFAS) are in use at the airport.

2.6.8 Releases because of any emergency incidents would be dealt with as part of the airport's emergency management plan. Typically, any runoff will be contained, and the drainage system isolated for disposal.

2.7 Foul water

2.7.1 Sources of foul water from the proposed development will include T2 and other landside developments (e.g., toilets and kitchens) and aircraft blue water (waste from aircraft toilets).

2.7.2 The composition of the foul water will be typical of domestic effluent and will include the following:

a. Biological compounds, bacteria;
b. Nitrogen and phosphorous compounds;
c. Detergents, soaps, oils;
d. Metals;
e. Pharmaceuticals and cosmetics; and
f. Suspended solids.

2.8 Pollution Prevention Measures

2.8.1 As described in the previous sections there are several activities at the airport where contaminants have the potential to enter the surface water drainage system.

2.8.2 The DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) describes a series of treatment and control measures which are to be incorporated in the airport pollution prevention philosophy and preliminary drainage design to limit pollutants entering the drainage system and to identify and remove those pollutants which are present in the drainage prior to discharge. These are:

a. Basic protection by ensuring that all Luton Airport vehicles carry the appropriate spill kits to limit vehicle fuel spill runoff;
b. Gullies with silt traps and/or filter drains adjacent to runway and parallel taxiway – these act as a first separation stage for the main areas where heavy metals may be present (i.e., the touch down and take off zones);
c. Class 1 oil separators are provided to all areas where there is a possibility of a fuel spillage. Class 1 oil separators limit the total concentration of fuels and oils to less than 5 mg/l;
d. A pollution monitoring chamber will be provided that contains a total organic carbon (TOC) monitor (for de-icer contaminated runoff detection, hydrocarbons and other organics) and a sensor to detect any floating pollutants (such as oil). Baseline monitoring will be undertaken during detailed design to calibrate the TOC monitor detection levels to identify de-icing products and other organic contaminants;
e. Dependant on whether pollutants are identified in the flow monitoring chamber, a flow control chamber is provided to direct and divert the flows as required. This is to be placed as far downstream of the pollution monitoring as possible to allow for adequate time for the mechanical flow control devices to operate.

2.8.3 Where there is a possibility of de-icing, the strategy below will be used:

a. Improved controls and management of the application of ground de-icers (e.g., bunds, vacuum pumps to tankers and off-site re-cycling);
b. Improved controls and management for dosing for application of de-icers to aircraft;

c. Any residual fluids resulting from the de-icing of aircraft and hard surfaces, would be collected by vacuum sweeper or collected by the drainage system, stored in the polluted storage tank, and discharged to the proposed water treatment plant. Monitoring within the drainage system will divert flow to the polluted storage tanks or water treatment plant when glycols are detected;

d. The aforementioned TOC monitor will be integral in diverting any remaining glycol that has been dissolved in rainwater runoff away from the clean water system.

2.8.4 An automated water quality monitoring system will be installed within the drainage infrastructure upstream of the WTP. The system will allow any water which contains elevated levels of contaminants to be diverted to the WTP rather than being discharged directly to Infiltration Tank 2.

2.8.5 The automated monitoring system will include continuous TOC monitoring (for de-icer contaminated and other organics runoff detection) and a sensor to detect any floating pollutants (such as oil).

2.8.6 The monitoring system to be used will established during detailed design. The monitors will be calibrated based on site-specific baseline monitoring data to be collected during detailed design and will continually be calibrated during the lifecycle of the development.

2.8.7 Current technology for TOC monitoring is capable of detecting concentrations as low as 0.1 mg/l.

2.9 Assumed drainage water quality

2.9.1 A preliminary assessment of the drainage water quality has been developed based on limited existing airport water quality monitoring data and an understanding of typical drainage systems from other sites.

2.9.2 Water quality sampling is regularly carried out by Luton Airport as part of their Environmental Management Systems. The water quality analysis includes a range of standard quality parameters (e.g., BOD, COD), heavy metals, glycols, and hydrocarbons. These are sampled at a number of boreholes, soakaways and drainage connections around the site.

2.9.3 The latest available airport drainage monitoring report for 2021/22 (Ref. 17) indicates the following:

a. Concentrations of total glycols in all samples obtained were generally below the laboratory limit of detection (<10 mg/l). On the occasions where glycols were recorded concentrations ranged from 76 to 470 mg/l (propylene glycol is typically the only product detected);

b. Total petroleum hydrocarbons (TPH) concentrations were typically less below the laboratory limit of detection (<0.01 mg/l). TPH was recorded in two out of 59 samples at concentrations of 0.16 mg/l and 0.37 mg/l;

c. Concentrations of metals were generally less than 1mg/l in all samples obtained.

2.9.4 Detailed information of the surface water quality in the existing airport drainage is not available. During detailed design, baseline monitoring will be undertaken to characterise the chemical components in the surface water runoff and determine the specific treatment processes that will be required.

Water quality – uncontaminated (clean) surface water runoff

2.9.5 Surface runoff that is considered to be uncontaminated rainfall runoff will be discharged to ground via Infiltration Tank 2 or reused as greywater. The upstream management and source control will ensure that runoff containing de-icing products and fuels and oils will not be discharged to ground via Infiltration Tank 2.

2.9.6 The water quality for the uncontaminated surface runoff to Infiltration Tank 2 is therefore assumed to comprise the following:

Heavy metals

2.9.7 Trace concentrations of heavy metals are anticipated in the drainage discharge as there are no significant sources and particles entering the drainage will be reduced by silt traps and filter drains.

2.9.8 Low concentrations of heavy metals have been recorded in the latest airport water monitoring report (Ref.17). Typical metal concentrations in urban runoff summarised in the CIRIA SuDS Manual (Ref.18) also indicate metal concentrations are low.

2.9.9 The water quality for the uncontaminated surface runoff to Infiltration Tank 2 is therefore assumed to comprise:

a. Cadmium 0.002 mg/l (Ref, 17)
b. Chromium 0.01 mg/l (Ref. 18)
c. Copper 0.01 mg/l (Ref. 17)
d. Nickel 0.01 mg/l (Ref. 17)
e. Zinc 0.01 mg/l (Ref. 17)

De-icing

2.9.10 Surface runoff from areas where de-icing products have been applied will be diverted to the contaminated water system and will not be discharged to Infiltration Tank 2. The TOC monitoring system will divert contaminated water and will be capable of detecting total organic concentrations 0.1 mg/l or greater which is considered sufficient to divert surface water away from Infiltration Tank 2 (glycol concentration <10mg/l to 470 mg/l based on latest airport monitoring data).

2.9.11 Glycols and other de-icing products in the discharge to Infiltration Tank 2 will not be present.

Fuels and oils

2.9.12 Significant concentrations of fuels and oils, anticipated to predominantly comprise BTEX and naphthalene, will not be present in the discharge to Infiltration Tank 2 as the monitoring system (TOC and product) and Class 1 separators (<5 mg/l) in the drainage are considered sufficient to divert these to the contaminated water system.

2.9.13 Trace amounts may be present in the discharge on rare occasions where there has been a minor fuel leak from vehicles in the landside areas, but these are considered unlikely to be below the laboratory limit of detection (typically less than 0.001 mg/l).

Herbicides

2.9.14 Concentrations of herbicides are not anticipated in the surface runoff as, where used, they would be applied to soft landscaping areas and are therefore unlikely to enter the drainage system.

Water quality – contaminated surface water runoff

2.9.15 Surface runoff that is contaminated will be diverted to the WTP and undergo treatment prior to discharge to ground via Infiltration Tank 3 or reused as greywater. The upstream management and source control, including drainage monitoring systems will ensure that runoff containing de-icing products and fuels and oils will be diverted to the WTP.

2.9.16 The final water quality following treatment will depend on the treatment systems used which will be defined during detailed design. The treated water quality has been assessed based on typical treatment processes.

2.9.17 The water quality for the treated surface water to Infiltration Tank 3 is therefore assumed to comprise the following:

Heavy metals

2.9.18 Trace concentration of heavy metals are anticipated in the drainage discharge as a significant source is not anticipated and particles entering the drainage will be reduced by silt traps and filter drains. Where metals are found to be present in the surface water the treatment process could result in a final effluent concentration for total metals of less than 0.001 mg/l.

2.9.19 The water quality for the treated surface runoff to Infiltration Tank 3 is therefore assumed to comprise:

a. Cadmium 0.001 mg/l
b. Chromium 0.001 mg/l
c. Copper 0.001 mg/l
d. Nickel 0.001 mg/l
e. Zinc 0.001 mg/l

De-icing

2.9.20 Surface runoff from areas where de-icing products have been applied will be diverted to the contaminated water system. The TOC monitoring system will divert contaminated water and will be capable of detecting concentrations of 0.1 mg/l and greater, which is considered sufficient to divert surface water away from Infiltration Tank 2 (glycol concentration <10mg/l to 470 mg/l based on latest airport monitoring data).

2.9.21 The treatment process will be designed to remove glycols and other de-icing products. Therefore, glycols and other de-icing products in the discharge to Infiltration Tank 3 will not be present.

Fuels and oils

2.9.22 The total hydrocarbon concentration in the contaminated surface water is likely to be less than 5mg/l. The treatment process is anticipated to result in a total hydrocarbon concentration in the final treated discharge of less than 0.01 mg/l. This will include all hydrocarbon compounds and concentrations of individual compounds are likely to be an order of magnitude lower (0.001 mg/l).

2.9.23 BTEX and naphthalene are the primary component of jet fuel and oils and are highly mobile in the water environment and are considered the key contaminants that may pose a risk in the discharge to Infiltration Tank 3. As a precautionary measure the concentrations of BTEX and naphthalene in the discharge is assumed to be 0.01 mg/l as the worst-case, although actual concentrations are likely to be much lower.

Herbicides

2.9.24 Concentrations of herbicides are not anticipated in the surface runoff as, where used, they would be applied to soft landscaping areas and are therefore unlikely to enter the drainage system.

Water quality – treated foul water

2.9.25 The final effluent quality of the treated foul water is considered likely to have a similar discharge concentration to the treated surface water.

2.9.26 It has been assumed that the preferred option of discharge of foul water to the TW system is likely to go ahead, an assessment of the treatment and final discharge effluent quality from the WTP to ground is not provided.

2.9.27 In the unlikely event that TW cannot accept the foul water and the reserve option of onsite treatment and discharge to ground is necessary, the effluent quality and treatment processes will be defined during detailed design and a risk assessment undertaken will be undertaken at that stage.

2.9.28 Current treatment technology is available that would allow the foul water to be treated to required standards for discharge to ground. As outlined in the drainage design principles in the DDS, no hazardous substances will be discharged to ground.

3 SITE SETTING

3.1 Location

3.1.1 The Main Application Site of the Proposed Development (as defined in **Chapter 2** of the ES **[TR020001/APP/5.01]** and shown on **Figure 2.2** of the ES **[TR020001/APP/5.03]**) is located approximately 3km south east of Luton town centre and incorporates the area around the airport, with the majority of the undeveloped land required for the Proposed Development to the east of the existing airport.

3.1.2 The proposed WTP and two infiltration tanks will be located in the east of the Main Application site as shown in **Inset 1** on land which is currently undeveloped agricultural land.

3.2 Topography

3.2.1 The airport is located immediately north east of the River Lee on an elevated escarpment area that forms part of a scarp slope of the Chilterns Hills.

3.2.2 The topography of the land within the Order limits, encompassing the whole of the proposed airport expansion, varies between 98 to 164 metres Above Ordnance Datum (mAOD). The highest ground is located in the north west and the land gradually lowers to the south east where the topography includes a dry valley network. The Main Application Site includes two branches of the dry valley network which join approximately 250m south east of the Proposed Development.

3.2.3 Existing ground levels in the locations of the proposed Infiltration Tanks are approximately 125mAOD (Infiltration Tank 3) and 120mAOD (Infiltration Tank 2).

3.3 Hydrology

3.3.1 No surface watercourses run through the Main Application Site. The nearest large watercourses are the River Lee situated 450m to the south west of the Main Application Site (as defined in **Chapter 2** of the ES **[TR02000/APP/5.01]**) and the River Mimram situated 3.5km east of the Main Application Site. These are both likely to be in hydraulic continuity with the Chalk aquifer.

3.3.2 The watershed line between the two river catchments divides the airport into two, with the west of the airport within the River Lee catchment and the east within the River Mimram catchment. The WTP and proposed infiltration tanks are within the Mimram catchment. The River Mimram is approximately 4km to the east of the proposed Infiltration Tank 2 and 4.5km to the east of the proposed Infiltration Tank 3.

3.4 Geology

3.4.1 The understanding of the geology around the airport has been developed through the following resources:

a. the British Geological Survey (BGS) report “The physical properties of major aquifers in England and Wales” (Ref. 4);
b. BGS Geology of Britain webviewer (Ref. 5); and
c. on-site ground investigation as documented in a Contamination Quantitative Risk Assessment (Ref. 6).

Superficial deposits

3.4.2 Superficial deposits that occur within the Order limits include:

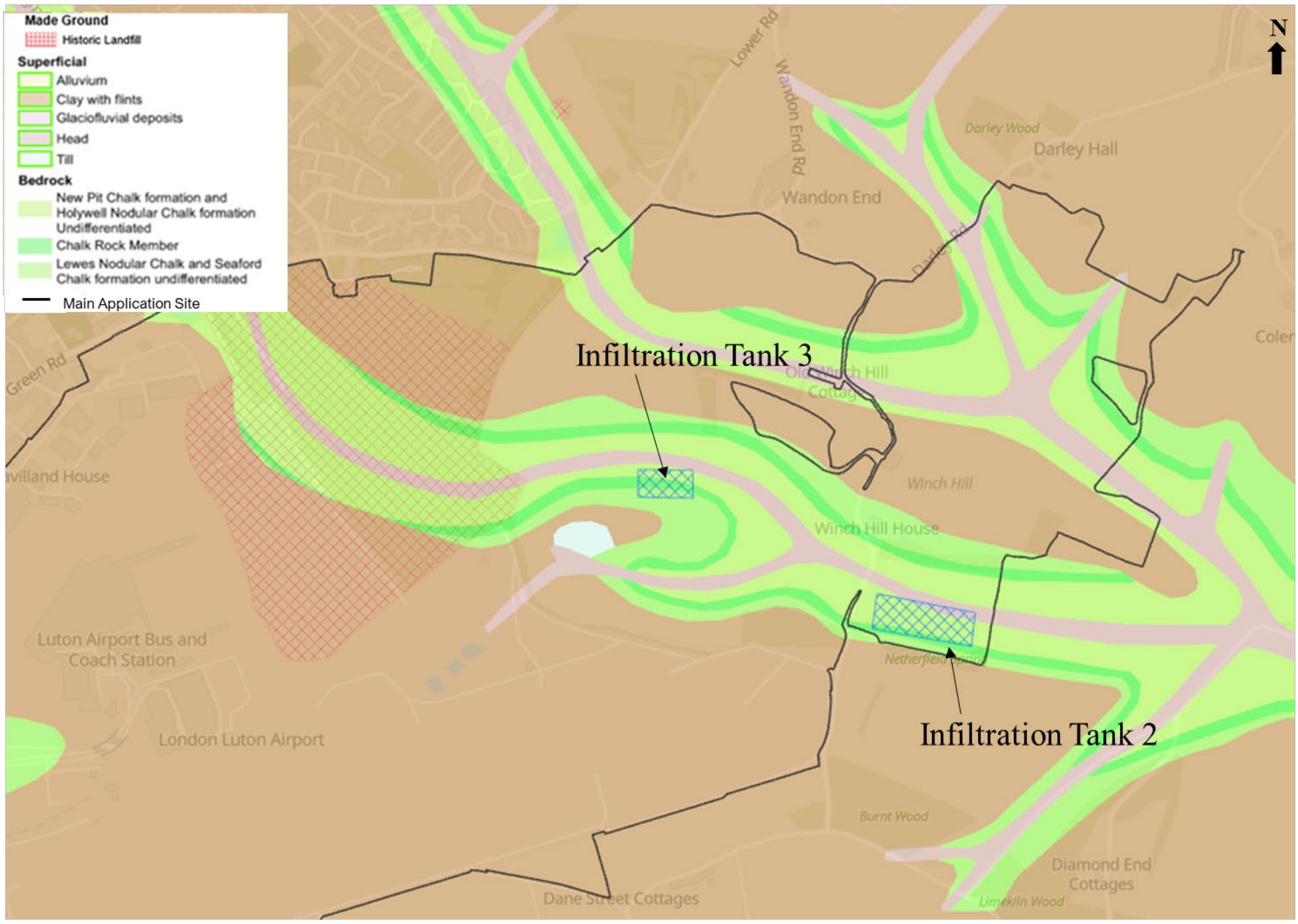
a. Made Ground;
b. Head deposits; and
c. Clay-with-Flints.

3.4.3 Both the Made Ground and Clay-with-Flints underlie the majority of the Main Application Site whereas the Head deposits are found in a thin band within the dry valley bottoms.

3.4.4 A historic landfill is present beneath the east of the current airport and approximately 300m to the west of the proposed Infiltration Tank 3.

3.4.5 The geological map of the Proposed Development is shown in **Inset 6** which shows where superficial deposits are expected to be absent at the proposed locations of the infiltration tanks.

Inset 6: Geology Map for the Main Application Site



Bedrock

3.4.6 The bedrock beneath the Main Application Site consists of Cretaceous Chalk (undifferentiated Lewes Nodular and Seaford Chalk formations and Chalk Rock Member). These are classified as being part of the “White Chalk Subgroup”.

3.4.7 These are composed of firm and hard chalk strata with common nodular and tabular flints and hardgrounds.

3.4.8 These in turn are underlain by the older Holywell Nodular and New Pit Chalk formations, also part of the “White Chalk Subgroup”, which outcrop within the dry valleys. These are generally similar in composition to the overlying Chalk formations but are generally flintless.

3.4.1 The condition of the Chalk encountered beneath the Main Application Site is variable. In the upper levels of the Chalk the material has been found to be heavily weathered and was generally recovered as structureless sandy to very silty gravel or sandy gravelly silt. The Chalk material recovered was occasionally recorded as having yellowish brown staining on what are considered to be natural fracture surfaces. Soft grey marl bands were also recovered from within the Chalk.

3.4.2 As shown in **Inset 6** the proposed infiltration tanks are to be installed directly onto the Chalk bedrock and are located around the dry valleys.

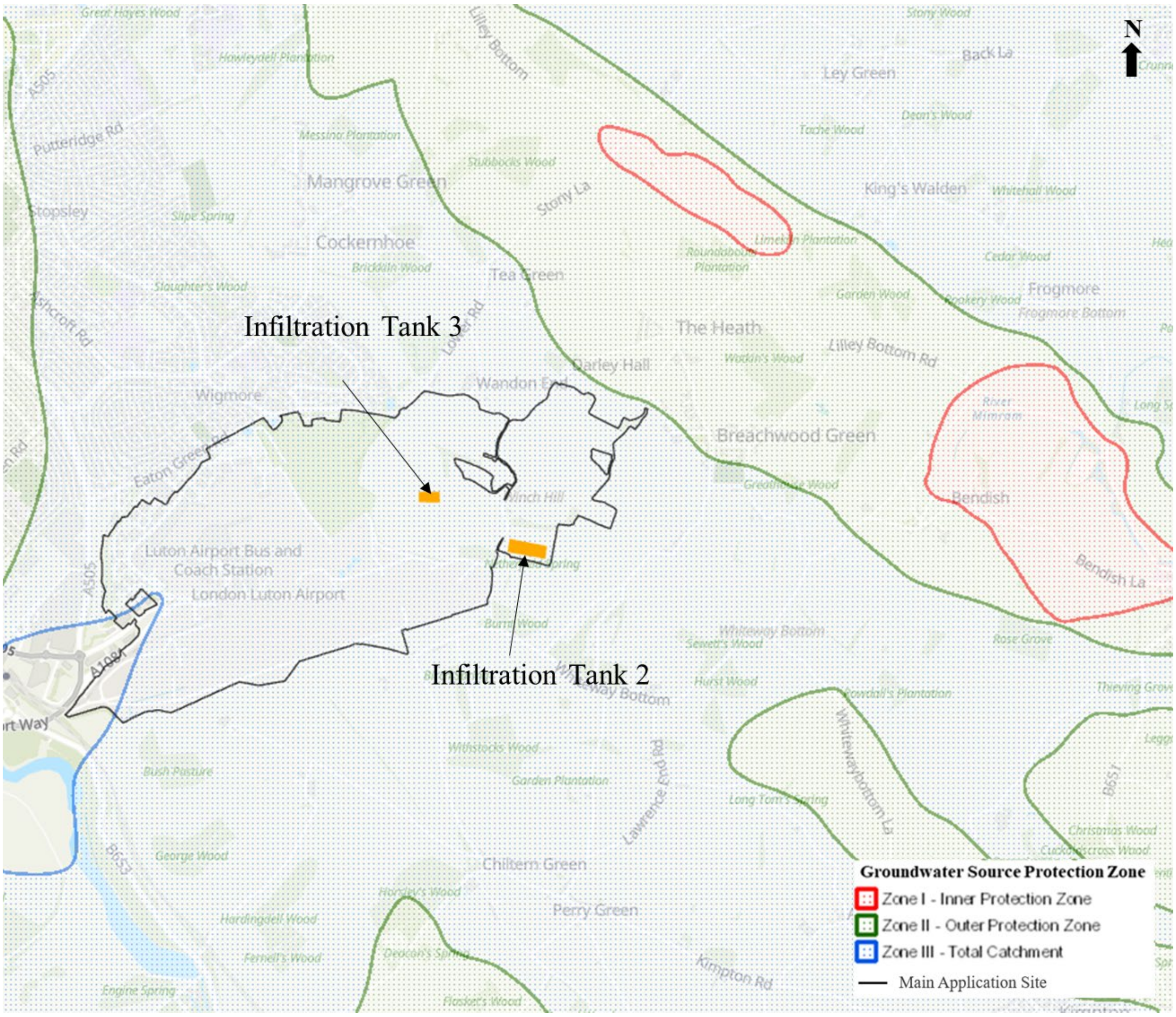
3.5 Hydrogeology

3.5.1 A detailed description of the hydrogeological regime beneath the Main Application Site is described in the Hydrogeological Characterisation Report provided in **Appendix 20.3** of the ES **[TR020001/APP/5.02]** and key characteristics are summarised here.

3.5.2 The Chalk bedrock beneath the Site forms the main water bearing strata in the region and most important aquifer unit within the Thames Basin. It is classed as a Principal aquifer and supplies drinking water for public consumption and supports river flow. The flow through this geology is predominantly through fractures and associated dissolution features.

3.5.1 The Main Application Site is located within a groundwater Source Protection Zone 3 (total catchment) for the public water supply (PWS) abstractions (see **Inset 7**). There are no private groundwater abstractions within 250m of the Main Application Site.

Inset 7: Groundwater Source Protection Zones



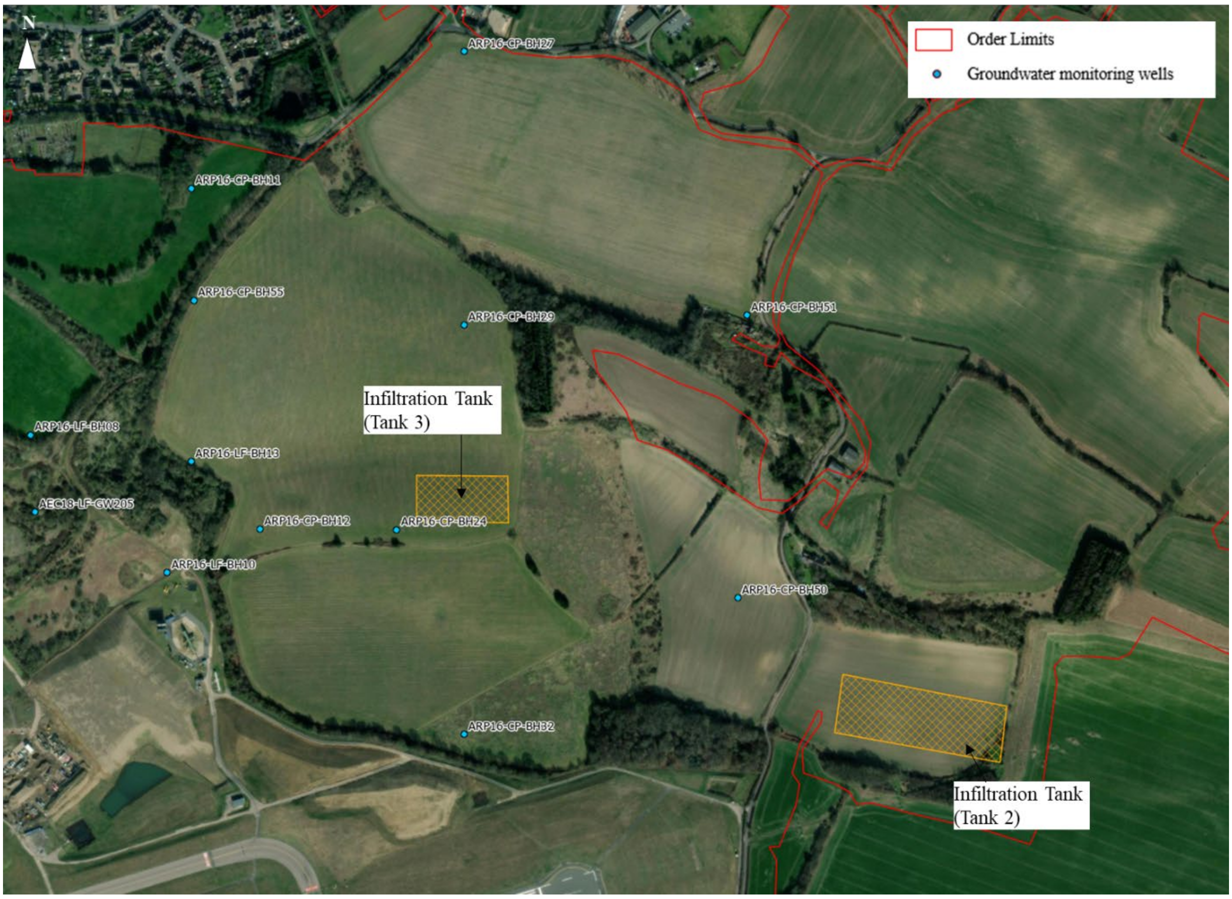
Groundwater flow and levels

3.5.2 The regional groundwater flow system is modified locally by abstraction and discharge to groundwater. The east of the Main Application site is located within the Mimram catchment and groundwater flow is in a general easterly direction towards the Affinity Water PWS abstractions near Kings Walden, approximately 2.6km to the east.

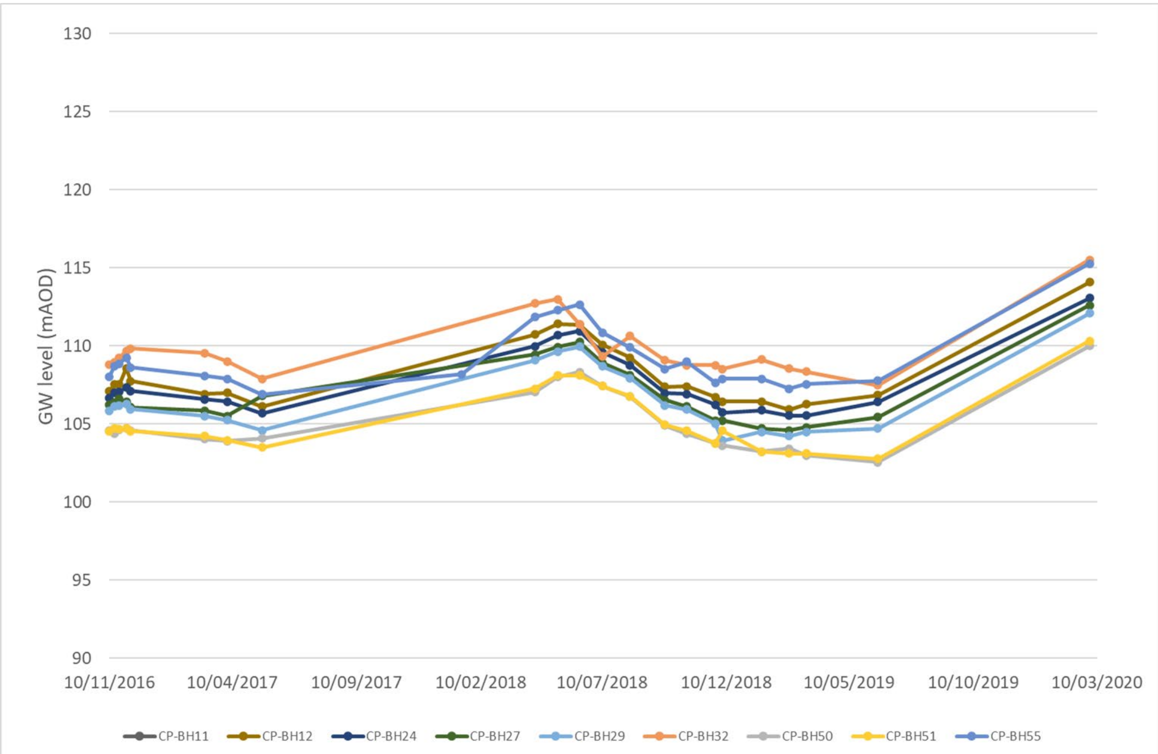
3.5.3 The **Hydrogeological Characterisation Report** (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**) presents a detailed discussion on groundwater levels beneath the Main Application Site.

3.5.4 As shown on **Inset 8**, there are a number of groundwater monitoring boreholes in the vicinity of the proposed infiltration tanks with the closest being ARP-CP-BH24, ARP-CP-BH32 and ARP-CP-BH50. Groundwater levels in these boreholes were monitored between November 2016 and March 2020 as presented in the hydrograph shown in **Inset 9**.

Inset 8: Location of groundwater monitoring wells in the vicinity of the proposed infiltration tanks



Inset 9: Groundwater hydrograph from monitoring boreholes



3.5.5 Seasonal variation in groundwater levels can be significant within the Chalk in the regional area, with groundwater levels typically showing seasonal ranges of between 5m and 10m. Peak groundwater levels generally occur between February to April each year and then recede to seasonal lows in August to October.

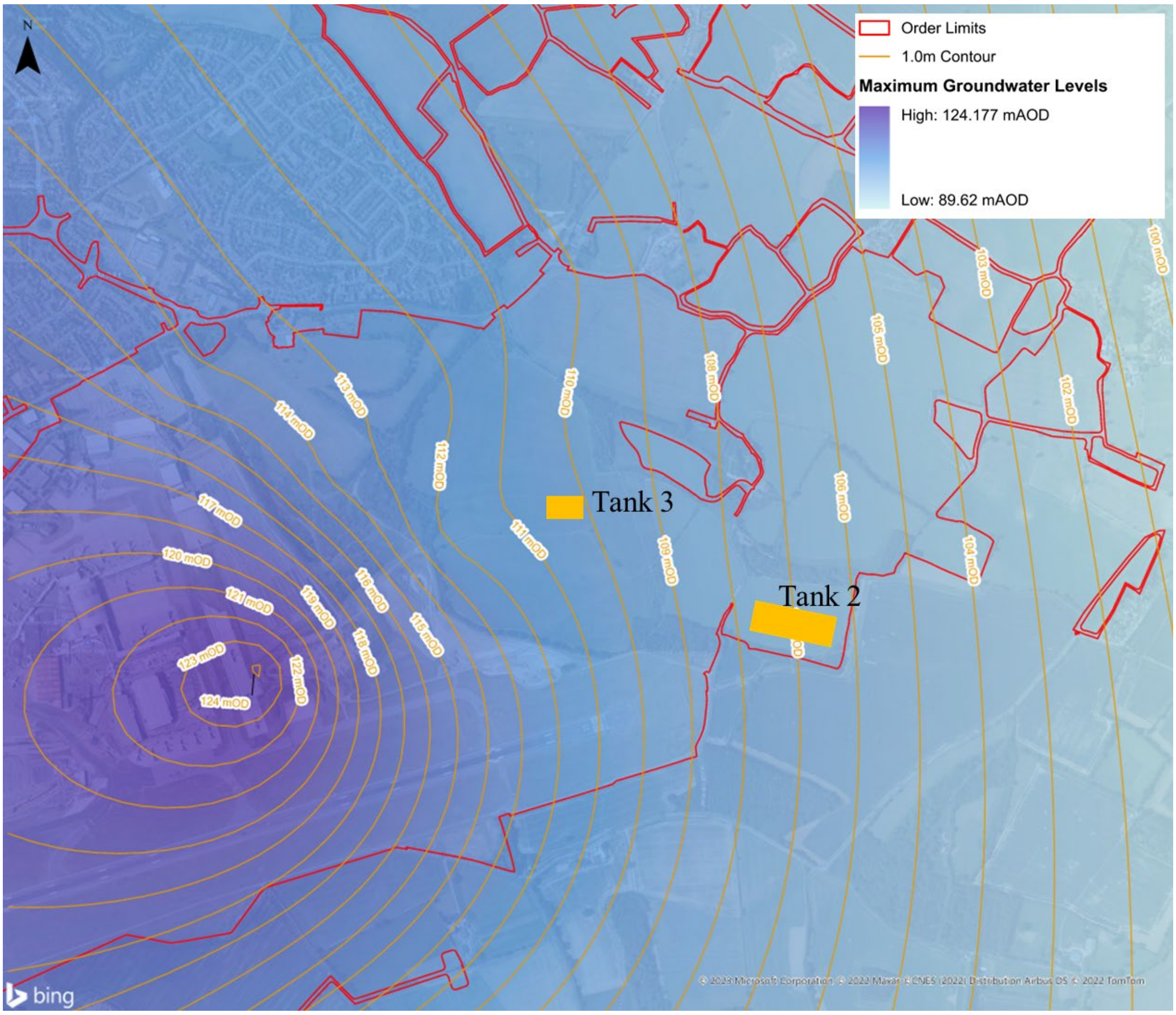
3.5.6 The monitoring boreholes near the infiltration tanks recorded the following range in groundwater levels between 2016 and 2020.

a. ARP-CP-BH24 – 105.5mOD to 113mOD
b. ARP-CP-BH32 – 107.5mOD to 115.5mOD
c. ARP-CP-BH50 – 102.5mOD to 110mOD

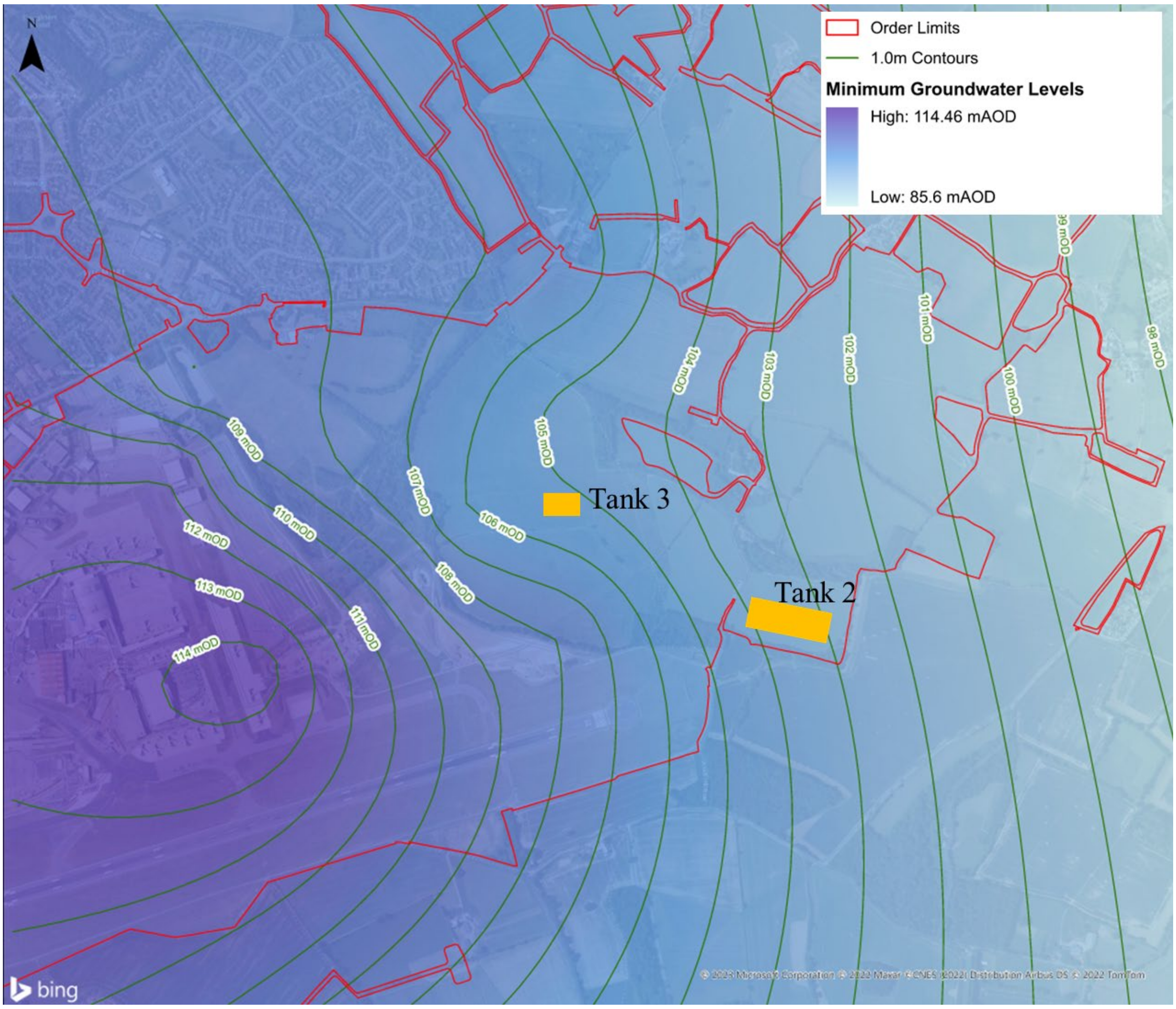
3.5.7 A series of groundwater contour plans are presented in the **Hydrogeological Characterisation Report** (**Appendix 20.3** of the ES **[TR020001/APP/5.02]**).

3.5.8 The groundwater contours based on the peak and lowest recorded groundwater level during the borehole monitoring in 2018 and 2017 are shown in **Inset 10** and **Inset 11** respectively. The predicted groundwater contours based on a 1 in 100-year groundwater level are shown in **Inset 12**.

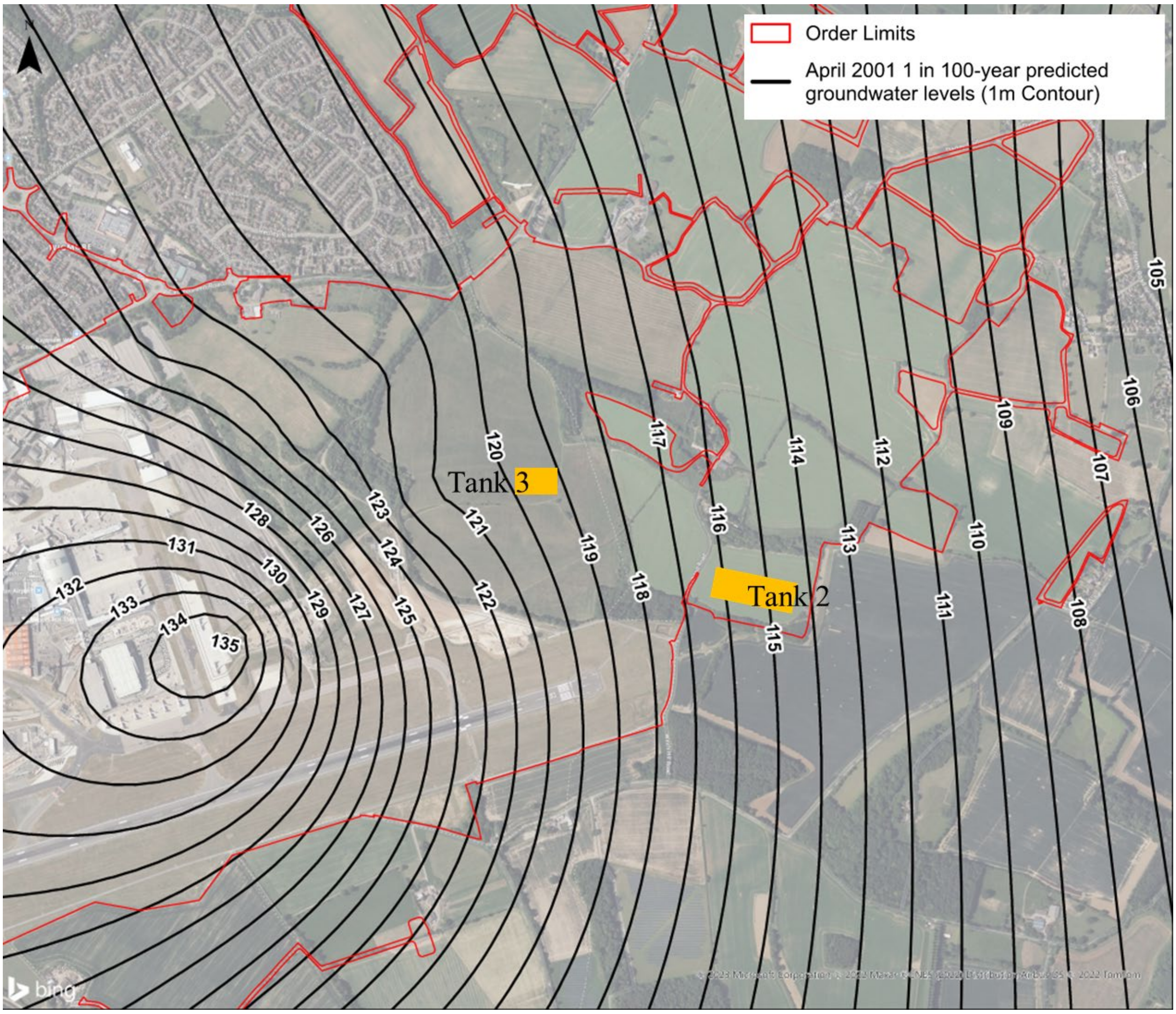
Inset 10: Peak groundwater level (2018) (from **Appendix 20.3** of the ES **[TR020001/APP/5.02]**)



Inset 11: Minimum groundwater level (2017) (from **Appendix 20.3** of the ES **[TR020001/APP/5.02]**)



Inset 12: 1 in 100 year predicted groundwater level (from **Appendix 20.3** of the ES **[TR020001/APP/5.02]**)



3.5.9 Based on the groundwater contour plots, the predicted groundwater levels beneath the proposed infiltration tanks is summarised in **Table 3.1**.

3.5.10 There is potential for groundwater levels beneath the tanks to be highly variable. As a result, the thickness of the unsaturated zone beneath the tanks may be as low as 1m during a 1 in 100-year event and more than 10m thick during drier periods.

Table 3.1: Summary of predicted groundwater levels beneath proposed infiltration tanks

	Infiltration Tank 2	Infiltration Tank 3
Ground Level	120.3 mOD	125.5 mOD
Tank Base	116.1 mOD	121.8 mOD
1 in 100-year groundwater level	115.1 mOD	120.8 mOD
Peak groundwater level (2018)	108 mOD	112 mOD

	Infiltration Tank 2	Infiltration Tank 3
Minimum groundwater level (2017)	104 mOD	106 mOD

3.5.1 An assessment of the winter rainfall (Oct-Mar) at Runley Wood rainfall gauge was undertaken for the period of monitoring (1990 to 2022). The average winter rainfall between 1990 and 2022 was 370mm. In comparison, the winter rainfall in 2018 was below average at around 300mm. Seasonal high groundwater levels in 2018 was therefore likely to be below average.

3.5.2 Based on the groundwater level interpretation in **Appendix 20.3** of the ES **[TR020001/APP/5.02]** and the winter rainfall data, it is likely that seasonal high groundwater levels under average winter rainfall conditions are likely to be between 111mOD and 112mOD for Tank 2 and 115mOD and 116mOD for tank 3.

3.5.3 The estimated 1 in 100-year groundwater level occurred following a winter rainfall of 662mm, in 2000/2001, the highest recorded winter rainfall over the period of available data. 95% of the rainfall data between 1990 and 2022 had a winter rainfall of less than 540mm, highlighting the extreme nature of the 2000/2001 rainfall and groundwater level.

3.5.4 The estimated hydraulic gradient based on the 1 in 100-year groundwater contours beneath the proposed infiltration tanks is estimated to be 0.0075 (0.75%) in an easterly direction. The estimated hydraulic gradient based on the maximum seasonal groundwater contours beneath the proposed infiltration tanks is estimated to be 0.0055 (0.55%) in an easterly direction.

Hydraulic conductivity

3.5.5 Predicting the hydraulic conductivity of Chalk is difficult due to most of the flow occurring through fractures. Hydraulic conductivity within the Chalk shows a variation laterally and with depth.

3.5.6 On-site packer testing in the Chalk to the west of the proposed infiltration tank locations indicated that in the top 20m of the Chalk had an average hydraulic conductivity of 2.4×10^{-5}m/s. At 40m to 52m from the top of the Chalk, the average hydraulic conductivity was two orders of magnitude lower at 3.4×10^{-7}m/s. This is likely due to the presence of more permeable zones associated with fractures and increased dissolution within the zone of water table fluctuation at the top of the Chalk.

3.5.7 The locations of the available site investigation boreholes, trial pits and packer test data across the site cover both the interfluve and dry valley areas.

3.5.8 The assessment of hydraulic conductivity is based on available on-site permeability testing during ground investigation undertaken across the wider airport area (discussed in **Appendix 20.4** of the ES **[TR020001/APP/5.02]**). Actual hydraulic conductivities would be confirmed following a detailed investigation at the proposed infiltration tank locations as part of the detailed design.

Groundwater quality

3.5.9 Groundwater quality sampling of the onsite monitoring boreholes shown in **Inset 8** was undertaken between 2016 and 2019 and the results are presented in the **generic quantitative risk assessment** (**Appendix 17.2**) (Ref. 6) of the ES **[TR020001/APP/5.02]**.

3.5.10 The background groundwater quality for selected contaminants is presented in **Table 3.2**. The background groundwater quality does not indicate any significant groundwater contamination in the vicinity of the proposed infiltration tanks.

Table 3.2: Summary of background groundwater quality (2016-2019) in boreholes adjacent to the proposed infiltration tanks

Determinand	Minimum Concentration (mg/l)	Maximum Concentration (mg/l)	95th percentile concentration (mg/l)
Cadmium	<0.0002	0.0006	0.0002
Chromium (total)	<0.0002	0.0016	0.007
Copper	<0.0005	0.027	0.006
Nickel	<0.0005	3	0.0119
Zinc	<0.0005	0.026	0.012
Propylene glycol	<10	<10	-
Benzene	<0.001	<0.001	-
Toluene	<0.001	<0.001	-
Ethylbenzene	<0.001	<0.001	-
Xylene	<0.001	<0.001	-
Naphthalene	<0.0001	0.00073	<0.0001

4 CONCEPTUAL SITE MODEL

4.1 Introduction

4.1.1 The following section outlines the conceptual site model and assumptions used to undertake the assessment of impact to groundwater quality from the discharge to ground of uncontaminated surface water to Infiltration Tank 2, and treated surface water to Tank 3.

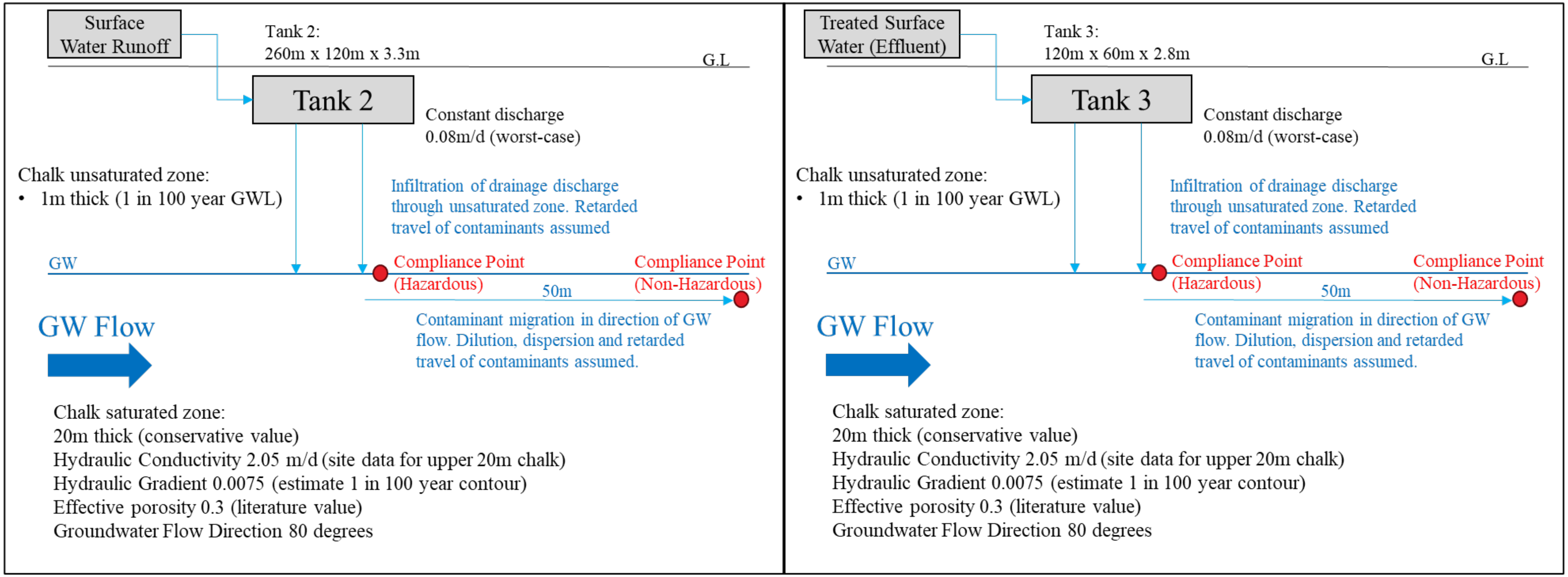
4.1.2 Due to the potential for significant variation in groundwater levels beneath the infiltration tanks two main conceptual site model scenarios have been considered:

a. The first model considers a 1m unsaturated zone beneath the base of the tanks to represent the worst-case 1 in 100-year groundwater level. The conceptual model is presented in **Inset 13**;

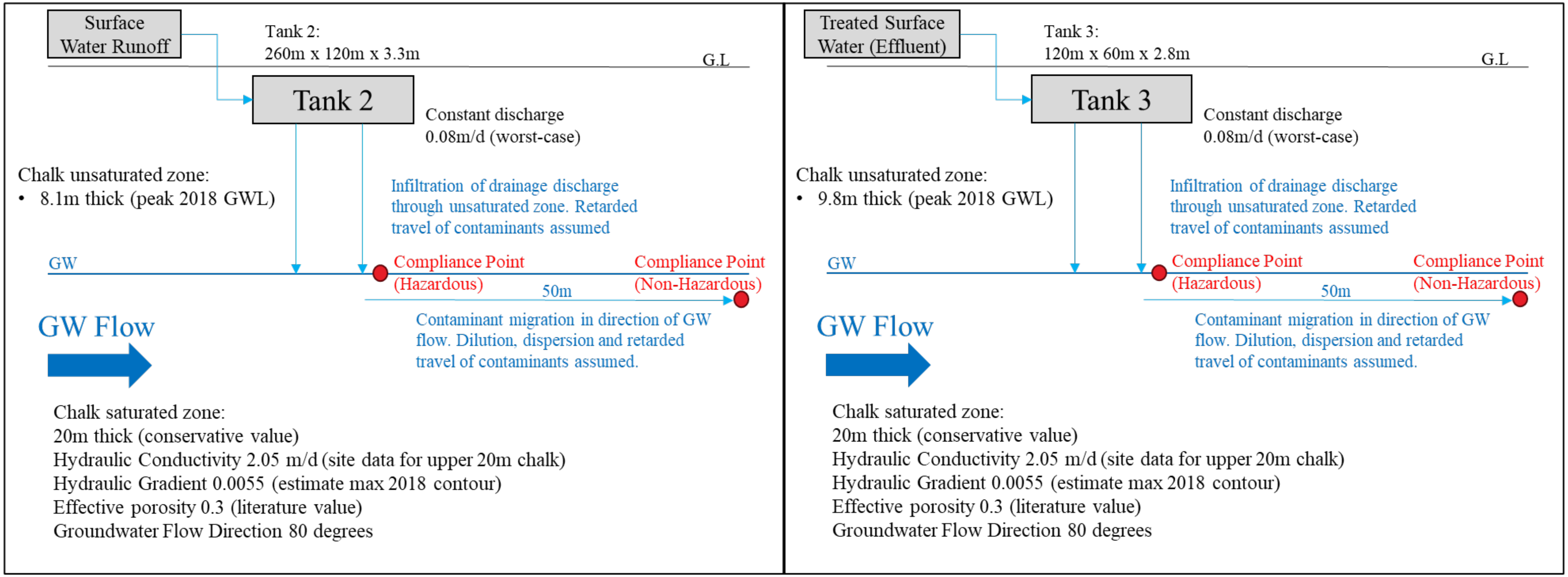
b. The second model considers a 8.1m unsaturated zone beneath Tank 2 and 9.8m thick unsaturated zone beneath Tank 3, based on the peak 2018 groundwater level. The conceptual model is presented in **Inset 14**.

4.1.3 The conceptual site model is described in the following sections.

Inset 13: Conceptual Site Model (1 in 100 groundwater level)



Inset 14: Conceptual Site Model (peak 2018 groundwater level)



4.2 Source

4.2.1 The drainage infrastructure to be constructed as part of the Proposed Development would manage surface water runoff and discharge to ground, via a combination of two infiltration tanks.

4.2.2 Discharge to Infiltration Tank 2 will predominantly comprise uncontaminated surface water runoff from the Proposed Development. Discharge to Infiltration Tank 3 will comprise treated surface runoff from the WTP.

Infiltration Tank 2

4.2.3 The proposed concentrations of contaminants in the uncontaminated surface water discharge to Infiltration Tank 2 are summarised in **Table 4.1** and have been compared to water quality criteria, with UK drinking water standards (DWS) selected as the most appropriate water quality criteria. Where UK DWS are not available environmental quality standards (EQS) have been selected. Concentrations of hazardous substances have been compared to the Environment Agency Minimum Reporting Values (MRV). The concentrations have also been compared to the site background water quality.

Table 4.1: Comparison of proposed water quality discharge to Infiltration Tank 2 to water quality criteria

Determinand	Units	Proposed maximum Discharge Concentration	DWS	MRV	Background Concentration
Cadmium	mg/l	0.002	0.005		0.0002
Chromium (total)	mg/l	0.01	0.05		0.007
Copper	mg/l	0.01	2		0.006
Nickel	mg/l	0.01	0.02		0.0119
Zinc	mg/l	0.01	0.0112**		0.012
Propylene glycol	mg/l	<10			<10
Benzene*	mg/l	<0.001	0.001	0.001	<0.001
Toluene*	mg/l	<0.001	0.074**	0.004	<0.001
Ethylbenzene*	mg/l	<0.001	0.02**		<0.001
Xylene*	mg/l	<0.001	0.03**	0.003	<0.001
Naphthalene*	mg/l	<0.001	0.002		<0.0001
* Hazardous substance ** Environmental Quality Standard (EQS)					

4.2.4 No hazardous substances are expected to be discharged to Infiltration Tank 2 with concentrations in the discharge assumed to be less than the laboratory limit of detection.

4.2.5 No de-icing products, including glycol will be discharged to Infiltration Tank 2.

4.2.6 The proposed discharge concentrations for the metals chromium, copper, and zinc are below the DWS and below or close to the background groundwater quality. The concentration of cadmium in the discharge is an order of magnitude higher than the background groundwater quality but below the DWS. Overall, the discharge of these metals at these concentrations to ground is not considered to pose a risk to groundwater beneath Infiltration Tank 2.

4.2.7 While the predicted contaminant discharge from Tank 2 is not considered to pose a risk to groundwater quality, a quantitative assessment of the metals and benzene (as an indicator compound for hydrocarbons) has been undertaken to understand the transport of these contaminants in the aquifer (**Section 5**).

4.2.8 A constant discharge to ground in the Infiltration Tank 2 has been assumed for this assessment based on the proposed design infiltration rate of 0.085m/hr. This is considered a conservative assumption as seasonal variations in surface runoff and greywater reuse will result in lower discharges to ground at some points during a calendar year, which will reduce the loading of contaminant discharge to ground. The infiltration tanks are designed to be generally dry and only fill to discharge during rainfall events. During prolonged dry periods there is likely to be limited to no discharge to ground.

Infiltration Tank 3

4.2.9 The proposed concentrations of contaminants in the treated surface water discharge to Infiltration Tank 3 are summarised in **Table 4.2** and have been compared to water quality criteria.

Table 4.2: Comparison of proposed water quality discharge to Infiltration Tank 3 to water quality criteria

Determinand	Units	Proposed maximum Discharge Concentration	DWS	MRV	Background Concentration
Cadmium	mg/l	0.001	0.005		0.0002
Chromium (total)	mg/l	0.001	0.05		0.007
Copper	mg/l	0.001	2		0.006
Nickel	mg/l	0.001	0.02		0.0119
Zinc	mg/l	0.001	0.0112**		0.012
Propylene glycol	mg/l	<10			<10
Benzene*	mg/l	0.01	0.001	0.001	<0.001

Determinand	Units	Proposed maximum Discharge Concentration	DWS	MRV	Background Concentration
Toluene*	mg/l	0.01	0.074**	0.004	<0.001
Ethylbenzene*	mg/l	0.01	0.02**		<0.001
Xylene*	mg/l	0.01	0.03**	0.003	<0.001
Naphthalene*	mg/l	0.01	0.002		<0.0001
* Hazardous substance ** Environmental Quality Standard (EQS)					

4.2.10 The treatment process is anticipated to result in a total hydrocarbon concentration in the final treated discharge of less than 0.01 mg/l. This will include all hydrocarbon compounds and concentrations of individual compounds are likely to be an order of magnitude lower (0.001 mg/l).

4.2.11 As a precautionary measure for this assessment the concentrations of BTEX and naphthalene in the discharge is assumed to be 0.01 mg/l as the worst-case, which exceeds the respective water quality criteria. Where the more likely concentration of 0.001 mg/l are assessed, these would be below the water quality criteria.

4.2.12 No de-icing products, including glycol will be discharged to Infiltration Tank 3 as these would be removed in the treatment process.

4.2.13 The proposed discharge concentrations for chromium, copper, and zinc are below the DWS and background groundwater quality. The concentration of cadmium in the discharge is an order of magnitude higher than the background groundwater quality but below the DWS. Overall, the discharge of these metals at these concentrations to ground is not considered to pose a risk to groundwater beneath Infiltration Tank 3.

4.2.14 While the predicted contaminant discharge of metals from Tank 3 is not considered to pose a risk to groundwater quality, a quantitative assessment of the metals has been undertaken alongside the hydrocarbon contaminants to understand the transport of these contaminants in the aquifer (**Section 5**).

4.2.15 A constant discharge to ground in the Infiltration Tank 3 has been assumed for this assessment based on the proposed design infiltration rate of 0.085m/hr. This is considered a conservative assumption as seasonal variations in surface runoff and greywater reuse will result in lower discharges to ground at some points during a calendar year, which will reduce the loading of contaminant discharge to ground. During prolonged dry periods there is likely to be limited to no discharge to ground.

4.3 Pathway

4.3.1 A granular drainage layer approximately 0.3m thick will be provided at the base of the infiltration tank. The tank will be constructed directly onto the chalk bedrock. Discharge from Infiltration Tank 3 will infiltrate down through the chalk to the underlying groundwater.

4.3.2 The thickness of the unsaturated zone will vary with seasonal changes in groundwater level. Two scenarios have been considered:

c. A worst case a 1m unsaturated zone beneath both infiltration tanks; and
d. A 8.1m unsaturated zone beneath Infiltration Tank 2 and 9.8m thick unsaturated zone beneath Infiltration Tank 3, representing the peak 2018 groundwater level.

4.3.3 Available site-specific data indicates that the hydraulic conductivity of the upper 20m of the chalk is approximately 2.08 m/d.

4.3.4 Attenuation and degradation of contaminants as they migrate through the unsaturated zone has been assumed.

4.3.5 Groundwater flow is to the east towards the PWS abstraction 2.6km down hydraulic gradient.

4.3.6 Dilution and dispersion of contaminants within the aquifer has been assumed.

4.3.7 The saturated aquifer thickness has been assumed to be 20m as a conservative assumption.

4.4 Receptor

4.4.1 Groundwater in the chalk principal aquifer is the primary receptor. Groundwater is abstracted from the chalk for drinking water supply with the nearest PWS abstraction location 2.6km to the east.

4.4.2 In accordance with the Water Framework Directive (2000/60/EC) (Ref. 14) (WFD) and Groundwater Daughter Directive (2006/118/EC) (Ref. 15) (GDD), the input of hazardous substances into groundwater should be prevented and the input of non-hazardous pollutants into groundwater should be limited and should not cause pollution (typically assessed by comparison to appropriate water quality standard).

4.4.3 The compliance point considered in this assessment for non-hazardous pollutants is a nominal point located 50m down gradient of the Infiltration Tanks 2 and 3.

4.4.4 The compliance point for hazardous substances considered in this assessment is the base of the unsaturated zone.

4.4.5 The predicted concentrations at each of the receptors has been compared to appropriate water quality criteria at each of the receptors to assess if the discharge from the infiltration tanks has potential to cause pollution of groundwater.

4.4.6 The input of hazardous substances is considered to have been prevented if there are no attributable, discernible concentrations of hazardous substances in groundwater immediately down gradient of the discharge zone.

4.4.7 The discernible concentration for a hazardous substance is whichever of the following two has the highest concentration (Ref.19):

a. The natural background groundwater quality; or
b. The minimum reporting value (typically the limit of detection)

4.4.8 The predicted concentrations of non-hazardous pollutants at the receptors have been compared to DWS and background groundwater quality.

5 QUANTITATIVE RISK ASSESSMENT

5.1 Approach

5.1.1 The modelling tool ConSim (Ref.1) has been used for undertaking the quantitative risk assessment to assess the potential impact of discharge from Infiltration Tanks 2 and 3 to groundwater for the identified source contaminants.

5.1.2 ConSim allows multiple contaminants, sources, and receptors to be assessed simultaneously and enables an assessment of the risk posed by contaminants at each receptor to be defined. It models contaminant mobilisation and transport.

5.1.3 ConSim deals with uncertainty by using a probabilistic method of modelling known as the Monte Carlo method. In this method, the calculations are carried out many times, with a different parameter value randomly selected from the input range of values each time. The input range of values for each parameter can be entered as a probability density function. The choice of probability density function depends on how much data is available and the quality of the data.

5.1.4 ConSim has the option for modelling a soakaway source. The soakaway option simulates the intense recharge originating from a designed infiltration zone. For this assessment the infiltration tanks have been modelled as non-drainage system soakaways, where a known amount of liquid is placed in a soakaway to infiltrate to ground. Contaminant concentrations in the discharge are entered in ConSim as leachate source concentrations to simulate the discharge of runoff to ground.

5.1.5 A Level 3 assessment has been undertaken on the key contaminants of concern in the infiltration tank discharges. The Level 3 assessment allows concentrations of contaminants to be modelled at compliance point downgradient in the aquifer and at the base of the unsaturated zone beneath the source.

5.1.6 The following receptor compliance points have been modelled in ConSim:

a. Base of the unsaturated zone beneath Infiltration Tanks 2 and 3;
b. Compliance point 50m down gradient from both Infiltration Tanks 2 and 3.

5.2 Input parameters

5.2.1 The main hydrogeological model input parameters are provided in **Table 5.1** and the contaminant source parameters are in **Table 5.2**. The following assumptions have been made as part of the ConSim model:

a. Groundwater flow is assumed to occur towards the east in the Chalk aquifer and the thickness of the aquifer is constant throughout the flow path;
b. Retardation in both the unsaturated zone and saturated zone have only been modelled in the dissolved phase;

c. The whole footprint of the two infiltration tanks is assumed to be the source of contamination. The boundaries have been set at the area and location shown in the drawings provided in the DDS;

d. No biodegradation is assumed;

e. 1,001 iterations of the simulation have been applied;

f. Time slices varying from 1-7,000 years have been modelled;

g. Mixing zone thickness is calculated in ConSim. ConSim estimates this from the source length, the aquifer properties and infiltration rate.

Table 5.1: Hydrogeological model input parameters

Parameter	Value	Unit	Justification/ Notes[A]
Source – Infiltration Tank 2			
Thickness	3.3	m	Height of tank from **DDS** (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510]**
Source	Non-drainage soakaway	-	Most appropriate option in ConSim
Infiltration rate	2.04	m/d	Tank infiltration rate from **DDS** (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**).
Source – Infiltration Tank 3			
Thickness	2.8	m	Height of tank from DDS (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**) drawing **[LLADCO-3C-CAP-INF-DRN-DR-CE-5510]**
Source	Non-drainage soakaway	-	Most appropriate option in ConSim
Infiltration rate	2.04	m/d	Tank infiltration rate from **DDS** (**Appendix 20.4** of the ES **[TR020001/APP/5.02]**)
Unsaturated Zone – 1 in 100 year groundwater levels (both infiltration tanks)			
Thickness of unsaturated zone	1	m	Minimum unsaturated zone based on level of base of tank and worst case 1 in 100 year groundwater level
Unsaturated zone water filled porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Saturated effective porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)

Parameter	Value	Unit	Justification/ Notes[A]
Dry bulk density	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Saturated hydraulic conductivity	2.4x10^{-5}	m/s	Average hydraulic conductivity value of upper 20m of chalk (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Vertical dispersivity	0.001	m	0.001 of path length
Unsaturated Zone – peak 2018 groundwater level Infiltration Tank 2			
Thickness of unsaturated zone	8.1	m	Unsaturated zone based on level of base of tank 2 and predicted maximum seasonal groundwater level
Unsaturated zone water filled porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Saturated effective porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Dry bulk density	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Saturated hydraulic conductivity	2.4x10^{-5}	m/s	Average hydraulic conductivity value of upper 20m of chalk (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Vertical dispersivity	0.0081	m	0.001 of path length
Unsaturated Zone – peak 2018 groundwater level Infiltration Tank 3			
Thickness of unsaturated zone	9.8	m	Unsaturated zone based on level of base of tank 3 and predicted maximum seasonal groundwater level
Unsaturated zone water filled porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Saturated effective porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Dry bulk density	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Saturated hydraulic conductivity	2.4x10^{-5}	m/s	Average conductivity value of upper 20m of chalk (Appendix 20.3 of ES [TR020001/APP/5.02])
Vertical dispersivity	0.0098	m	0.001 of path length
Aquifer properties – 1 in 100-year groundwater levels (both infiltration tanks)			
Thickness	20	m	Assumed saturated thickness for chalk, considered to be

Parameter	Value	Unit	Justification/ Notes[A]
			conservative value based on estimated depth of predominant flow path in upper chalk.
Dry bulk density	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Effective porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Hydraulic conductivity of aquifer	2.4x10^{-5}	m/s	Average conductivity value of upper 20m of chalk (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Hydraulic gradient	0.0075	-	Calculated from 1 in 100-year seasonal groundwater level contour plan (**Appendix 20.3** of ES **[TR020001/APP/5.02]**
Fraction of organic carbon	0.003	-	Average site data
Aquifer properties – peak 2018 groundwater levels (both infiltration tanks)			
Thickness	20	m	Assumed saturated thickness for chalk, considered to be conservative value based on estimated depth of predominant flow path in upper chalk.
Dry bulk density	1.55	g/cm^3	Average value from site data for chalk (Ref. 6)
Effective porosity	0.3	-	Estimate based on literature value for chalk (Ref. 3)
Hydraulic conductivity of aquifer	2.4x10^{-5}	m/s	Average conductivity value of upper 20m of chalk (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Hydraulic gradient	0.0055	-	Calculated from 1 in 100 year seasonal groundwater level contour plan (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
Fraction of organic carbon	0.003	-	Average site data
Down Gradient Compliance Point (both infiltration tanks)			
Distance to compliance point	50	m	Nominal 50m groundwater compliance point down-gradient of each infiltration tank
Vertical dispersivity	0.05	m	0.001 of path length

Parameter	Value	Unit	Justification/ Notes[A]
Longitudinal dispersivity	0.5	m	0.01 of path length
Lateral dispersivity	5	m	0.1 of path length
Groundwater flow direction	80	degrees	Groundwater flow path direction beneath tank areas based on groundwater contour plans (**Appendix 20.3** of ES **[TR020001/APP/5.02]**)
[A] appropriate literature values have been used where site-specific data is not currently available. Further ground investigation and assessment during detailed design will undertake to provide site specific data for the input parameters where possible.			

Table 5.2: Contaminant input parameters

Contaminant	Source concentration Infiltration Tank 2 (mg/l)	Source Concentration Infiltration Tank 3 (mg/l)	K_{oc} (l/kg)	K_d (l/kg)	Water quality criteria (mg/l)
Cadmium	0.002	0.001	-	100 [C]	0.005[A]
Chromium	0.01	0.001	-	7,943[D]	0.05[A]
Copper	0.01	0.001	-	501.2 [D]	2[A]
Nickel	0.01	0.001	-	1,258 [D]	0.02[A]
Zinc	0.01	0.001	-	1,258 [D]	0.0112[A]
Benzene	0.001	0.01	79[E]	-	0.001[A&B]
Toluene	-	0.01	250[E]	-	0.004[B]
Ethylbenzene	-	0.01	1,600[E]	-	0.001[F]
Xylene	-	0.01	1,600[E]	-	0.003[A&B]
Naphthalene	-	0.01	2,500[E]	-	0.0001[B]
[A] UK drinking water standard (DWS) [B] Minimum reporting value (MRV) [C] Literature value (Ref. 21) [D] Literature value (Ref. 20) [E] Literature value (Ref. 22) [F] Background					

5.3 Results – 1 in 100-year groundwater level

5.3.1 The ConSim model has predicted the concentrations of contaminants entering the groundwater table (at the base of the unsaturated zone) and predicts concentrations of contaminants at the receptors though migration in groundwater. The outputs of the Level 3 ConSim assessment based on a 1m thick unsaturated zone beneath each infiltration tank are presented in **Table 5.3** for Infiltration Tank 2 and **Table 5.4** for Infiltration Tank 3.

Table 5.3: Output from assessment for 1m unsaturated zone for Infiltration Tank 2

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.005	0.002	0.002	0.2	0.002	9
Chromium	0.05	0.01	0.01	16.5	0.0099	716.5
Copper	2	0.01	0.01	1	0.0099	45.2
Nickel	0.02	0.01	0.01	2.6	0.0099	113.6
Zinc	0.0112	0.01	0.01	2.6	0.0099	113.6
Benzene	0.001	0.001	0.001	0.0004	0.00099	0.018

Table 5.4: Output from assessment for 1m unsaturated zone for Infiltration Tank 3 (shaded cells indicate contaminants reaching receptor at concentrations above the water quality criteria)

Determinand	**Water quality criteria (mg/l)**	**Discharge concentration (mg/l)**	**Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)**	**Retarded travel time to base of unsaturated zone (years)**	**Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)**	**Retarded travel time to 50m compliance point (years)**
Cadmium	0.002	0.001	0.001	0.2	0.00099	7.5
Chromium	0.01	0.001	0.001	16.5	0.00099	591
Copper	0.01	0.001	0.001	1	0.00099	37.3
Nickel	0.01	0.001	0.001	2.6	0.00099	93.7

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Zinc	0.01	0.001	0.001	2.6	0.00099	93.7
Benzene	0.001	0.01	0.01	0.0004	0.0099	0.014
Toluene	0.004	0.01	0.01	0.0004	0.0099	0.015
Ethylbenzene	0.001	0.01	0.01	0.0005	0.0099	0.018
Xylene	0.003	0.01	0.01	0.0005	0.0099	0.018
Naphthalene	0.0001	0.01	0.01	0.00056	0.0099	0.02

5.3.2 The predicted concentrations of metals and hydrocarbons in groundwater at the base of the 1m unsaturated zone beneath Infiltration Tanks 2 and 3 and at the 50m compliance point are equal to the source input concentration indicating limited attenuation.

5.3.1 The predicted concentration of metals at the 50m compliance point down gradient of both infiltration tanks does not indicate a pollution risk as the source discharge concentrations are below the chosen water quality criteria.

5.3.2 Cadmium is predicted to reach the 50m compliance point of both infiltration tanks in less than 10 years, copper in less than 50 years and nickel and zinc in less than 120 years. Chromium is predicted to reach the 50m compliance point in less than 720 years.

5.3.3 Although the concentrations of the metals at the receptors do not indicate a risk of pollution to groundwater, the relatively rapid travel times for metals (in particular, cadmium, copper, nickel, and zinc) do not allow for any significant attenuation and dispersion in the aquifer. Therefore, it will be essential to ensure that source discharge concentrations to the infiltration tanks are less than the water quality criteria.

5.3.4 BTEX and naphthalene concentrations exceed the water quality criteria at the base of the unsaturated zone beneath Infiltration Tank 3 and indicate a risk of pollution to groundwater. These contaminants are highly mobile, and the model results indicates travel times through the unsaturated zone will be less than 1 day.

5.3.5 As discussed in Section 4 the assumed source concentrations for BTEX and naphthalene in the treated surface water discharged to Infiltration Tank 3 are a worst-case scenario and it is likely that the input concentration could be at least an order of magnitude lower. The model results indicate that the surface water would need to undergo treatment to ensure BTEX and naphthalene concentrations are equal to the water quality criteria to prevent discharge of hazardous substances and a pollution risk to groundwater. Treatment options will need to be assessed during detailed design.

5.4 Results – peak 2018 groundwater level

5.4.1 The outputs of the Level 3 ConSim assessment based on an 8.1m thick unsaturated zone beneath Infiltration Tank 2 are presented in **Table 5.5** and a 9.8m unsaturated zone beneath Infiltration Tank 3 in **Table 5.6**.

Table 5.5: Output from assessment for 8.1m unsaturated zone for Infiltration Tank 2

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.005	0.002	0.002	2	0.002	10.5
Chromium	0.05	0.01	0.01	134	0.0099	832
Copper	2	0.01	0.01	8	0.0099	52.5
Nickel	0.02	0.01	0.01	21	0.0099	132
Zinc	0.0112	0.01	0.01	21	0.0099	132
Benzene	0.001	0.001	0.001	0.003	0.00099	0.02

Table 5.6: Output from assessment for 9.8m unsaturated zone for Infiltration Tank 3 (shaded cells indicate contaminants reaching receptor at concentrations above the water quality criteria)

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.002	0.001	0.001	2	0.00099	9
Chromium	0.01	0.001	0.001	162	0.00099	737
Copper	0.01	0.001	0.001	10	0.00099	46.5
Nickel	0.01	0.001	0.001	26	0.00099	117

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Zinc	0.01	0.001	0.001	26	0.00099	117
Benzene	0.001	0.01	0.01	0.001	0.0099	0.08
Toluene	0.004	0.01	0.01	0.004	0.0099	0.02
Ethylbenzene	0.001	0.01	0.01	0.005	0.0099	0.022
Xylene	0.003	0.01	0.01	0.005	0.0099	0.022
Naphthalene	0.0001	0.01	0.01	0.006	0.0099	0.025

5.4.2 Like the 1m unsaturated zone model, the predicted concentrations of metals and hydrocarbons in groundwater at the base of the unsaturated zone beneath Infiltration Tanks 2 and 3 and at the 50m compliance point are equal to the source input concentration.

5.4.3 The predicted concentration of metals at the 50m compliance point down gradient of both infiltration tanks does not indicate a pollution risk as the source discharge concentrations are below the chosen water quality criteria.

5.4.4 The increased unsaturated zone beneath each of the tanks, results in an increase in the predicted travel time for contaminants through the unsaturated zone.

5.4.5 Cadmium is predicted to reach the 50m compliance point of both tanks in less than 11 years, copper in less than 55 years and nickel and zinc in less than 135 years. Chromium is predicted to reach the 50m compliance point in less than 840 years.

5.4.6 Although the concentrations of the metals at the receptors do not indicate a risk of pollution to groundwater, the relatively rapid travel times for metals (in particular, cadmium, copper, nickel, and zinc) do not allow for any significant attenuation and dispersion in the aquifer.

5.4.7 BTEX and naphthalene concentrations exceed the water quality criteria at the base of the unsaturated zone beneath Infiltration Tank 3 and indicate a risk of pollution to groundwater. These contaminants are highly mobile, and the model results indicates travel times through the unsaturated zone will be less than 2 days.

5.4.8 The model results indicate that the surface water would need to undergo treatment to ensure BTEX and naphthalene concentrations were equal to the water quality criteria to prevent discharge of hazardous substances and a pollution risk to groundwater. Treatment options will need to be assessed during detailed design.

5.5 Sensitivity analysis

5.5.1 Sensitivity analysis demonstrates how the predicted effect on groundwater and associated receptors may change when parameters in the model are adjusted. This analysis identified the most sensitive parameters do a reasoned judgement can be made on whether further data is needed to better constrain the parameter being tested. This provides greater confidence in the mode results.

5.5.2 Several parameters in the hydrogeological CSM are considered sensitive with regards to contaminants transport. **Table 5.7** indicates the main sensitivity parameters and a justification for their exclusion/inclusion in the sensitivity analysis.

Table 5.7: Influence of model parameters on contaminant transport

Parameter	Influence on contaminant transport	Included in sensitivity analysis (Y/N)	Justification
Hydraulic conductivity	Rate of contaminant transport (advection) and arrival time at receptor. Calculated groundwater dilution	Y	Predicting the hydraulic conductivity of Chalk is difficult due to most of the flow occurring through fractures. There was a large range in results from the packer testing undertaken at site (see **Table 6.1** of the GQRA (Ref.2) (**Appendix 17.2**) of the ES **[TR020001/APP/5.02]**)) which covered both interfluve and dry valley areas. Hydraulic conductivity can vary due to weathered chalk, solution features.
Fraction of organic carbon (foc)	Calculation of partition coefficient	N	Organic carbon in the unsaturated and saturated zone provides sites for hydrophobic contaminants to sorb to and reduces contaminant transport. No further data is available to refine the value. Foc of Chalk is likely to be low.
Hydraulic gradient	Rate and direction of groundwater flow. Calculated groundwater dilution.	N	The current hydraulic gradient in the modelling is based on maximum measured groundwater levels and 1 in 100-year groundwater levels and therefore is considered to be representative of a reasonable worst-case hydraulic gradient.
Infiltration rate	Dilution. Contaminant loading	Y	The modelling assumes a constant discharge rate from the infiltration tanks equal to the proposed tank design value. The actual volume of discharge from the infiltration tanks will vary significantly due to weather conditions and the volume of surface water reused as greywater in the proposed development. Therefore, sensitivity analysis of this parameter is useful to understand the impact of lower discharge rates.

Parameter	Influence on contaminant transport	Included in sensitivity analysis (Y/N)	Justification
Unsaturated aquifer thickness	Rate of contaminant transport (advection) and arrival tie at receptor. Calculated groundwater dilution.	N	The groundwater is known to vary seasonally. The model scenarios considered in this assessment already account for worst case groundwater levels and the seasonal maximum. Further sensitivity analysis is therefore not considered necessary.
Biodegradation	Reduction of contaminant mass and concentration.	N	No site-specific data is available. Literature values are not specific to site conditions but are extensively researched and observed under multiple scenarios and conditions.

Input parameters

5.5.3 Sensitivity analysis had been conducted on the parameters identified above in **Table 5.7**. model runs have been undertaken varying each of the parameters in turn to examine which parameters have the greatest influence on the modelling result. The results of the sensitivity analysis are presented in **Appendix A** of this document and summarised in **Table 5.8**.

Table 5.8: Parameters varied for sensitivity analysis

Parameter	Value	Units	Data Source
Hydraulic conductivity of aquifer in which dilution occurs	2.4×10^{-4}	m/s	Predicting the hydraulic conductivity of Chalk is difficult due to most of the flow occurring through fractures. Hydraulic Conductivity used in ConSim modelling was based on the mean value (2.4×10^{-5} m/s) obtained from the top 20m of Chalk. An order of magnitude increase to the hydraulic conductivity has been used in the sensitivity analysis to examine the importance of this parameter.
Infiltration – 25%	0.51	m/d	The volume of discharge rate from the infiltration tanks will vary seasonally. Reduction in amount of infiltration to 25% of the current value has been assessed to examine the importance of this parameter.

Results

Infiltration

5.5.4 The results of the sensitivity analysis identify infiltration of surface water runoff is a key parameter that influences the travel time of contaminants to the receptors. There is no significant impact on the predicted contaminant concentration.

5.5.5 The results indicate that by reducing the infiltration to 25%, contaminant travel times through the unsaturated zone show a fourfold increase. Full results are provided in **Appendix A** of this document.

5.5.6 The volume of surface water runoff discharged to the infiltration tanks will vary seasonally and there are likely to be periods of the year where there is no or very little discharge to the infiltration tanks. Using the storage capacity in the infiltration tanks to control the rate of discharge to ground would provide some additional mitigation to protect the underlying groundwater.

Hydraulic conductivity

5.5.7 Hydraulic conductivity is a sensitive parameter in relation to the rate of contaminant transport and arrival at the receptor. The use of the increased hydraulic conductivity of $2.4x10^{-4}$ m/s compared to the mean of $2.4x10^{-5}$ m/s resulted in the similar predicted concentrations at the receptors. The predicted travel times are slightly faster and show a 0.5% to 2.5% increase in contaminant travel times to the compliance point 50m down gradient.

The assessment of hydraulic conductivity is based on available on-site permeability testing during ground investigation undertaken across the wider airport area (discussed in Appendix 20.4 of the ES [TR020001/APP/5.02]). The locations of available site investigate boreholes, trial pits and packer test data across the site cover both he interfluve and dry valley areas. Hydraulic conductivities would be confirmed following a detailed investigation at the proposed infiltration tank locations as part of the detailed design.

5.6 Discussion

5.6.1 The results of the quantitative risk assessment have predicted that proposed concentrations of contaminants discharged as uncontaminated surface runoff to Infiltration Tank 2 are unlikely to pose a risk of groundwater pollution as the source discharge concentration are below the water quality criteria.

5.6.2 The discharge of treated surface water to Infiltration Tank 3 indicates a potential pollution risk to groundwater because of discharge of hydrocarbons. BTEX and naphthalene concentrations exceed the water quality criteria at the base of the unsaturated zone beneath Infiltration Tank 3. These contaminants are highly mobile, and the model results indicates travel times through the unsaturated zone will be less than 1 day (for a 1m unsaturated zone).

5.6.3 The assumed source concentrations for BTEX and naphthalene in the treated surface water discharged to Infiltration Tank 3 are a worst-case and it is likely that the input concentration could be at least an order of magnitude lower. The model results indicate that the surface water would need to undergo treatment to ensure BTEX and naphthalene concentrations were equal to the water quality criteria to prevent discharge of hazardous substances and a pollution risk to groundwater. Treatment options will need to be assessed during detailed design.

5.6.4 Although the concentrations of the metals at the receptors do not indicate a risk of pollution to groundwater, the relatively rapid travel times for metals (in particular, cadmium, copper, nickel, and zinc) do not allow for any significant attenuation and dispersion in the aquifer. Therefore, it will be essential to ensure that source discharge concentrations to the infiltration tanks are less than the water quality criteria.

5.6.5 Sensitivity analysis has indicated that the depth of the unsaturated zone beneath the infiltration tanks and the volume of discharge will impact the predicted travel times of the contaminants to the receptors but not so significantly change the predicted concentration.

5.6.6 The volume of surface water runoff discharged to the infiltration tanks will vary seasonally and there are likely to be periods of the year where there is no or very little discharge to the infiltration tanks. The infiltration tanks are designed to be generally dry and only fill to discharge during rainfall events. Using the storage capacity in the infiltration tanks to control the rate of discharge to ground would provide some additional mitigation to protect the underlying groundwater.

5.6.7 The quantitative risk assessment will need to be revised once the detailed design of the drainage infrastructure has been confirmed to support an application for the Environmental Permit to discharge prior to the construction of the infiltration tanks and WTP.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 This report has been produced to provide an initial HRA to assess the acceptability of the proposed discharge of surface runoff to ground from the proposed infiltration tanks in terms of the groundwater quality impact.

6.1.2 The proposed drainage infrastructure comprises the construction of a WTP and two infiltration tanks for the discharge of uncontaminated surface water runoff and treated surface water runoff to ground.

6.1.3 Infiltration Tank 2 will be used for the discharge of uncontaminated surface runoff to ground. Infiltration Tank 3 will be used for the discharge of surface runoff which has undergone treatment at the proposed WTP to remove key contaminants including de-icing products and hydrocarbons.

6.1.4 Foul water from the proposed development is expected to be discharged to the Thames Water network as the preferred drainage design option. An assessment of the risk of discharging foul water to ground is not included in this report. In the unlikely event that TW cannot accept the foul water, the reserve option of effluent being treated on site and discharged to ground via Infiltration Tank 3 would be adopted, and an updated risk assessment will be undertaken during detailed design to consider the risks to groundwater.

6.1.5 The proposed drainage infrastructure is to be installed during assessment Phases 2a and 2b and therefore this risk assessment will need to be revised to account for the final detailed drainage design and to support an application to the Environment Agency for an Environmental Permit to discharge closer to the time of construction. In addition, Requirement 13 of the Development Consent Order (DCO) requires the details of the surface and foul drainage system to be approved by the relevant planning authority following consultation with various bodies.

6.1.6 Surface runoff entering the drainage system will be sourced from both landside and airside areas of the Proposed Development.

6.1.7 The main activities within the airside areas of the Proposed Development which could result in contaminants in the surface runoff include:

a. de-icing of aircraft and hard surfaces (glycols and formates)
b. spills from refuelling of aircraft and vehicles (BTEX and naphthalene)
c. wear and corrosion of aircraft and infrastructure (heavy metals)
d. weed control in area of soft landscaping (herbicides)

6.1.8 The main activities within the landside areas of the Proposed Development which could result in contaminants in the surface runoff include:

a. minor leaks of fuel from vehicles in car parks (BTEX and naphthalene)
b. wear and corrosion of vehicles and infrastructure (heavy metals)
c. weed control in area of soft landscaping (herbicides)

6.1.9 Emergency incidents such as fires and large-scale fuel spills also have the potential to result in contaminants being present in the drainage system. Releases because of any emergency incidents would be dealt with as part of the airport's emergency management plan. Typically, any runoff will be contained, and the drainage system isolated for disposal.

6.1.10 Several management and control measures will be implemented to limit contaminated runoff entering the drainage system. This will include improved application and reuse of de-icing products and spill management measures.

6.1.11 Where contaminants such as de-icing products and fuel and oils enter the drainage, a continuous monitoring system will be installed to divert any contaminated runoff to the WTP prior to discharge to ground.

6.1.12 Based on available information, assumptions about the water quality of the uncontaminated surface runoff and treated surface runoff which will be discharged to ground have been made. During the detailed design, site-specific water quality monitoring will be undertaken to assess fully the likely contaminant concentrations which will be present in the influent to the WTP and to determine appropriate monitoring systems and trigger levels.

6.1.13 The key contaminants likely to be discharged to ground include heavy metals and hydrocarbons (BTEX and naphthalene).

6.1.14 The results of the quantitative risk assessment have predicted that proposed concentrations of contaminants discharged as uncontaminated surface runoff to Infiltration Tank 2 are unlikely to pose a risk of groundwater pollution as the source discharge concentration are below the water quality criteria.

6.1.15 The discharge of treated surface water to Infiltration Tank 3 indicates a potential pollution risk to groundwater because of discharge of hydrocarbons. BTEX and naphthalene concentrations exceed the water quality criteria at the base of the unsaturated zone beneath Infiltration Tank 3. These contaminants are highly mobile, and the model results indicates travel times through the unsaturated zone will be less than 1 day (for a 1m unsaturated zone).

6.1.16 The assumed source concentrations for BTEX and naphthalene in the treated surface water discharged to Infiltration Tank 3 are a worst-case and it is likely that the input concentration could be at least an order of magnitude lower. The model results indicate that the surface water would need to undergo treatment to ensure BTEX and naphthalene concentrations were equal to the water quality criteria to prevent discharge of hazardous substances and a pollution risk to groundwater. Treatment options will need to be assessed during detailed design.

6.1.17 Although the concentrations of the metals at the receptors do not indicate a risk of pollution to groundwater, the relatively rapid travel times for metals (in particular, cadmium, copper, nickel, and zinc) do not allow for any significant attenuation and dispersion in the aquifer. Therefore, it will be essential to ensure that source discharge concentrations to the infiltration tanks are less than the water quality criteria.

6.1.18 The volume of surface water runoff discharged to the infiltration tanks will vary seasonally and there are likely to be periods of the year where there is no or very little discharge to the infiltration tanks. The infiltration tanks are designed to be generally dry and only fill to discharge during rainfall events. Using the storage capacity in the infiltration tanks to control the rate of discharge to ground would provide some additional mitigation to protect the underlying groundwater.

6.1.19 The quantitative risk assessment will need to be revised once the detailed design of the drainage infrastructure has been confirmed to support an application for the Environmental Permit to discharge prior to the construction of the infiltration tanks and WTP. In addition, Requirement 13 of the Development Consent Order (DCO) requires the details of the surface and foul drainage system to be approved by the relevant planning authority following consultation with various bodies.

6.2 Recommendations

6.2.1 This risk assessment is based on the concept drainage design for the Proposed Development. The risk assessment will need to be revised once the detailed design of the drainage infrastructure has been confirmed to support an application for an Environmental Permit to discharge prior to the future construction of the infiltration tanks and WTP. In addition, Requirement 13 of the DCO requires the details of the surface and foul drainage system to be approve the relevant planning authority following consultation with various bodies. It is acknowledged that regulatory requirements for discharge to groundwater (including changes to water quality standards and emerging contaminants) may have changed by the time the permit application is made and water treatment technology may have improved.

6.2.1 During the detailed drainage design stage, site specific water quality monitoring will be undertaken to assess fully the likely contaminant concentrations which may be present in the surface water drainage influent to the WTP and discharge effluent to the infiltration tanks and to determine appropriate monitoring systems and trigger levels.

6.2.2 The ground conditions parameters used in this risk assessment are based on available ground investigation information from the wider airport site. Site specific infiltration and permeability testing will be undertaken at the proposed infiltration tank locations to confirm the infiltration rates and detailed design of the tanks.

6.2.3 Groundwater quality monitoring boreholes are likely to be required by the Permit down gradient of the proposed infiltration tanks for compliance monitoring of groundwater during operation.

GLOSSARY AND ABBREVIATIONS

Term	Definition
Aquifer	An aquifer is a body of rock and/or sediment that holds groundwater.
BGS	British Geological Survey
Chalk	Chalk is a soft, white, porous, sedimentary carbonate rock. It is a form of limestone composed of the mineral calcite and originally formed deep under the sea by the compression of microscopic plankton that had settled to the sea floor.
Clay with Flints	Superficial deposits of stiff red, brown or yellow clay containing unworn whole flints as well as angular shattered fragments, also with a variable admixture of rounded flint, quartz, quartzite and other pebbles
DCO	Development Consent Order
DDS	Drainage Design Statement
EA	Environment Agency
ES	Environmental Statement
Groundwater	Groundwater is any water found beneath the surface that fills pores or cracks in the underlying soil and rocks.
Groundwater mounding	A localised increased in groundwater level.
HCR	Hydrogeological characterisation report
Hydraulic conductivity	Hydraulic conductivity is a physical property which measures the ability of the material to transmit fluid through pore spaces and fractures in the presence of an applied hydraulic gradient.
LBC	Luton Borough Council
mAOD	Metres above ordnance survey
mBGL	Metres below ground level
Permeability	A measure of the ability of a material (such as rocks) to transmit fluids
PWS	Public Water Supply
River Lee	Main river located 450m to the west of the Proposed Development. A tributary of the River Thames. Upper reaches are groundwater fed.
River Mimram	Main river located 3.5km to the south-east of the Proposed Development. A tributary of the River Thames. Upper reaches are groundwater fed.
WFD	Water Framework Directive
WTP	Water Treatment Plant

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APPENDIX A SENSITIVITY ANALYSIS

A1.1 HYDRAULIC CONDUCTIVITY

Output from sensitivity analysis on hydraulic conductivity for Infiltration Tank 2, assuming a 1m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.005	0.002	0.002	0.2	0.002	8.99
Chromium	0.05	0.01	0.01	16.5	0.0099	713
Copper	2	0.01	0.01	1	0.0099	45
Nickel	0.02	0.01	0.01	2.6	0.0099	113
Zinc	0.0112	0.01	0.01	2.6	0.0099	113
Benzene	0.001	0.001	0.001	0.0004	0.00099	0.018

Output from sensitivity analysis on hydraulic conductivity for Infiltration Tank 3, assuming a 1m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.002	0.001	0.001	0.2	0.00099	7.3
Chromium	0.01	0.001	0.001	16.5	0.00099	579.7
Copper	0.01	0.001	0.001	1	0.00099	36.6
Nickel	0.01	0.001	0.001	2.6	0.00099	91.9
Zinc	0.01	0.001	0.001	2.6	0.00099	91.9
Benzene	0.001	0.01	0.01	0.0004	0.0099	0.014
Toluene	0.004	0.01	0.01	0.0004	0.0099	0.015
Ethylbenzene	0.001	0.01	0.01	0.0005	0.0099	0.02
Xylene	0.003	0.01	0.01	0.0005	0.0099	0.018
Naphthalene	0.0001	0.01	0.01	0.0006	0.0099	0.02
Note: Cells shaded indicate contaminant reaching receptor within 1,000 years at concentrations above the water quality criteria						

A1.2 INFILTRATION 25% (1 IN 100 YEAR UNSATURATED ZONE)

Output from sensitivity analysis with 25% infiltration rate for Infiltration Tank 2, assuming a 1m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.005	0.002	0.002	0.8	0.002	36
Chromium	0.05	0.01	0.01	66	0.0099	2,843
Copper	2	0.01	0.01	4	0.0099	179
Nickel	0.02	0.01	0.01	11	0.0099	451
Zinc	0.0112	0.01	0.01	11	0.0099	51
Benzene	0.001	0.001	0.001	0.002	0.00099	0.07

Output from sensitivity analysis with 25% infiltration rate for Infiltration Tank 3, assuming a 1m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.002	0.001	0.001	0.8	0.00099	30
Chromium	0.01	0.001	0.001	66	0.00099	2,351
Copper	0.01	0.001	0.001	4	0.00099	148
Nickel	0.01	0.001	0.001	11	0.00099	373
Zinc	0.01	0.001	0.001	11	0.00099	373
Benzene	0.001	0.01	0.01	0.002	0.0099	0.06
Toluene	0.004	0.01	0.01	0.002	0.0099	0.06
Ethylbenzene	0.001	0.01	0.01	0.002	0.0099	0.07
Xylene	0.003	0.01	0.01	0.002	0.0099	0.07
Naphthalene	0.0001	0.01	0.01	0.002	0.0099	0.08
Note: Cells shaded indicate contaminant reaching receptor within 1,000 years at concentrations above the water quality criteria						

A1.3 INFILTRATION 25% (PEAK 2018 GROUNDWATER LEVEL UNSATURATED ZONE)

Output from sensitivity analysis with 25% infiltration rate for Infiltration Tank 2, assuming a 8.1m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.005	0.002	0.002	7	0.002	42
Chromium	0.05	0.01	0.01	535	0.0099	3,342
Copper	2	0.01	0.01	34	0.0099	211
Nickel	0.02	0.01	0.01	85	0.0099	530
Zinc	0.0112	0.01	0.01	85	0.0099	530
Benzene	0.001	0.001	0.001	0.013	0.00099	0.08

Output from sensitivity analysis with 25% infiltration rate for Infiltration Tank 3, assuming a 9.8m unsaturated zone

Determinand	Water quality criteria (mg/l)	Discharge concentration (mg/l)	Base of unsaturated zone concentration (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to base of unsaturated zone (years)	Concentration at 50m compliance point (95% of values less than (mg/l) at 1,000 years)	Retarded travel time to 50m compliance point (years)
Cadmium	0.002	0.001	0.001	8	0.00099	37
Chromium	0.01	0.001	0.001	647	0.00099	2,943
Copper	0.01	0.001	0.001	41	0.00099	186
Nickel	0.01	0.001	0.001	103	0.00099	467
Zinc	0.01	0.001	0.001	103	0.00099	467
Benzene	0.001	0.01	0.01	0.02	0.0099	0.07
Toluene	0.004	0.01	0.01	0.02	0.0099	0.07
Ethylbenzene	0.001	0.01	0.01	0.02	0.0099	0.09
Xylene	0.003	0.01	0.01	0.02	0.0099	0.09
Naphthalene	0.0001	0.01	0.01	0.02	0.0099	0.1
Note: Cells shaded indicate contaminant reaching receptor within 1,000 years at concentrations above the water quality criteria						